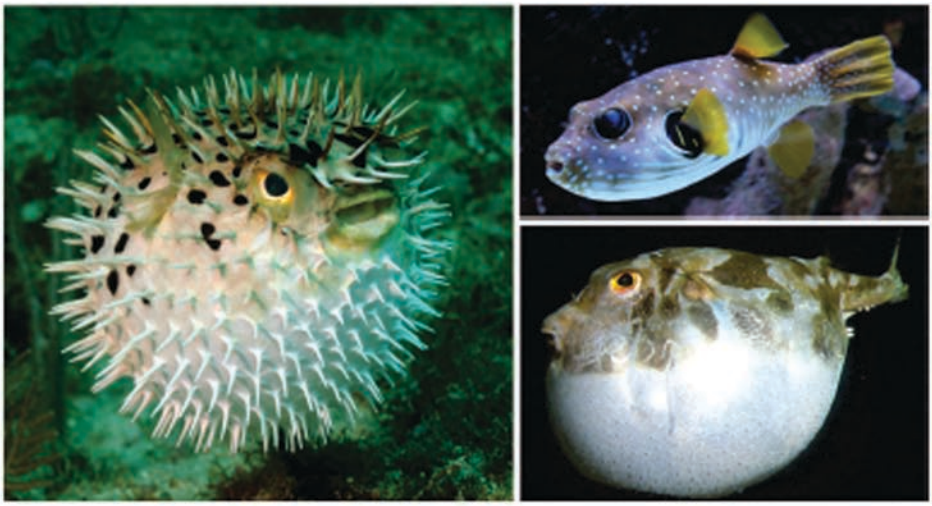
Biology and Ecology of Marine Life

Biology and Ecology of Toxic Pufferfish



Ramasamy Santhanam

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Ramasamy Santhanam, PhD

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LIST OF ABBREVIATIONS

ABC	airway breathing, and circulation
DHA	docosahexaenoic acid
EAC	ehrlich ascites carcinoma
ELISA	enzyme-linked immunosorbent assay
EPA	eicosapentaenoic acid
FDA	Food and Drug Administration
FEHD	Food and Environmental Hygiene Department
GH	general hardness
GI	gastrointestinal
IRL	Indian River Lagoon
IUCN	International Union for Conservation of Nature
IWT	International Wex Technology
LC	least concern
MST	mean survival time
MTV	male-territory-visiting
MU	mouse units
ORAC	oxygen radical absorbance capacity
PFP	puffer fish poisoning
PSP	paralytic shellfish poisoning
PST	paralytic shellfish toxins
PUFA	polyunsaturated fatty acids
SG	specific gravity
SL	standard length
SPFP	saxitoxin pufferfish poisoning
STX	saxitoxin
TAA	total amino acid
TPFP	tetodotoxin pufferfish poisoning
TPNNV	tiger puffer nervous necrosis virus
TTX	tetrrodotoxin
UV	ultraviolet

VER	viral encephalopathy and retinopathy
VGSC	voltage-gated sodium channels
VNN	viral nervous necrosis

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Dr. Ramasamy Santhanam is the former Dean of the Fisheries College and Research Institute at the Tamilnadu Veterinary and Animal Sciences University in Thoothukudi, India. His fields of specialization are marine biology and fisheries environment. Presently he is serving as a resource person for various universities in India. He has also served as an expert for the Environmental Management Capacity Building Technical Assistance Project, a World Bank-aided project of the Department of Ocean Development, India. He was a member of the American Fisheries Society, the World Aquaculture Society, the Global Fisheries Ecosystem Management Network (GFEMN), and the International Union for Conservation of Nature's (IUCN) Commission on Ecosystem Management, Switzerland. Dr. Santhanam has published 20 books on fisheries science/marine biology as well as 70 research papers.

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PREFACE

Pufferfish (also known as blowfish, swellfish or globefish) (family: Tetraodontidae) are believed to be the second most poisonous vertebrates in the world, after the golden poison frog. A total of 197 species of pufferfish have so far been recorded from the marine, brackish and freshwater habitats of the tropical to sub-tropical regions around the world. The poisonous nature of these pufferfish is largely due to the tetrodotoxin (TTX) and paralytic saxitoxin content of their internal organs viz. liver, ovary, intestine, skin, etc. Tetrodotoxin is a potent neurotoxin, specifically blocking voltage-gated sodium (Na) channels on the surface of nerve membranes. It has been reported that the internal organs of almost all the species of pufferfish contain tetrodotoxin, which is 100 times more potent than cyanide, and one puffer fish contains enough toxin to kill 30 adult men. The muscle portion of some species of pufferfish, which is free of toxin however, is used to prepare a delicious meal (called fugu in Japan) by specially trained/licensed chefs in China, Japan, Taiwan and Korea. Further, owing to their beautiful colorations of the body, many species of pufferfish are of great use in freshwater, brackish and marine aquariums. TTX is also a promising source in the development of new drugs. The drug Tetrodin, obtained from the highly purified TTX, has been reported to mitigate the sufferings of cancer patients, and it is found that it is 3,000 times more potent than the pain-killer morphine, without the crippling side-effects of addiction and nausea.

A thorough understanding about the diversity, biology and ecology of pufferfish would largely improve the public health community's ability to better manage and to prevent pufferfish poisonings. Although several books on hazardous marine animals are available, a comprehensive book on the pufferfish of the world seas and other aquatic bodies is still wanting. Aspects such as biology and ecology of pufferfish; profile of world's marine, brackish and freshwater pufferfish species; characteristics of TTX and STX of pufferfish; pufferfish poisoning and their symptoms, treatment and management; aquarium uses of pufferfish; and nutritional and

pharmaceutical values of pufferfish are dealt with in this publication with suitable illustrations. It is hoped that this publication would be of great use for the students of fisheries science, marine biology, aquatic biology and environmental sciences; as a standard reference for all the libraries of colleges and universities and as a guide for seagoers and divers.

I am highly indebted to Dr. S. Ajmal Khan, Professor (Emeritus), Centre of Advanced Study in Marine Biology, Annamalai University, Parangipettai, India, for his valued comments and suggestions on the manuscript. I am very much grateful to all my international friends who were very kind enough to provide me with certain photographs of pufferfish at the time of need. I also thank Mrs. Albin Panimalar Ramesh for her secretarial assistance and help with photography.

CHAPTER 1

INTRODUCTION

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1.1 INTRODUCTION ABOUT PUFFERFISH

Pufferfish (Order: Tetraodontiformes; Family: Tetraodontidae) are commonly called as balloonfish, blowfish, bubblefish, globefish, swellfish, toadfish, and toadies and sea squab. These fishes are generally believed to be the second-most poisonous vertebrates in the world, after the golden poison frog. They are the ancient fishes emerging from coral-dwelling species about 40 million years ago. Well-known saltwater species of the pufferfish of the Tetraodontiformes are the Porcupinefish (Diodontidae family), Boxfish (Ostraciidae family), Filefish (Monacanthidae family), and the Triggerfish (Balistidae family).

Diversity and Distribution: A total of 197 species of pufferfish (including 2 new species) have so far been recorded. With regard to the taxonomy of this group, a lot of confusions prevail due to synonyms. Pufferfish are basically ubiquitous in tropical and sub-tropical waters. Some live in the extreme shallow waters, while others may range down to several hundred feet deep (Hanley III, http://www.qualitymarine.com/News/Species-Spotlight/Puffer-Fish). Majority of the pufferfish (i.e., 112 species) live in a marine environment and are found worldwide in the Atlantic, Pacific, and Indian Oceans in a belt of about 47 degrees north to 47 degrees south latitude in the coastal regions of tropical and

warm seas including coral reefs or seagrass beds. Though most of the marine puffers are found in coastal regions, some are oceanic (e.g., *Lagocephalus lagocephalus*) or live in the deep sea (e.g., *Sphoeroides pachygaster*). Interestingly, puffers are relatively uncommon in the temperate zone and completely absent from cold waters. Only 37 species are truly freshwater pufferfish and 48 species are in brackish water (http://animal-world.com/encyclo/fresh/Puffers/Pufferfish.php. Animal-World. Pet and Animal Information.). The brackish water species are found primarily in estuaries, where river mouths meet the ocean. Some will enter periodically for feeding or breeding, and possibly stay as juveniles, while others spend their entire lives in brackish conditions. Freshwater species occur in Amazonia, in tropical Africa, in eastern India and Southeast Asia (Puffer Fish Facts: http://www.snorkelingpattaya.com/blog/fish/puffer-fish.html).

Chief Taxonomical Characteristics of Pufferfish: Pufferfish range in size from the 2.5-centimeter-long dwarf, pea or pygmy puffer to the freshwater giant puffer, which can grow to more than 60 centimeters in length. They normally have the appearance of a large tadpole, with bulging eyes and an elongated snout. They may be found in a variety of colors but can sometimes be hard to identify when they are not inflated. All the tetraodontids possess robust, oval-shaped bodies and are characterized by a tough skin that is often covered with small spinulous scales, a beak-like dental plate (four large teeth, fused into an upper and lower plate) divided by a median suture, a slit-like gill opening anterior to the base of the pectoral fin, no pelvic fins, no fin spines, a single usually short-based dorsal fin, a single usually short-based anal fin, and no ribs. Pufferfish are generally divided into two groups: the short-nosed puffers (family Tetraodontinae) and the long-nosed puffers (family Canthigasterinae) (http://www.divegallery.com/pufferfish.htm).

Locomotion: Unlike more typical fish, the body of the pufferfish is rigid. Hence, it largely relies on its fins for motion and balance. It is driven mainly by the pectoral fins, dorsal fin and anal fin. Caudal peduncle and caudal fin serve as a rudder. Thus, the puffer is indeed quite slow, but extremely agile. It can both forward and backward swim and climb up and down.

Adaptations: Pufferfish have an unusual defense mechanism – expanding into an enormous ball if threatened. They deploy a special valve in their mouths to suck water or air into a pleated stomach, expanding up to 3 times their normal size (http://www.seafocus.com/species_pufferfish.html).

Diet: Pufferfish are omnivorous animals and eat a variety and plants and animals. They mainly feed on the algae that grow on the rocks and coral and also the invertebrates that inhabit these areas. Large species of pufferfish will also eat shellfish such as shrimp and crabs and molluscs.

Breeding: Pufferfish have unique breeding methods. The male pufferfish guides the female pufferfish towards the shore where she releases between 3 and 7 eggs. The eggs of the puffer fish are extremely light and float on the surface of the water until they hatch in about a week's time. The fry are still not fully developed and have a hard shell that protects them until their limbs begin to grow. The shell of the baby pufferfish then cracks off and the tail and fins develop. When the puffer fish is big enough, it will swim down and integrate itself into its reef community.

Use as Food Fish: The skin and internal organs such as liver, ovary, testis and intestine of many pufferfish species like *Takifugu poecilonotus, T.pardalis, T.vermicularis, T.chrysops* and *T.rubripes* are highly toxic to humans, but nevertheless the meat of some species is considered a delicacy in Japan (as fugu) and Korea (as boh-guh) (http://memim.com/tetraodontidae.html). According to Chinese,

"No food is tasty after eating the puffer."

"The man that eats fugu is stupid; the man that does not eat fugu is also stupid." (Cohen and Law-Yone, http://www.imagequest3d.com/pages/general/news/puffertoxin/; https://www.travelblog.org/Asia/Japan/Okinawa/Camp-Kinser/blog-305533.html).

The pufferfish meat that exceeded the regulatory limit of 2 $\mu g.g^{-1}$ (10 $MU \cdot g^{-1}$) TTX as established by the by the Japan Food Hygiene Association (2005) is not considered safe for human consumption. This calls for removing TTX to ensure the safe consumption of pufferfish (Mohamad, 2013; Nuñez-Vazquez et al., 2012). In this book, the toxic and less toxic puffers have been considered as 'poisonous to eat' and ' harmless' species, respectively. In the former (poisonous to eat) pufferfish species, the safe level (2 $\mu g.g^{-1}$) of TTX exceeds in their meat and the whole fish is unfit for human consumption. On the other hand, in the harmless species, after the

removal of toxic internal organs, the meat TTX is less than 2 μg.g^{-1} and such species are considered fit for human consumption.

Pufferfish are prepared as meals in the name called "fugu". This carefully prepared dish is named after one of the numerous species from the *Fugu* genus among which is *Fugu rubripes*. Some restaurants in Japan have specially licensed chefs that prepare "fugu" from very thin slices of the flesh of certain species of pufferfish. The skin is removed and the flesh is carefully separated from all internal organs, minimising the amount of toxin in the portion to be consumed. Fugu is regarded as a delicacy, but despite the care taken in its preparation, it often produces mild symptoms due to minute traces of tetrodotoxin remaining in the flesh. In Japan serious poisoning and death from eating fugu is not uncommon.

Cultured Pufferfish: Three common edible species of pufferfish, *Takifugu obscurus, T. flavidus* and *T. rubripes* are cultured in various locations in the Yangtze River, the East Sea, the Yellow Sea, the South Sea and the Bohai Sea of China. These cultured pufferfish, which are very popular among consumers, not only have a high growth rate but yield non-toxic meat, which still retains a delicious taste. They are regarded as a high quality fish because of their high protein content and special flavor.

Aquarium Use: Some pufferfish species can be kept as aquarium fish in freshwater, brackish and saltwater aquariums. In freshwater aquariums, they can be used for the biological control of snails.

Toxicity: The toxin of pufferfish is variously used as a defensive biotoxin to ward off predation. Predators that do not head the danger signals, eat puffers anyway and may die from choking, or from toxic poisoning. Majority of the pufferfish species are toxic with a potent neurotoxin viz tetrodotoxin (TTX), a potent neurotoxin and the paralytic saxitoxin (STX) is seen in certain species as the secondary toxin. Depending on the nature of actions of TTX, Nader et al. (2012) reported three toxic levels as detailed below:

Weakly toxic (10–100 MU/g tissue) (2–20 μg/g tissue)
Moderately toxic (100–1000 MU/g tissue (20–200 μg/g tissue)
Strongly toxic (>1000 MU/g tissue) (> 200 μg/g tissue)
(1 MU = 0.2 μg of TTX/g tissue)

Sabrah et al. (2006) on the other hand classified the toxic levels of TTX as follows:

Non-toxic < 10 MU/g (< 2 µg/g tissue)
Weakly toxic ≥ 10–99 MU/g (≥ 2 – 198 µg/g tissue)
Moderately toxic ≥ 100–999 MU/g (≥200–1998/g tissue)
Strongly toxic ≥ 1000 MU/g (≥ 2000/g tissue)

The above classifications could not be applied presently to the various species of pufferfish as the toxic level of different species varies with their areas of catch or size. Further, detailed research/information is needed on this aspect. The toxic (poisonous to eat) and less toxic (harmless) species among the recorded pufferfish species of the world are given in the following table.

Toxic and Less Toxic Pufferfish of different Biotopes

Habitat	Toxic (Poisonous to eat)	Less Toxic (Harmless)	Total
Marine	33	79	112
Brackish water	21	27	48
Freshwater	1	36*	37
Total	55	142	197

* including two new species of unknown toxicity.

Origin of Toxin: It is believed that puffers do not actually produce toxin and those kept in the aquarium or in fish farms are totally toxin-free. They most likely accumulate the toxins in the wild as they feed on shellfish prey that may be carriers. According to available reports, several bacterial strains which are either harbored or eaten by these pufferfish are responsible for the production of tetrodotoxin (TTX). Accumulation of saxitoxin (STX), the secondary toxin in the pufferfish is however, due to the paralytic shellfish toxin (PST) producing *Pyrodinium bahamense* and associated "red tide'.

Symptoms of Pufferfish Poisoning: Pufferfish poisoning has occurred in several countries including Japan, Korea, Thailand and The Philippines. The symptoms associated with this poisoning are:

Dangerousness: Severe poisoning possible, potentially lethal.

General Systemic Effects: Variable non-specific effects which may include headache, nausea, vomiting, abdominal pain, diarrhoea, tachypnoea, respiratory distress, hypotension, dizziness, collapse or convulsions.

Neurotoxic Paralysis: Common, flaccid paralysis is major clinical effect.

Poisoning Treatment: Puferfish poisoning treatment consists of intestinal decontamination with gastric lavage and activated charcoal. Case reports suggest anticholinesterases such as edrophonium may be effective.

Conservation Status of Pufferfish: Some species of pufferfish are considered vulnerable due to pollution, habitat loss, and overfishing, but most populations are considered stable. Knowledge on the conservation status of pufferfish is very much limited. Out of a total of 197 species of pufferfish recorded so far, information on their conservation status is available only for a few species.

Conservation Status of Pufferfish

Not evaluated	145 species
Data Deficient	9 species
Least Concern	36 species
Vulnerable	5 species
Endangered	1 species
Critically Endangered	1 species

Among the pufferfish species, only one species viz. *Takifugu chinensis* is under the "Critically Endangered" category of the International Union for Conservation of Nature (IUCN). The global population of *T. chinensis* has been estimated to have declined by over 99.99% over the last 40 years. This estimate is based on landing statistics from the East China Sea and Yellow Sea provided by the Sekai National Fisheries Institute in Nagasaki and the National Fisheries University in Shimonoseki City. The population decline of this species is largely due to its large scale consumption and over exploitation. On the other hand, *Takifugu plagiocellatus*) is under the "Endangered" category and it is due to its coral habitat degradation. "Vulnerable" category of 5 species is resulting from habitat modifications caused by deforestation and conversion of lands in agricultural areas, increasing urbanization, and overharvest-

ing for the aquarium trade. The long felt gap on the conservation status of this globally important group of fishes calls for further, immediate research on this aspect.

KEYWORDS

- **edrophonium**
- **golden poison frog**
- **paralytic shellfish toxin (PST)**
- **pufferfish**
- **pufferfish poisoning**
- **saxitoxin (STX)**
- **Tetrodotoxin (TTX)**

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CHAPTER 2

TOXIC PUFFERFISH: BIOLOGY AND ECOLOGY

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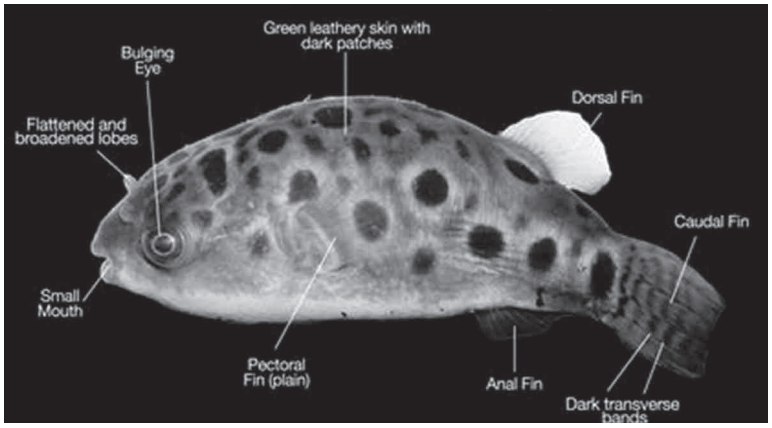
Pufferfish (Family: Tetraodontidae) are small to moderate-sized fishes as their body length varies between 2 cm (dwarf or pea puffer, *Carinotetraodon travancoricus*) and 120 cm (giant puffer, *Arothron stellatus*). They have a heavy, blunt body capable of rapid inflation by intake of water (or air). Head is large and blunt. Jaws are modified to form a beak of 4 heavy, powerful teeth, 2 above and 2 below. Gill openings are simple slits anterior to pectoral fins. Eyes are located high on head. Pelvic fins are absent. Dorsal and anal fins are located far posteriorly, containing no spines, but 7 to 15 soft rays. Caudal fin is truncate, rounded, or emarginate to somewhat lunate. Lateral lines, when present are often indistinct, forming an interconnecting pattern on the sides of head and body, but quite distinct in some genera, for example, *Fugu* and *Torquigener*. Typical scales are absent, but numerous small spiny prickles are often present on back and/or belly, sometimes on sides. Most species are mottled and variegated on back and sides, sometimes with spots of various sizes and colors, while others are of plain coloration. Though most of the pufferfish are demersal, a few species are pelagic. Usually found alone, although some

species school together, especially for mating purposes (ftp://ftp.fao.org/docrep/fao/009/ad468e/AD468eNB.pdf).

2.1 PUFFERFISH ANATOMY - AN INTRODUCTION

Fins: Fins of the pufferfish are unique and they are used in a different manner. Puffers use mainly their pectoral fins along with dorsal and anal fins for moving. The tail fin is used for the purpose of changing direction only. Such fins allow easy movement even backwards.



External anatomy of pufferfish

Body: The bodies of pufferfish look mostly like a ball, however, they are perfectly adapted to their environment and living habits. The head is large and they have big eyes which are wide apart. Such eyes allow puffers to hunt effectively. Also, most of these fish have toxic skin which avoids natural predators.

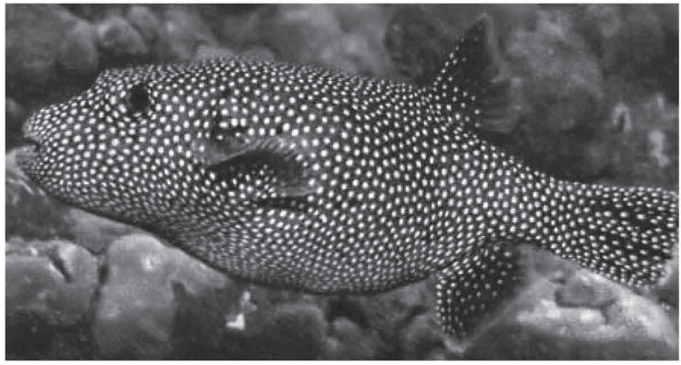
Teeth: Tetraodontids lack true teeth, the jawbone itself being modified into four fused beak -like structures. There are two teeth in the upper mandible and two in the lower mandible. These teeth grow continuously at a faster rate, so such a diet is essential in order to maintain them at a reasonable length. It is also crucial to feed them food which is hard enough to naturally grind their teeth. Such food includes normally aquatic snails, cockles and crustaceans with shells.

Teeth of *Sphoeroides pachygaster*

Adaptations: The important characteristic of puffers is their ability to balloon out from a reasonable fish shape into a sphere two or three times larger. This is facilitated by its elastic skin which can stretch very well. When the pufferfish is frightened, excited or annoyed, it gulps water or air (when it is out of water) into a sac on the belly. This adaptation is a natural defence of the pufferfish achieved mainly by the rib-free pectoral muscles and is to discourage predators or intimidate enemies. However, when the fish feels safe, it ejects water or air out thus deflating to its normal shape. It is also interesting to note that the balloon full of water is very strong enough for even a big man to stand on it (Santhanam, 1990a).

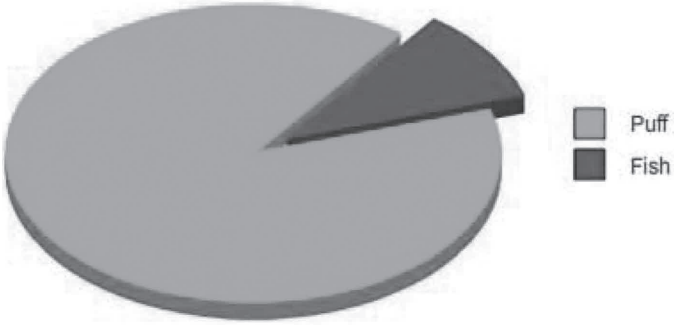
Mechanism of inflation in pufferfish: Studies have already been made to understand the morphological variations and functional adaptation during the inflation in *Takifugu obscurus* through morphological dissection, X-ray and staining methods. The results have indicated that after receiving stimulation, the pufferfish quickly and frequently swallows water or/and air into the flexible but tough sac, which is a distinct portion of the specialized oesophagus. For adapting the inflation, the anterior and posterior joints of the sac and the digestive duct are tightened by special musculature; and the structure and arrangement of the skin of the body, as well as the abdomen muscle bundles are particularly modified to be elasticated. Moreover, even the backbone and the nerve are ready for flexible positioning change. During inflation, the pufferfish seems to hold its breath, presumably to keep the ingested water in the stomach. If this is true, it is likely that the pufferfish inflation would have a limited dura-

tion, due to a lack of oxygen getting into vital body organs (Fagundes, http://www.bv.fapesp.br/en/bolsas/138343/morphological-description-of-digestive-tube-of-sphoeroides-testudineus-linneaus-1758-tetraodonti/; Zhao et al., 2010).



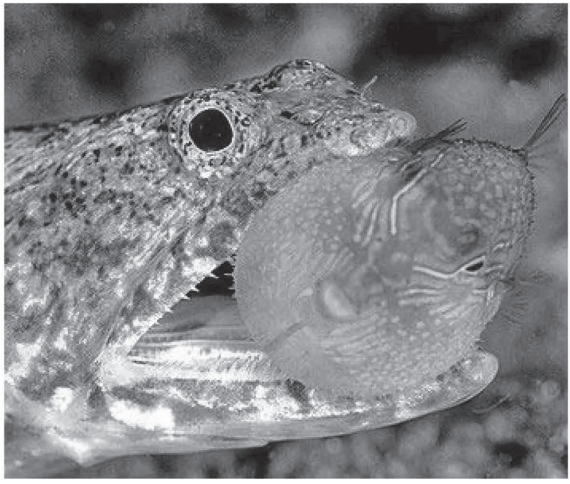
Normal, unpuffed, Guineafowl puffer

Inflated, puffed, Guineafowl puffer



Comparison between fish and puff in a pufferfish

Predators of pufferfish: Puffers are eaten routinely by some species of fish, such as lizardfish (*Synodus* spp.) and tiger sharks (*Galeocerdo cuvier*) (http://biology.stackexchange.com/questions/7337/are-there-predators-evolved-to-eat-puffer-fish). The deadliest sea snakes viz. beaked sea snake of Australia (*Enhydrina zweifeli*) and the Asian beaked sea snake (*E. schistosa*) have also been reported to feed primarily on pufferfish (http://www.reptilesmagazine.com/Wild-Snakes/Beaked-Sea-Snake-Actually-Two-Species/). Interestingly, these predators are immune to the pufferfish's toxin and they can eat pufferfish without any negative consequences and are unaffected by pufferfish toxin.



Lizardfish (*Synodus* sp.) eating a Bennett's pufferfish

Reproduction: Pufferfish possess unique breeding methods. Spawning of the pufferfish normally occurs from spring to summer. In the latter period of the spawning season, mating and hatching are observed in semi-lunar cycle around neap tide and spring tide, respectively. However, the periodicity is not consistent throughout the spawning season. One of the main reasons seems to be the change in water temperature (22–29°C). Hatching is delayed at low water temperatures and males are forced to continue parental egg care over a longer period in the beginning of the spawning season.

When females visit the males' nests on the sandy bottom, males court the females by stirring up sand in the nest and performing a rush and retreat behavior. The stirring up behavior is seen only when nest-holding males find a visiting female outside the circular structure; thus, the behavior seems to be important in determining the female's decision whether to inspect the nest site for spawning. It appears that, through the stirring-up behavior, the males may demonstrate to the females that the nest contains a sufficient quantity and/or quality of fine sand particles that construct irregular patterns in the nest.

Females and males mate in pairs, releasing gametes (i.e., eggs and sperm) on the nest within one second. They mate repeatedly until the females leave the nest. After leaving the females, the males continue to mate with other females on the same day. Thus, the mating system of the pufferfish is revealed to be male-territory-visiting (MTV) polygamy, while promiscuous group spawning and male-dominate harems of territorial females have been reported in the other species of pufferfish.

After mating, the males stay at the nest site and care for the eggs deposited on the sandy bottom until hatching. The males flap their fins to stir the eggs on the bottom and drive away other fishes that are passing close to the nest site. Hatching occurs synchronously with the male flapping behavior around sunset.

Many marine puffers have a pelagic, or open-ocean, life stage. The female releases between 3 and 7 eggs. The eggs of the pufferfish are extremely light and float on the surface of the water until they hatch in a week's time. The pufferfish fry are still not fully developed and have a hard shell that protects them until their fins begin to grow. The shell of the baby pufferfish then cracks off and the tail and fins develop. When the

pufferfish is big enough, it will swim down and integrate itself into the reef community.

Spawning nest (mystery circle) of *Torquigener albomaculosus*: Scientists have recently solved a 20-year-old mystery under the sea and discovered a new pufferfish species viz. *Torquigener albomaculosus*. Intricate circles with geometric designs about 2 m in diameter (found at 10–30 m depth on a sandy bottom along the south coast of Amami-Oshima Island in the Ryukyu Islands) have been found to be the work of this new species. Males construct these circles as spawning nests by swimming and wriggling in the seafloor sand. The nests, used only once, are made to attract females. The nests have double edges and radiating troughs in a spoke-like geometry. Scientists have also discovered that the ridges and grooves of the circle serve to minimize ocean current at the centre of the nest. This protects the eggs from the turbulent waters and possibly predators too.

Reproduction in freshwater species varies significantly. The dwarf puffers court with males following females, displaying the crests and keels unique to this subgroup of species. After the female accepts his advances, she will lead the male into plants or another form of cover, where she releases eggs for fertilization. The male may help the female by rubbing against her side. This has been observed in captivity, and they are the only commonly captive-spawned puffer species.

KEYWORDS

- **dwarf or pea puffer**
- ***Enhydrina schistosa***
- ***Enhydrina zweifeli***
- **giant puffer**
- **male-territory-visiting (MTV) polygamy**
- **mystery circle**

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CHAPTER 3

PROFILE OF TOXIC PUFFERFISH

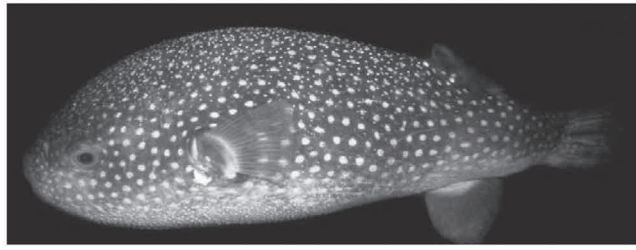
CONTENTS

3.1 MARINE PUFFERFISH

3.1.1 TOXIC (POISONOUS TO EAT) MARINE PUFFERFISH

Kingdom: Animalia
Phylum: Chordata
Subphylum: Vertebrata
Class: Actinopterygii
Order: Tetraodontiformes
Family: Tetraodontidae

***Arothron firmamentum* (Temminck & Schlegel, 1850)**



Common Name(s): Starry toadfish, starry toado, heavenly pufferfish.

Habitat: Marine; demersal; continental shelf and slope; depth range 10–360 m.

Global Distribution: Subtropical; Western Pacific: southern Japan to Australia (New South Wales, South Australia, and Tasmania) and New Zealand; Southeast Atlantic: south coast of South Africa; Southwestern Atlantic: Argentina.

Description: Shape and patterning of this species are distinctive. Body is elongated in profile and is laterally compressed. Head is particularly blunt and round. Dorsal profile is arched and is highest at mid back. Interorbital space is flattened. Mouth is terminal and is directed forward. Lateral line is indistinct. Coloration of body is medium brown to dark brown. It is dorsally with pale spots and pale ventrally usually without spots. This species feeds on shrimps, crayfish, crabs, small bivalves, sea urchins and snails. It grows to a maximum length of 35 cm.

Food Value: It is a poisonous species and is not to be eaten (FishBase).

Aquarium Value: It is also occasionally found in the marine aquarium trade. As a marine aquarium fish, it needs the following parameters:

Minimum volume of tank: 2000 liter.

Hardiness: Average.

Food: *Mostly*: Invertebrates; Soft coral; Large polyp stone coral; Small polyp stone corals.

Recommended**:** Microalgea (e.g., *Spirulina*); macroalgea (e.g., seaweed/nori); small crustaceans (krill, mysis, artemia, etc.); larger crustaceans (shrimp, crabs, etc.).

Aggressiveness: Mostly peaceful but might be aggressive towards similar species.

Toxicity: This species has a toxin in its skin, which it releases when highly stressed or dying. Toxicity assays using mice showed that only the skin and ovary of the females of this species are toxic. The toxicity of this species is attributed primarily to paralytic shellfish poison (STX), but also tetrodotoxin (TTX). The ovaries and liver are toxic (Shao et al., 2014s). Nakashima et al. (2004) reported that the skin of this species had TTX at 5–30 MU/g and STX as the major toxin in its ovary. Kim et al. (2008) reported that the toxicity values of muscle, skin, liver, intestine, and gonad of this species were less than 5, 13, 5, 5, and 87 MU/g, respectively. The muscle toxicity value of this report, however, reflects the harmless nature of this species.

Fisheries status: This species is taken as bycatch in tuna fisheries off Tasmania. It is also taken as bycatch in the otter-trawl sub-fishery of the commonwealth sector of the eastern and southern scalefish and shark fishery in Australia and in the purse-seine fishery off New Zealand (Shao et al., 2014s).

Conservation Status: Not evaluated; Least Concern.

***Arothron hispidus* (Linnaeus, 1758)**

Common Name(s): White-spotted puffer, stars-and-stripes pufferfish, Stripe belly puffer, white-spotted blaasop, white spotted blowfish, broad-barred toadfish.

Habitat: Marine; brackish; benthopelagic; lagoons, coastal bays and estuaries, usually near rocky reef or on sand-stretches between reefs with low algae-rubble reef to about 20 meters depth, or in shallow waters with sparse seagrass; mangroves; non-migratory; depth range 1–50 m.

Global Distribution: Tropical; Indo-Pacific: Red Sea and East Africa to Panama, north to southern Japan and the Hawaiian Islands, south to Lord Howe and Rapa islands. Eastern Pacific: Baja California and the Gulf of California to Panama.

Description: This species has the typical rounded body shape. It has a single dorsal fin positioned posteriorly on the body, opposite the similarly-sized anal fin. Small spinules are seen on head and body except snout and posterior caudal peduncle. Nostril is consisting of two fleshy flaps from a common base (characteristic of the genus). Caudal fin is rounded. Coloratin of body is greyish to greenish brown with small white spots on head, back and sides. One or 2 yellow rings and several yellow spots are seen around

pectoral fin. 2–5 bars are also seen across sides. A short dark bar is always found below eye and another below pectoral fin. It is carnivorous and is feeding on molluscs, tunicates, sponges, corals, anemones, crabs, tubeworms, sea urchins, brittle stars and starfishes (including crown-of-thorns), and hydroids. It grows to a maximum length of 50 cm and weight of 2 kg.

Food Value: Poisonous to eat (Fishbase); however, this species is consumed in Japan and is commercially traded there (Hardy et al., 2014a).

Aquarium Value: This species is a component of the marine aquarium trade. It is also used as a cleaning fish in marine culture tanks and cages. The ideal setup should be an established aquarium with good filtration and a protein skimmer. Aquascape should also have live rock and other materials to create an environment rich with nooks and crannies, caves, and overhangs while preserving easy access to large open areas. The aquarium parameters for this species are:

Minimum Tank Size: 720 liter
Water Conditions
Temperature: 23°C–26°C (73.4°F–78.8°F)
Hardness (dKH): 8–12
pH: 8.1–8.4
Specific Gravity: 1.020–1.025
Care Level: Easy
Temperament: Semi-aggressive

Toxicity: It contains considerable amounts of PSP toxins (major component, STX) besides tetrodotoxin (TTX). The toxicity has been detected in the liver, intestine, muscle and skin of this species (Egmond et al., 2004). The skin, testes, liver, and ovaries of this species are toxic (Hardy et al., 2014); Tetrodotoxin (TTX) has been detected in the flesh, pectoral fin and kidneys, as well as the skin slime of this species. *Vibrio harveyi* strains isolated from the skin slime and kidneys of this species were found to produce TTX, being the source of TTX produced in the pufferfish (Cambell et al., 2009). Toxicity symptoms were observed when the bacterial filtrate containing *Bacillus* spp. (isolated from *A. hispidus*) was intraperitoneally injected into mice. The bacterial filtrate caused adverse effects on viability of the mouse muscle cell line (L929) and leukemia cell line (P388). Maximum level of inhibition was observed on the growth of L929 cell line. *Bacillus lentimorbus* inhibited the cell line from 84.03 to 94.43%

whereas *Bacillus* spp. inhibited the growth in a range between 77.25 and 86.16% at the lowest dilution (Bragadeeswaran et al., 2010). Puilingi et al. (2015) reported that the maximum values of TTX toxicity of the skin, liver, ovary, testis, stomach, intestine and flesh of this species (collected from Solomon islands) were 51 µg/g, 7.99 µg/g, 1.89 µg/g, 11.7 µg/g, 9.45 µg/g, 5.45 µg/g and 0.07 µg/g, respectively; and 12.7 µg/g, 0.55 µg/g, 0.37 µg/g, 1.11 µg/g, 2.44 µg/g, 2.05 µg/g and 0.61 µg/g (collected from Japan), respectively.

Fisheries status: It has a minor commercial fishery.

Conservation Status: Not evaluated.

***Arothron inconditus* (Smith, 1958)**

Common Name(s): Bellystriped blaasop.

Habitat: Marine; demersal; depths ranging from 100 to 400 m,

Global Distribution: Subtropical; Southeast Atlantic: Knysna to East London (South Africa).

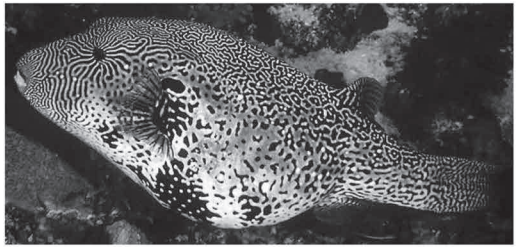
Description: Color of dorsum of this species is dark and belly is pale. Dark lines are seen from above anal fin to chin. Anus, pectoral base and gill opening are located in rounded black areas. A black bar is seen on each side of angle of mouth along lower lip. Fins are dusky. It is a colonial sessile insectivore. It grows to a maximum length of 40 cm.

Food Value: It is a poisonous species and is not to be eaten (FishBase). All the organs of this fish are considered to be toxic. There is no use and trade information available for this species. It is unlikely to be utilized.

Aquarium Value: It is used in marine aquarium within the following parameters.

Water Type: Seawater
Temperature: 23–26°C
Food/Feed: Shells, snails and crustaceans
Toxicity: Unknown.
Conservation Status: Vulnerable.

***Arothron mappa* (Lesson, 1831)**



Common Name(s): Map puffer, scribbled arothron puffer.

Habitat: Marine; clear lagoon and sheltered seaward reefs; depth range 4–30 m.

Global Distribution: Tropical; Indo-Pacific: East Africa south to Natal, South Africa and east to Samoa, northward to the Ryukyus and western sea of Japan, southward to New Caledonia and Queensland, Australia.

Description: This species is yellowish-grey dorsally, white ventrally and covered with an intricate pattern of dark lines. It lacks pelvic fins. Gill opening and pectoral fin base are both surrounded by a large black botch and black lines radiate from the eye. The dorsal and anal fins are set well back, the first counts 11–12 unarmed rays and the second, almost specular, 10–11. The ventral fins are lacking and the pectoral ones, fan-like, have 17–19 rays. The propulsion is entrusted mainly to the ample caudal fin, carried by a robust peduncle. For the reproduction, this species digs a hole into the sand where the fecundation takes place. It feeds on algae, sponges, and benthic invertebrates. It grows to a maximum length of 65 cm.

Food Value: It is poisonous to eat (FishBase). However, it is consumed in Japan and is commercially traded there.

Aquarium Value: This species has high value in the marine aquarium trade. The following are the aquarium requirements for this species.

Minimum Tank Size: 300 gallons.

Water Conditions

Temperature: 72–78°F

dKH: 8–12

pH: 8.1–8.4

Specific Gravity (SG): 1.020–1.025

Diet: Carnivore; varied diet of meaty foods including; squid, krill, clams, and hard-shelled shrimp.

Care Level: Moderate.

Temperament: Semi-aggressive.

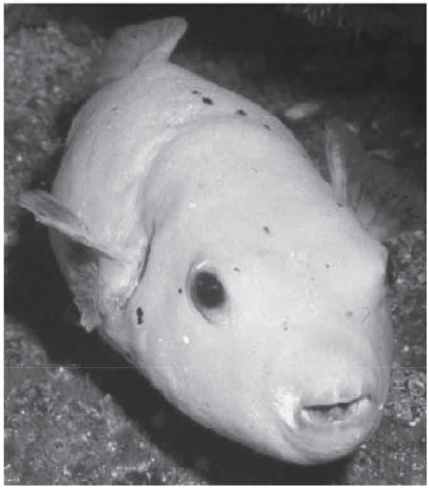
A 300 gallon or larger, fish-only aquarium with a good protein skimmer is suitable. It will generally live peacefully with other fish, even other puffers. It becomes alarmed when it is in a net. Therefore, a container should be used to transfer it.

Toxicity: It contains considerable amounts of PSP toxins (major component is STX) besides tetrodotoxin (TTX). The toxicity has been detected in the liver, intestine, muscle and skin of this species (Egmond et al., 2004).

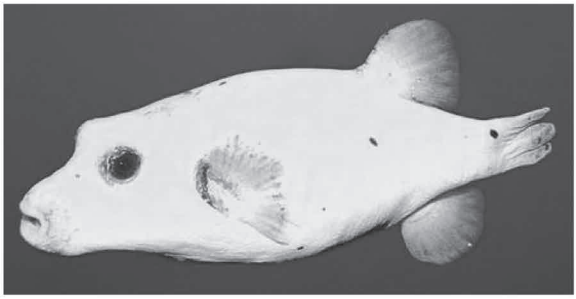
Fisheries status: It has minor commercial fisheries. It is also a component of artisanal fisheries in Madagascar.

Conservation Status: Not evaluated.

***Arothron meleagris* (Lacepède, 1798)**



Frontal view



Lateral view

Common Name(s): White-spotted puffer, guinea-fowl pufferfish, spotted puffer, velcro-fish, white-spotted balloon, guineafowl blaasop.

Habitat: Marine; shallow coral and rocky reefs; benthopelagic; depth range 1–73 m.

Global Distribution: Tropical; Indo-Pacific: East Africa south to Durban, South Africa and east to the Panama, north to Ryukyu Islands, south to Lord Howe and Easter islands. Eastern Pacific: Guaymas, Mexico to Ecuador.

Description: This puffer occurs in various natural color morphs. The most common is dark with white spots, resembling the coloration of the guinea-fowl (a pheasant-like bird, *Numida meleagris*). There are also white-splotched, yellow, gold, and white. They are diurnal feeders and feed mainly on tips of branching corals and to a lesser extent on sponges, molluscs, bryozoans, tunicates, foraminiferans, algae, and detritus. They are up to 50 cm in length.

Food Value: It is a poisonous species and is not to be eaten (FishBase). All the organs of this fish are considered to be toxic.

Aquarium Value: It is a component of the commercial marine aquarium fishery. The aquarium requirements of this species are given below:

Minimum Tank Size: 125 gallons.

Water Conditions

Temperature: 72–78°F

dKH: 8–12

pH: 8.1–8.4

Specific Gravity (SG): 1.020–1.025

Diet: Carnivore; varied diet of meaty foods including; squid, krill, clams, and hard-shelled shrimp.

Breeding: Not yet accomplished in captivity.

Care Level: Moderate.

Temperament: Peaceful.

Toxicity: The black morph of this species is more toxic, with the highest concentration of TTX being found in the liver, while the yellow morph is less toxic, and stores TTX in the mucous. Nunez-Vazquez et al. (2000) reported that the values of TTX toxicity of mucous, muscle, liver and intestine of black morph were 47 μg/g, 4.3 μg/g, 2.7 μg/g and 67 μg/g, respectively, and those of yellow morph were 2 μg/g, 2.9 μg/g, 0.85 μg/g and 2.1 μg/g, respectively.

Conservation Status: Not evaluated.

***Arothron nigropunctatus* (Bloch & Schneider, 1801)**

Common Name(s): Blackspotted puffer, dogface puffer, blackspotted toadfish, blackspotted blaasop, blackspotted blowfish.

Habitat: Coastal to outer reef crests and slopes with rich invertebrate growth.

Global Distribution: Tropical; Indo-Pacific: East Africa to Micronesia and Samoa, north to southern Japan, south to New South Wales.

Description: Color of this species is variable (grey, light brown, bright yellow, orange yellow, etc.). Skin is strewed with dark blotches which vary in size and shape. It changes appearance during different stages of life. While in the grey phase, it is grey with black markings around the mouth, eyes, and dorsal fin. Body is oval shape and has no pelvic fin and lateral line. Dorsal and anal fins are small, symmetric and are located at the end

of the body. Snout is short with two pairs of nostrils and mouth is terminal with four strong teeth. Skin is not covered with scales. It feeds on live corals (usually *Acropora* spp.), crustaceans, molluscs, sponges, tunicates and algae. This species grows to 25 cm in length.

Food Value: It is a poisonous species and is not to be eaten (FishBase). All the organs of this fish are considered to be toxic

Aquarium Value: It is a component of the public aquariums and marine aquarium trade. The aquarium requirements of this species are:

Minimum Tank Size: 150 gallons (large aquariums are preferred).

Water Movement: Weak, moderate, strong; no special requirements.

Water Conditions:

Temperature: 24–27°C (74–80°F)

dKH: 8–12.

pH: 8.1–8.4.

Specific Gravity (SG): 1.020–1.025

Care Level: Moderate.

Diet: Carnivore; shellfish, crustaceans and hard-shelled foods such as snails. A large variety of all kinds of live and frozen meaty foods are best. Food must be cleaned properly to prevent bacteria and other infections. Flake food or small marine pellets can also be offered.

Temperament: Semi-aggressive

Compatibility: To be kept alone or in very large aquariums.

Sex (Sexual differences): Unknown.

Breeding: Unfortunately, there are no reliable reported cases of the dogface pufferfish breeding in captivity.

Reef setup: It should involve live rock. Enough swimming space is allowed at the front of the aquarium and at the top of the reef to make the fish very active.

Light: Recommended light levels; no special requirements.

Toxicity: Poisonous and venomous (Wikipedia). Its internal organs contain 11-oxotetrodotoxin which is a paralytic poison and sodium channel blocker (Kishore and Yasumoto, 1989). It contains considerable amounts of PSP toxins (major component, STX) besides tetrodotoxin (TTX). The toxicity has been detected in the liver, intestine, muscle and skin of this species (Egmond et al., 2004). Puilingi et al. (2015) reported that the maximum values of TTX toxicity of the skin, liver, ovary, testis,

stomach, intestine and flesh of this species (collected from Japan) were 25.5 µg/g, 7.46 µg/g, 1.02 µg/g, 10.1 µg/g, 25.5 µg/g, 4.51 µg/g and 4.26 µg/g, respectively.

Fisheries status: It is fished mainly for aquarium purposes.

Conservation Status: Not evaluated.

***Canthigaster coronata* (Vaillant & Sauvage, 1875)**

Common Name(s): Saddle puffer, crowned puffer, crowned toby, saddle coronata, four bar pufferfish.

Habitat: Marine; reef-associated; benthopelagic; sand or sand and rubble bottom or algal flats; depth range 6–165 m.

Global Distribution: Tropical; Hawaii, Indo-Pacific, Japan, Red Sea, South Africa, Western Pacific.

Description: Color of body (in alcohol) is pale tan or yellowish with four blackish or dark brown bars (anterior most bar connects eyes and covers most of interorbital region; two middle bars extend from middorsal region to middle of sides; and posterior most bar covers dorsal portion of caudal peduncle). Pale portion of head and sides show numerous brown dots (may be whitish on some specimens). Around 5 to 10 dark lines are usually radiating from eye. Fins are pale except basal portion of upper and lower caudal fin margins, which may be brownish. It feeds on a wide variety of benthic organisms: gastropods, sponges, algae, bivalves, polychaetes, tunicates, crabs, sea urchins, heart urchins, brittle stars, bryozoans, peanut worms, various small crustaceans and foraminiferans. It grows to a maximum length of 14 cm (Gerald and Randall, 1977).

Food Value: It is a poisonous species and is not to be eaten (FishBase). All the organs of this fish are considered to be toxic (http://www.fishesofaustralia.net.au/home/species/1288).

Aquarium Value: It is a component of the aquarium trade and the suitable aquarium parameters are given below.

Size of Fish: under 11.9 cm
Tank Type: marine tank
Minimal Tank Volume: 200 liters (53 US gal)
Water Conditions:
Temperature: 72–78°F
pH Tolerance: 8–8.6
Water Hardness Tolerance: 17–18°dKH
Specific Gravity (SG): 1.020–1.025
Diet: omnivore.
Lifespan: 5–8 years.
Behavior: Semi-aggressive.
Care Level: Moderately difficult
Difficulty: Experienced aquarists.
Others: It has the ability, when threatened or alarmed, to inflate its body to almost twice its normal size. Further, it becomes alarmed when netted, therefore, a container is to be used to transfer it.
Toxicity: Unknown.
Conservation Status: Not evaluated.

***Canthigaster criobe* (Williams, Delrieu-Trottin & Planes, 2012)**

Common Name(s): Dwarf puffer, striped toby.

Habitat: Marine; reef-associated; depth range 15–20 m.

Global Distribution: Tropical; Central Pacific: French Polynesia.

Description: Dorsal profile of snout of this species is slightly concave. Interorbital space is slightly concave. Caudal fin is truncate. Upper and lower portions of pectoral fins are rounded. Skin is with numerous small spinules directed posteriorly, each fitting into a longitudinal groove. Skin is smooth when stroked posteriorly, but spinules are apparent when stroked anteriorly. Spinules densely cover head, nape and belly, but are absent from the body immediately behind the pectoral-fin base and from body posterior to an imaginary line between origin of dorsal fin and origin of anal fin. Coloration of body (when alive) is pale tan with orangish brown stripes. Head is with uniformly orangish brown snout anteriorly. At middle of snout there are 4 narrow, orangish brown stripes radiate posteriorly below eye; 3 stripes extend posteriorly from rear margin of eye; and a stripe runs along ridge of erectile tissue on top of head. At deepest part of body, there are 14 narrow orangish brown stripes, middle 5 of those stripes continue to base of caudal fin where they abruptly end. It grows to a maximum standard length of 3.9 cm. This species was discovered during an expedition to the Gambier archipelago in French Polynesia in 2010, by Jeffrey Williams of the Smithsonian National Museum of Natural History and Erwan Delrieu-Trottin and Serge Planes of Perpignan University, France (Williams et al., 2012).

Food Value: With regard to the food value of this species, there are contradictory reports as it is extremely poisonous (http://www.newsrt.co.uk/news/new-to-nature-no-94-canthigaster-criobe-1042765.html) and harmless (FishBase).

Aquarium Value: This species may serve as an attractive marine aquarium fish. However, there is no use and trade information available presently for this species as this new species is known from only a single specimen.

Toxicity: Unknown.

Conservation Status: Not evaluated.

***Canthigaster valentini* (Bleeker, 1853)**

Common Name(s): Valentinni's sharpnose puffer, saddled puffer, black saddled toby.

Habitat: Marine; reef-associated; among coral heads and rocks of subtidal lagoon and seaward reefs; depth range 1–55 m.

Global Distribution: Tropical; Indo-Pacific: Red Sea south to Durban, South Africa and east to the Tuamoto Islands, north to southern Japan, south to Lord Howe Island.

Description: This species is diagnosed by its dorsal rays (9), anal rays (9) and pectoral rays (16 or 17). Color of body (in alcohol) is pale tan or yellowish with four broad brownish or blackish bars (anterior most bar connects rear portion of each eye, the two middle bars extend from mid-dorsal region to abdomen, posterior most bar covers dorsal portion of caudal peduncle). Pale portion of head and sides are covered with numerous brown dots. Usually 5 to 7 dark lines are radiating from eye. Fins are pale except basal portion of upper and lower caudal fin margins, which are sometimes brownish. It is omnivorous, feeding on filamentous green and red algae, tunicates, and on smaller amounts of corals, bryozoans, polychaetes, echinoderms, molluscs, and brown and coralline red algae. The largest specimen measures 11 cm total length.

Reproduction: It is a oviparous species. Social and mating systems of this species are based upon female territoriality where polygyny results from males defending females occupying a certain territory (female-defense polygyny). All sexually mature females are territorial females. Neither parent guards the eggs which are laid in a nest located in the female's territory. During breeding, territorial females perform the 'caudal flexing with swollen abdomen display' to signal courtship and readiness

to spawn. The male acknowledges with no courtship or color displays but rather by visiting the sites frequently. The territorial female then begins pecking at the substrate in preparation for egg laying. The female initiates the spawning event by pressing her abdomen into the prepared site. The territorial male quickly lays his body across her caudal peduncle and both remained in this position for 5–10 sec. The male swims away after leaving the female beating her anal fin rapidly over the nest site to ensure fertilization of the eggs and to push the eggs deep into the algal substrate. All territorial males spawn with territorial females, depriving the bachelor males of the chance to copulate which nevertheless don't interfere with the spawning between the territorial male and females.

Food Value: It is a very poisonous species and is not to be eaten (FishBase). All the organs of this fish are considered to be toxic.

Aquarium Value: It is a component of commercial, marine aquarium and some of the aquarium parameters known are given below.

Minimum Tank Size: 30 gallons.

Water Conditions:

Temperature: 23–26°C (73.4–78.8°F)

dKH: 8–12

pH: 8.1–8.4

Specific Gravity (SG): 1.020–1.025

Diet: Omnivore.

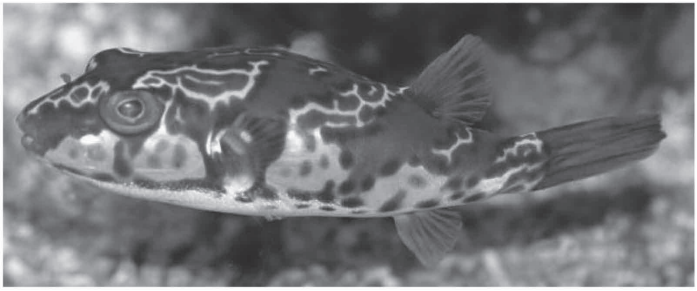
Care Level: Moderate.

Temperament: Peaceful.

Toxicity: Unknown.

Conservation Status: Not evaluated.

***Chelonodon pleurospilus* (Regan, 1919)**



Common Name(s): Blaasop beauty, rock beauty.

Habitat: Marine; demersal.

Global Distribution: Subtropical; Western Indian Ocean: from Xora mouth to Durban (South Africa).

Description: This species is diagnosed by its absence of dorsal and anal spines, 8–9 dorsal soft rays, 8 anal soft rays, and 19 vertebrae. Body is heavy and fairly elongate. Gill opening is not reaching below middle of pectoral fin base. Nasal organ is in the form of a depression with slightly raised margin expanded before and behind into a pair of elongate flaps. Pectoral fin is round and caudal fin is tunicate with round corners. Back and sides of body are with round spots, variable in number and size. This species grows to a maximum total length of 20 cm.

Food Value: It is a poisonous species and is not to be eaten (FishBase). All the organs of this fish are considered to be toxic. This species is not utilized.

Aquarium Value: This species is used as a component in saltwater aquarium and some of the aquarium parameters known are given below.

Suitable Fish Size: up to 20 cm

Temperature: 68°F–75.2°F (20°C–24°C)

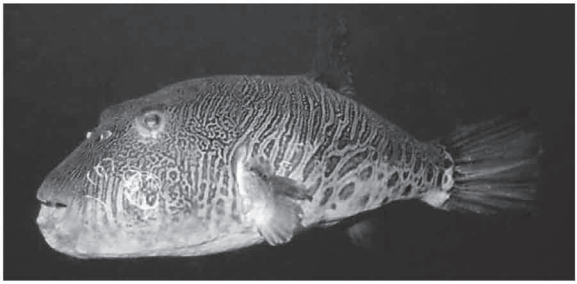
Diet: Clams, crustaceans, sea urchins, snails, starfish.

Degree of Difficulty: Only for advanced aquarists.

Toxicity: Unknown

Conservation Status: Not evaluated.

***Feroxodon multistriatus* (Richardson, 1854)**



Common Name(s): Many-striped blowfish, many-striped pufferfish, scribbled toadfish, ferocious puffer.

Habitat: Marine; reef-associated; shallow inshore waters and offshore soft bottoms.

Global Distribution: Tropical; Western Pacific: north-western Australia and elsewhere in the region but mainly southwest Pacific.

Description: Its common name (ferocious puffer) comes from reports of unprovoked attacks on swimmers resulting in loss of toes. It can be recognized by its distinctive coloration. It has curved posteriorly sloping lines on the head and body. Lower regions of the head, body and caudal peduncle are spotted. It feeds on fishes and invertebrates. It has a maximum total length of 90 cm.

Food Value: It is an extremely poisonous species unfit for human consumption.

Aquarium Value: The suitability of this fish for aquarium is unknown.

Toxicity: It is a highly toxic fish and is responsible for amputation of swimmers toes. In spite of its small size, this fish is known to make unprovoked attacks on humans. This species has also been implicated in several attacks on male genitalia and in poisoning deaths.

Conservation Status: Not evaluated.

***Lagocephalus cheesemanii* (Clarke, 1897)**

Common Name(s): Cheeseman's puffer.

Habitat: Marine; demersal; continental shelf; over sandy or muddy bottoms. Depths ranging from 0–100 m.

Global Distribution: Subtropical; Southwest Pacific: New Zealand and Australia.

Description: This species has two separate lateral lines, the lower usually on a fold of skin. A caudal peduncle is rather narrow. Caudal fin is lunate. There are two nostrils on each side of the snout with more or less developed papilla, and there are no bony plates on the back. It feeds on molluscs, crustaceans and fishes.

Food Value: It is a poisonous species and is not to be eaten (FishBase; Paulin et al., 1989). All the organs of this fish are considered to be toxic. However, this fish is widely utilized in the dry fish market through much of east Asia. This species and *L. spadiceus* are considered non-toxic, and are approved for use in Taiwan for the dry fish market. In Japan, the muscle, skin, and male gonad of this species are consumed (Shao et al., 2014m).

Aquarium Value: The suitability of this fish for aquarium is unknown.

Toxicity: Unknown.

Conservation Status: Not evaluated.; Data Deficient.

***Lagocephalus gloveri* (Abe & Tabeta, 1983)**

Common Name(s): Brown-backed toadfish.

Habitat: Marine; demersal; continental shelf; over sandy or muddy bottoms; depths ranging from 0 to 100 m.

Global Distribution: Tropical; from the Andaman Sea east to Indonesia, north to southern Japan (Shizuoka Prefecture, West Pacific); coasts of the South China Sea, East China Sea, Yellow Sea and Bohai Sea.

Description: Body of this species is covered with prickles. Caudal fin is double emarginated and middle of fin is convex. Blackish-brown dorsally and silvery ventrally. Pectoral and dorsal fins are dark. Anal fin is white. Caudal fin is black with upper and lower white tips. It feeds on molluscs, crustaceans and fishes. This species grows to a maximum standard length of 35 cm.

Food Value: It is a poisonous species and is not to be eaten (FishBase; Masuda and Allen, 1993). All the organs of this fish are considered to be toxic. However, it is widely utilized in the dry fish market through much of east Asia. This species and *L. spadiceus* are considered non-toxic, and are approved for use in Taiwan for the dry fish mar-

ket. In Japan, the muscle, skin, and male gonad are consumed (Shao et al., 2014v).

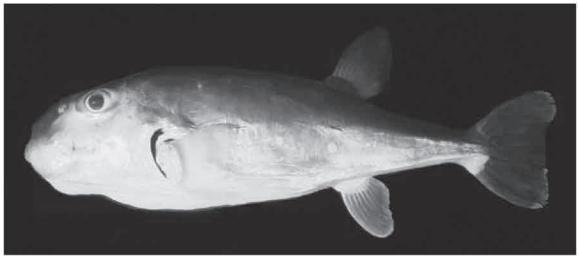
Other uses: Collagen was isolated and characterized from the processing wastes of the skin of this species. The total collagen yield extracted was 54.3% on the basis of lyophilized dry weight compared to other vertebrates. There is a possibility to use the skin of this as an alternative source of collagen for industrial purposes and subsequently it may maximize the economical value of the fish (Senaratne et al., 2006).

Aquarium Value: The suitability of this fish for aquarium is unknown.

Toxicity: Kim et al. (2008) reported that the toxicity values of the muscle, skin, liver, intestine and gonad of this species were less than 7, 53, 5, 11 and 22 MU/g, respectively. The muscle and liver toxicity of this report however, reflects the harmless nature of these organs.

Conservation Status: Data deficient.

Lagocephalus inermis (Temminck & Schlegel, 1850)



Common Name(s): Smooth blaasop, smooth-back puffer, smooth-backed blowfish, smooth golden pufferfish.

Habitat: Marine; demersal; continental shelf; shelf edge.

Global Distribution: Tropical; Indo-West Pacific: Algoa Bay, South Africa to southern Japan.

Description: This species is rounded in cross-section. It has a smooth body with a patch of low spines from the chin to the anus. Two teeth in both jaws form a powerful beak. Dorsal part of body is without prickles and belly is covered with prickles. Gill opening is black. Body and head are green-brown above, yellow-silver on the sides and white below. Pectoral fin is bright yellow and anal fin is white. This species grows to a maximum standard length of 90 cm.

Food Value: It is a poisonous species (FishBase). This species is however, harvested for human consumption. In India, this species is dried and salted for export, or consumed fresh after beheading and removal of the skin and organs. In Japan, the muscle, skin, and male gonad are also consumed.

Aquarium Value: The suitability of this fish for aquarium is unknown.

Toxicity: The toxicity in the liver and ovary of this species has been found to be 4.9 MU/g and 14.2 MU/g, respectively (Ghosh et al., 2004). Toxicity studies made in the fishes of this species of the Malaysian waters have shown that the TTX concentration of liver, muscle and skin was at 46.0 µg/g, 75.8 µg/g and 2.64 µg/g, respectively (Azman et al., 2014). Kim et al. (2008) reported that the toxicity values of the muscle, skin, liver, intestine, and gonad of this species were less than 5, 5, 7, 5, and 21 MU/g, respectively. This report suggests that except the gonad all other organs of this species are of edible value.

Fisheries status: There is increasing interest in developing this fishery in the seas of its occurrence, and landings appear to be increasing, particularly in India where this species is dried and sold as an ingredient for poultry or prawn feed

Conservation Status: Not evaluated.

***Lagocephalus sceleratus* (Gmelin, 1789)**

Common Name(s): Silver-cheeked toadfish, silver-stripe blaasop.

Habitat: Marine; reef-associated; offshore reefs; sandy bottom; depth range 18–100 m.

Global Distribution: Tropical; Indo-West Pacific; Lessepsian migrant (migration across the Suez Channel) to the Mediterranean Sea.

Description: This species is diagnosed by its dorsal fin with 10–12 rays; anal fin with 8–11 rays and pectoral fin with 15–18 rays. Body is almost square in cross-section. Body and caudal peduncle are elongated

and depressed. Spinules on back extend past dorsal fin almost to caudal fin. Caudal fin is moderately lunate. Dorsal surface is greenish with dark brown or black spots. Belly is white. A broad silver band is seen along sides from mouth to caudal fin. A silver blotch is also present in front of eye. Pectoral base and inside of gill opening are black. It preys upon benthic invertebrates. This species has a maximum standard length and weight of 110 cm and 7 kg, respectively.

Food Value: It is an extremely poisonous species and is not to be eaten (FishBase). All the organs of this fish are considered to be toxic. Although landing of the buffer fish is prohibited in the Red Sea, it is illegally landed and consumed as a good food along the Gulf of Suez and Red Sea coasts (Sabrah et al., 2006).

Aquarium Value: It is a component of commercial, brackish aquarium and some of its aquarium parameters are given below.

Aquarium Tank: 700 liters (185 US Gallons)

Suitable Size of fish: below 110 cm

Water Conditions:

Temperature: 23°C (73.4°F)–26°C (78.8°F)

pH: 8.0–8.3

Behavior: semi-aggressive.

Toxicity: The tetrodotoxin of this species has lead to paralysis of voluntary muscles, which may cause its victims to stop breathing or induce heart failure. Fatal intoxications due to this species have been reported in Egypt and Israel. Ha et al. (2012) reported on the toxicity of the internal organs of this species as follows:

Skin: 0.6–59.1 MU/g;

Meat: 3.8–213.0 MU/g;

Intestine: 0.2–559.1 MU/g;

Liver: 0–289.2 MU/g.

Kheifets et al. (2012) reported about a patient with a particularly severe and life-threatening TTX poisoning caused by consumption of *Lagocephalus sceleratus*. This patient according to them was treated by cholinesterase inhibitor to a complete and uneventful recovery. Toxicity studies made in the fishes of this species of the Malaysian waters have shown that the TTX concentration of liver, muscle and skin was at 24.7 µg/g, 30.0 µg/g and 0.51 µg/g, respectively (Azman et al., 2014).

The toxicity of this species has been reported to increase just before the spawning season and then decreases sharply after spawning activity. The toxicity values of its gonads ranged between 5 MU/g and 3950 MU/g. The average toxicity scores were not significantly different between males (659.79 MU/g) and females (636.09 MU/g). The highest toxicity was recorded in the spawning stage of maturity (3500 MU/g for males and 3950 MU/g for females). While most of the specimens in maturity stage II (developing stage) were found nontoxic (Sabrah et al., 2006).

Nader et al. (2012) reported that the individuals of this species in the premature stage with sizes of less than 16 cm in length usually do not possess enough TTX to be lethal, but that as an adult, as little as 200 grams of its flesh are lethal to humans. They also found that the TTX was present mainly in the gonads, liver, intestines and skin of this species and occasionally in the muscles. The ovaries were strongly toxic (>1000 MU/g tissue), the intestines moderately toxic (100–1000 MU/g tissue) while the liver, muscles and skin were weakly toxic (10–100 MU/g tissue). Moreover, when the fish encounters enemies, its body swells and TTX is excreted from the skin as a repellant. Furthermore, according to them, the females were found to be generally more toxic than males.

Fisheries status: There is no commercial fishery for this species. This species was found to be abundant (CPU-average, 4.2 kg/h) all over the Gulf of Suez (Sabrah et al., 2006).

Conservation Status: Not evaluated.

***Omegophora armilla* (Waite & McCulloch, 1915)**

Common Name(s): Ringed toadfish, ringed pufferfish.

Habitat: Marine; demersal; continental shelf; associated with soft-bottom habitats; depth range up to 146 m.

Global Distribution: Temperate; Eastern Indian Ocean: southern Australia, from southern Western Australia to southern New South Wales and Tasmania.

Description: Body of this species is elongated with somewhat bulky head and pectoral region. It is rounded dorsally and flattened ventrally, tapering to the moderately thickened caudal peduncle. Mouth is small and terminal on a protruding snout. Lips are moderately thick, and are covered with numerous short papillae. Chin is lacking. Nasal organ is a small, single tentacle and is slightly expanded distally. Eye is smallish, round and completely adnate. Pectoral fins are more or less bilobed and the median rays are shorter than those above or below. Body spines are short, multi-rooted and are densely scattered over body from mid snout to caudal peduncle though more sparse on ventral aspect of latter. Dorsal base color is light to medium brown or grey, sometimes with pale patches about mid-dorsum. Two brown bars extend down each side of body, first passing obliquely through eye to lower jaw, joining with corresponding bar from other side, second just posterior to pectoral fin. Interspaces on sides are pale. Ventral surface is white. A thin, black ring, sometimes open ventrally, encircles pectoral fin base. Area enclosed by ring medium is brown or greyish. Adult males are with blue spots on the head and sides, and a thin, blue ring outside and encircling black ring. Fins are yellow. Caudal fin is more dusky with lowermost rays blackish. It is a sexually dimorphic species. It feeds on small crustaceans and other invertebrates. It grows to a maximum total length of 25 cm.

Food Value: It is a poisonous species and is not to be eaten (FishBase). All the organs of this fish are considered to be toxic.

Aquarium Value: The suitability of this fish for aquarium is unknown.

Toxicity: Unknown.

Fisheries status: There is no commercial fishery. This species is not utilized but is taken as bycatch by trawl.

Conservation Status: Not evaluated.

***Sphoeroides dorsalis* (Longley, 1934)**

Common Name(s): Marbled puffer.

Habitat: Marine; demersal; depth range 20–100 m; found over soft bottoms.

Global Distribution: Subtropical; Western Central Atlantic: Throughout the area, from North Carolina, USA to Suriname.

Description: It is a blunt-headed fish with heavy jaws forming a beak of 2 teeth in both upper and lower jaws. Dorsal and anal fins are set far back near caudal fin. Dorsal-fin rays are 8, anal-fin rays are 7 and pectoral-fin rays are 16. Prickles are always present on the dorsal surface to near origin of dorsal fin. A single pair of dark lappets is seen on dorsal surface midway between eyes and dorsal-fin origin. Basal pigmentation is uniform grey or brown, with a few diffuse spots are seen laterally, posterior to pectoral fins. Males exhibit a distinctive but irregular pattern of scrawl-like markings on cheek. This species may a reach a maximum size of 20 cm, although its common size is 122.5 cm.

Food Value: Though this species is harmless, many of its congeners are toxic. Hence it should not be consumed (FishBase).

Aquarium Value: Though this species is used as a component in saltwater aquarium, much of its aquarium parameters are not known.

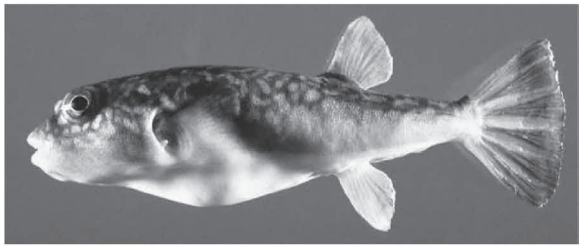
Suitable Size of Fish: Under 20 cm.

Tank Type*:* marine tank.

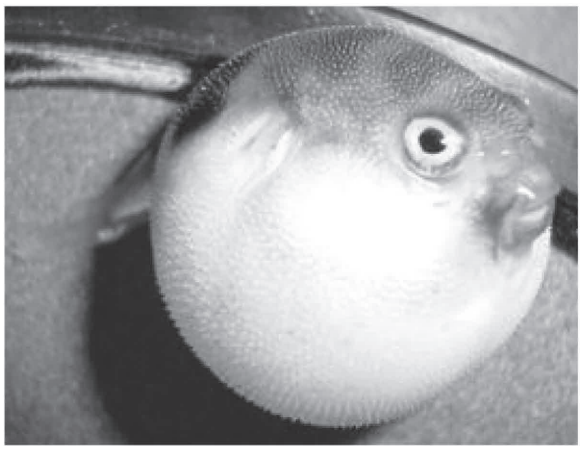
Toxicity: Unknown.

Conservation Status: Not evaluated.

***Takifugu alboplumbeus* (Richardson, 1845)**



Normal fish



Inflated fish

Common Name(s): Hong Kong pufferfish, chicken bubble.

Habitat: Marine; demersal; hard or sandy substrates in shallow waters to depths of 50 m; solitary, but larger fishes sometimes form small aggregations in large crevices.

Global Distribution: Subtropical; Indo-West Pacific.

Description: Body of this species has an approximately sickle-shaped dorsal fin which is located at the rear of the body, with 12–14 soft rays. Anal fin is with 10–11 soft rays. It has a cylindrical body and its front side is slightly flattened, Orbital interval is greater than snout length. There are no pelvic fins. Pectoral fins are wide and short. Caudal fin is large, truncate, or slightly rounded. Body back is dark brown or blue-black; side is brown and ventral side is milky white. Fins are pale yellow or pale;

Caudal fin is with a dark edge. This species has a maximum standard length of 23 cm.

Food Value: It is a poisonous species and is not to be eaten (FishBase). All the organs of this fish are considered to be toxic.

Aquarium Value: The suitability of this fish for aquarium is unknown.

Toxicity: While the flesh has sometimes been considered innocuous, it is toxic. Additionally, the liver and ovaries are extremely toxic, and the testes, skin and intestine are highly toxic (Shao et al., 2014n). It has a common belief that all pufferfish are more toxic in their spawning seasons which is largely to protect their fertilized eggs. But in this species, the ovaries were highly toxic (100–1000 MU/g) in its non-spawning seasons. And they were weakly toxic (less than 10–100 MU/g) throughout the whole year. Testes which were developed in the spawning season were also non-toxic ((Yu and Yu, 2002).

Conservation Status: Not evaluated.

***Takifugu bimaculatus* (Richardson, 1845)** (=*Tetrodon bimaculatus*)

Common Name(s): Two-spotted puffer.

Habitat: Marine; demersal.

Global Distribution: Subtropical; Northwest Pacific: Yellow Sea and East China Sea.

Description: This species is diagnosed by its 13–14 dorsal fin rays and 11–12 anal fin rays. Body is without distinct lateral fold. Nasal papilla is moderately elevated with 2 nostrils. Body is nearly as broad as deep. Jaws are subequal in height, without well-marked ridges at the sides of the median groove, and with slightly concave cutting-edges. Spines are moderately strong and are closely set. They are extending on the back from between the eyes nearly to the dorsal, and on the abdomen from below the level of the eyes to the vent. Snout, sides of head and body, and caudal

peduncle are naked. All the fin rays are pointed; subequal in height and their longest ray is nearly half the length of head. Caudal fin is truncated. Greyish above and white below. 11 or 2 dark transverse stripes are seen on the head and back before the dorsal, the posterior ones are becoming horizontal and running back on the caudal peduncle. A blackish spot is also seen on each side. This species has a maximum total length of 30 cm.

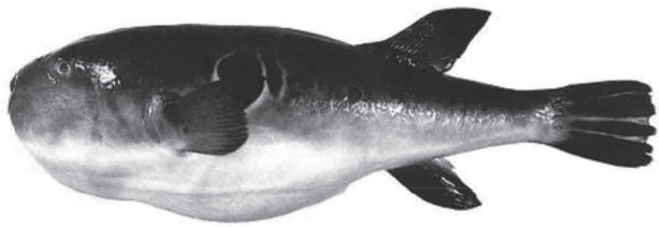
Food Value: It is a poisonous species and is not to be eaten (FishBase). All the organs of this fish are considered to be toxic.

Aquarium Value: The suitability of this fish for aquarium is unknown.

Toxicity: Gonad, blood, skin, flesh and liver of this fish are toxic. The cultured fish of this species however, has shown slight toxicity (<10 MU–125 MU) (Nuñez-Vazquez et al., 2012).

Conservation Status: Not evaluated.

***Takifugu chinensis* (Abe, 1949)**



Common Name(s): Chinese puffer, eyespot puffer.

Habitat: Marine; benthic; continental shelf and sandy bottoms; depth range 50–100 m.

Global Distribution: Temperate; Northwest Pacific: West of Tsushima, Japan to the East China and Yellow Seas.

Description: Body of this species is covered with prickles. A large round black blotch edged with a white line is seen on side just behind pectoral fin. Anal fin is black. This species feeds on shrimps, crabs and other finfish and shellfish. It has a maximum standard length of 55 cm.

Food Value: It is a poisonous species and is not to be eaten (FishBase). All the organs of this fish are considered to be toxic. This species, however, is a highly-desirable, commercially important species and is commonly consumed in Japan. According to Shao et al. (2014), the ovaries

and liver of this species contain tetrodotoxin and are considered extremely toxic; the flesh, skin and testes are innocuous (Shao et al., 2014d).

Aquarium Value: The suitability of this fish for aquarium is unknown.

Toxicity: Unknown.

Conservation Status: Critically endangered; It is a poisonous delicacy on brink of extinction. Its population has dropped by 99.99 percent in just 40 years due to overexploitation for sashimi in Japan (http://news.mongabay.com/2014/11/of-bluefin-and-pufferfish-310-species-added-to-iucn-red-list/).

***Takifugu chrysops* (Hilgendorf, 1879)**

Common Name(s): Akamefugu red-eye blowfish, Akamefugu.

Habitat: Marine; demersal; rocky reefs and sandy bottoms at depths ranging from 2 to 30 m.

Global Distribution: Temperate; Northwest Pacific: Tokyo Bay to Tosa Bay in Japan.

Description: Body of this species is oblong and smooth without prickles (spines). Dorsal ½ of body is dull orange with many small black spots, and white ventrally. It reaches a total length of 30 cm.

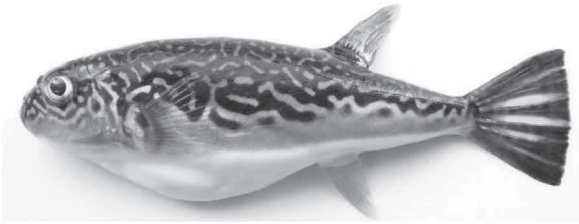
Food Value: It is a poisonous species and is not to be eaten (FishBase). All the organs of this fish are considered to be toxic.

Aquarium Value: This species is used as a component in saltwater aquarium and its aquarium parameters are given below.

Water Type: Seawater

Tank Size: 800 liters
Temperature: 23–26°C
Food/Feed: Snails, shellfish and crustaceans
Toxicity: The ovaries, liver and skin are highly toxic, the intestine slightly toxic, and the flesh and testes innocuous (Shao et al., 2014a).
Conservation Status: Not evaluated.

***Takifugu exascurus* (Jordan & Snyder, 1901)**



Common Name(s): Brown puffer.
Habitat: Marine; demersal.
Global Distribution: Temperate; Northwest Pacific: Japan and the Sea of Japan.
Description: This species is diagnosed by its 12–13 dorsal soft rays; 10–13 anal soft rays and 14–16 pectoral fin rays. Body is oblong and is covered with full of small prickles. Body is dark green or dark brown dorsally and is covered with many irregular white stripes. Belly is white. It reaches a maximum standard length of 15 cm.
Food Value: It is a poisonous species and is not to be eaten (FishBase). All the organs of this fish are considered to be toxic. According to some reports, the liver, skin, and ovaries of this species are toxic, but muscle is non-toxic. However, it is not to be eaten. It is occasionally used as a bait.
Aquarium Value: This species is used as a component in saltwater aquarium and some of its aquarium parameters are given below.
Water Type: Seawater
Tank Size: 500 liters
Temperature: 23–26°C
Food/Feed: Snails, shellfish and crustaceans
Toxicity: Unknown.
Conservation Status: Not evaluated.

***Takifugu flavidus* (Li, Wang & Wang, 1975)**

Common Name(s): Yellowbelly pufferfish, tawny puffer.

Habitat: Marine; demersal; near shore; over sandy or muddy bottoms at depths ranging from very shallow waters to 20 m.

Global Distribution: Temperate; Northwest Pacific: Yellow Sea, the Gulf of Po-Hai and northern East China Sea.

Description: Body of this species is covered with prickles. Yellowish-brown or greenish brown with many round white spots dorsally. An irregular small black blotch is seen on side just behind pectoral fin. A longitudinal yellow band is running on ventrolateral part of body from corner of mouth to lower base of caudal fin. It feeds on molluscs and crustaceans and grows to a maximum standard length of 35 cm.

Food Value: It is a poisonous species and is not to be eaten (FishBase). All the organs of this fish are considered to be toxic.

Aquarium Value: The suitability of this fish for aquarium is unknown.

Toxicity: The ovaries, liver, and intestine are highly toxic. The skin is less toxic. The testes are innocuous, but sometimes toxic (Liu et al., 2014). The cultured fish of this species however, has shown slight toxicity (<10 MU–125 MU) (Nuñez-Vazquez et al., 2012).

Conservation Status: Not evaluated.

***Takifugu niphobles* (D. S. Jordan & Snyder, 1901) (= *Fugu niphobles*)**

Common Name(s): Grass puffer, snowy puffer.

Habitat: Marine; demersal; most frequently found in shallow areas over sandy or rubble bottoms at depths ranging from very shallow

waters to 20 m; a peripheral freshwater fish, which is often seen in brackish water and is known to occasionally make short trips into small freshwater streams, possibly to rid itself of ectoparasites.

Global Distribution: Temperate; Northwest Pacific: Japan and southern Korea to Vietnam.

Description: This species is diagnosed by its 12–14 dorsal soft rays, 10–11 anal soft rays and 14–16 pectoral soft rays. Body is elongated, with spinules. Interorbital space is longer than snout length. Nostrils are covered by membrane. Body is dark green dorsally with small pale greenish yellow spots. A dark patch is seen above pectoral fin, the upper side of the patch is edged with little greenish yellow spots. Lower side is edged with little white spots. All fins are pale yellow in color. There is an yellow trailing edge in caudal fin. It is a top predator of hard-shelled prey such as molluscs. It grows to a total length of 15 cm.

Food Value: It is a poisonous species and is not to be eaten (FishBase). All the organs of this fish are considered to be toxic.

Aquarium Value: It is a popular fish in aquarium trade. This species is used as a component in saltwater aquarium and its aquarium parameters are given below.

Suitable Size of Fish: under 15 cm

Water Type: marine conditions, or at least strongly brackish water

Minimal Tank Volume: 200 liters (53 US gal)

Water Conditions:

Temperature: 18°C (64.4°F)–25°C (77°F)

pH: 7.5–8.5

Water Hardness: 5–15 °dKH

Floor Water Column: entire water column

Behavior: aggressive

Care Level: very difficult

Feeding: carnivore - molluscs, small crustaceans, including copepods, amphipods, isopods and mysids, as well as crabs, shrimps and insects.

Breeding: Not known to have been bred in aquaria. In wild it spawns on rising spring tides at dusk. It lays eggs on and around pebbles near the shoreline. Some eggs die when they are exposed to heat and air at low tide.

Toxicity: The ovaries, liver and intestine are extremely toxic. The skin is highly toxic. The flesh and testes are slightly toxic (Shao et al., 2014i). The cultured fish of this species however has shown slight toxicity (<1 MU; 9–20 ng) (Nuñez-Vazquez et al., 2012). It has a common belief that all puffer fishes are more toxic in their spawning seasons which is largely to protect their fertilized eggs. But in this species, the ovaries were highly toxic (100–1000 MU/g) in its non-spawning seasons. And they were weakly toxic (less than 10–100 MU/g) throughout the whole year. Testes which were developed in the spawning season were also non-toxic ((Yu and Yu, 2002). In this species, the proportion of toxic specimens containing more than 10 MU/g exceeded 90% for the ovary and skin, 60–80% for the fins, liver, intestine, and gallbladder, and 4.5% for the muscle. No toxicity was however, detected in the testis or eyeball using the mouse bioassay. The highest toxin levels were thousands (2,291–7,777) of MU per gram in the liver, intestine, ovary, and gallbladder, hundreds (146–328) of MU per gram in the skin and fins, and 18 MU/g in the muscle. The toxicity in the edible muscle of this species was at acceptable levels for human consumption, while the toxicity of its skin was very high, so that care must be taken when used for human consumption (Kim et al., 2007). A gram-negative, non-acid-fast, non-sporing and rod shaped bacterial strain viz. *Raoultella terrigena* has been isolated from the intestine of this species and it was shown to produce tetrodotoxin (TTX) (Yu et al., 2011).

Conservation Status: Data deficient.

***Takifugu pardalis* (Temminck & Schlegel, 1850)**

Common Name(s): Panther puffer.

Habitat: Marine; demersal; near shore in sandy, muddy or rock bottoms; seagrass beds; at depths ranging from 1 to 20 m.

Global Distribution: Temperate; Northwest Pacific: Hakodate, Japan to the East China and Yellow seas.

Description: This species is diagnosed by its 11–14 dorsal soft rays, and 9–12 anal soft rays. Body is without prickles and is covered with small rounded elevations of skin. Pale brown with many blackish spots dorsally and white ventrally. Pectoral, dorsal and anal fins are dull orange. Caudal fin is blackish. Adults feed mainly on hard-shelled animals such as gastropods, bivalves and crabs. It grows to a maximum standard length of 30 cm.

Food Value: It is a poisonous species and is not to be eaten (FishBase). All the organs of this fish are considered to be toxic. The ovaries and liver are extremely toxic; the skin and intestine are highly toxic; the testes are slightly toxic; and the flesh is generally believed to be innocuous. However, some specimens have been found to be toxic. Despite a ban on the sale of toxic pufferfish in fish markets, this species may sometimes be found in processed fish products in Taiwan (Shao et al., 2014z).

Aquarium Value: This species is used as a component in saltwater aquarium and its aquarium parameters are given below.

Minimum Tank Size: 75 gallon

Suitable Size of Fish: under 35 cm

Food and Feeding: Live foods include shellfish, crustaceans and hard-shelled foods such as snails; all kinds of live and frozen meaty foods (include prawns, crabs/crabs legs, bloodworms (live or frozen), blackworms (live or frozen), silversides, and mussels); and occasionally algae wafer. It is best to feed small amounts several times a day.

Social Behavior*:* unknown.

Sex: Sexual differences: Unknown.

Light: Recommended light levels: No special requirements.

Temperature: No special requirements. Normal temperatures for marine fish is between 74 and 79 °F.

Water Movement: Weak, moderate, strong.

Water Region: Top, middle, bottom.

Difficulty: Very hardy and easy to maintain.

Maintenance: Although it is easy to feed and generally hardy, these fishes require special care and a special diet to stay healthy. They need to be offered hard-shelled live food often to keep their teeth worn down. Because they eat a meaty diet and are often messy eaters, this species will

produce a large bio load on the biological filter of your aquarium requiring frequent water changes and good maintenance practices.

Toxicity: In this species, the proportion of toxic specimens containing more than 10 MU/g exceeded 90% for the skin, fins, liver, intestine, ovary, and gallbladder, 11.1% for the testis, and 6.9% for the muscle. In each of the organs, the highest toxin levels were several tens (14–39) of mouse units (MU) per gram in the muscle, testis, and eyeball, but thousands (1,444–5,755) of MU per gram in the skin, liver, intestine, ovary, and gallbladder. The toxicity in the edible muscle of this species was at acceptable levels for human consumption, while the toxicity of its skin was very high, so that care must be taken when used for human consumption (Kim et al., 2007). A new TTX analogue, 6-deoxy-TTX (2), was isolated from the ovary of this species (This compound has also been identified in other marine animals such as *Nassarius* snail and blue-ringed octopuses). The voltage-gated sodium channel blocking activity of this compound was found out by examining the inhibitory activities to cytotoxicity induced by ouabain and veratridine in mouse neuroblastoma cells (Neuro-2a). The activities were then compared with those of 1, 11-deoxy-TTX (3), and 6,11-dideoxy-TTX (4). The EC50 value for 2 was estimated to be 6.5 ± 2.2 nM, approximately 3-fold larger than that of 1 (2.1 ± 0.6 nM) and approximately 20-fold smaller than that of 3. These results suggested that contribution of the C-6 hydroxy group to the activity is less than that of the C-11 hydroxy group (Kudo et al., 2014).

Conservation Status: Not evaluated.

***Takifugu porphyreus* (Temminck & Schlegel, 1850)**

Common Name(s): Purple puffer.

Habitat: Marine; demersal; sublittoral zone; coastal, pelagic species; main aggregation is concentrated over the shelf, at depths shallower than 200 meters; juveniles in near-shore areas.

Global Distribution: Temperate; Northwest Pacific: southern Hokkaido, Japan to the East China Sea.

Description: This species is diagnosed by its 11–15 anal fin soft rays, 14–18 pectoral fin soft rays and 12–17 dorsal fin soft rays. Body is without prickles. It is brown dorsally and white ventrally. A large black blotch is seen behind pectoral fin, another on base of dorsal fin. This species feeds on crustaceans, squids and other shellfish. It grows to a maximum total length of 52 cm.

Food Value: It is a poisonous species and is not to be eaten. The skin, gonads, liver, intestines and even the blood contain deadly toxin but still utilized fresh for human consumption, especially in Japan (FishBase). In general, this species is commercially targeted for the consumptive pufferfish trade and it commands a high price.

Aquarium Value: This species is used as a component in saltwater aquarium and some of its aquarium parameters are given below.

Water Type: Seawater

Tank Size: 1500 liters

Temperature: 23–26°C

Food/Feed: Snails, shellfish and crustaceans.

Toxicity: According to (Shao et al., 2014o), the highest concentrations of TTX are found in the liver and ovaries, with moderate concentrations found in the skin and intestine. The flesh and testes according to these authors are innocuous. In this species, the proportion of toxic specimens containing 10 MU/g was 58.3% for the ovary, 32.6% for the skin, 12.0% for the gallbladder, 11.6% for the liver and intestine, and 9.3% for the fin. No toxicity was however, detected in the muscle and testis. The highest toxin levels were 531 MU/g in the liver, 253 MU/g in the intestine, 136 MU/g in the gallbladder, 118 MU/g in the skin, 116 MU/g in the ovary, and 108 MU/g in the fin. The skin, which is used for human consumption, showed significantly high toxicity with an average of 11 MU/g. Acceptable toxin level in this species suggests that this species is harmless. However, the skin of *T. porphyreus*, which

showed significantly high toxicity, requires special attention when used for human consumption (Kim et al., 2006).

Fisheries Status: It is a component of commercial fisheries.

Conservation Status: Not evaluated.

***Takifugu pseudommus* (Chu, 1935)**

Common Name(s): Nameradamashi.

Habitat: Marine; demersal.

Global Distribution: Temperate; Northwest Pacific: Yellow Sea and the Northern East China Sea.

Description: This species is diagnosed by its 13–15 anal fin soft rays, 17 pectoral fin soft rays and 16–18 dorsal fin soft rays. Body of this species is long, somewhat egg-shaped and is covered with prickles. Tail sacks are slender. Mouth is small. Coloration is dark brown with many round white spots dorsally. A large round black blotch is edged with a white line on side just behind pectoral fin. This species has a maximum standard length of 35 cm.

Food Value: It is a poisonous species and is not to be eaten (FishBase). All the organs of this fish are considered to be toxic. This species is commercially targeted for the consumptive pufferfish trade and it commands a high price.

Aquarium Value: This species is used as a component in saltwater aquarium and some of its aquarium parameters are given below.

Water Type: Seawater

Tank Size: 800 liters

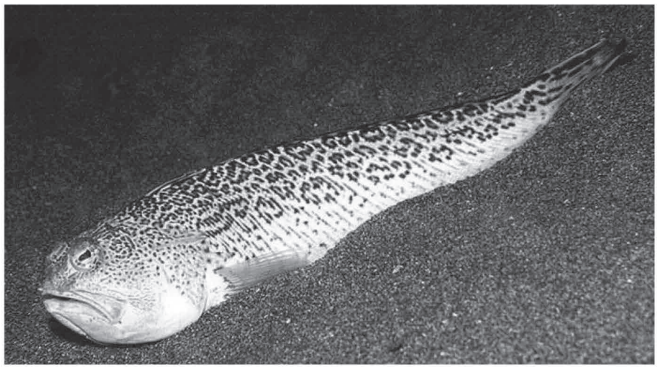
Temperature: 23–26 °C

Food/Feed: Snails, shellfish and crustaceans.

Toxicity: The ovaries are highly toxic, the liver, skin, and intestine are slightly toxic, and the testes and flesh are innocuous (Matsuura, 2014).

Conservation Status: Not evaluated.

***Takifugu radiatus* (Abe, 1 947)**



Common Name(s): Chinese puffer fish, spoke spotted puffer.

Habitat: Sea; demersal; warm coastal waters; sometimes found in estuary, steam and river.

Global Distribution: Northwest Pacific: Kyushu, Japan to East China Sea.

Description: Body of this species is without prickles. It is brown with white vermiculation dorsally and white ventrally. An irregular brown blotch edged with white is seen on dark side of upper body part of just behind pectoral fin. It feeds mainly on molluscs, crustaceans, echinoderms and fish. This species has a maximum standard length of 20 cm.

Food Value: It is a poisonous species and is not to be eaten (FishBase). All the organs of this fish are considered to be toxic.

Aquarium Value: The suitability of this fish for aquarium is unknown.

Toxicity: The intestine of the puffer fish *Fugu vermicularis radiatus* has been reported to harbor Vibrio strains and the latter were found to produce TTX, 4-epi-TTX, and anhTTX. It is also suggested that these bacterial strains are responsible for the toxification of this species (Lee et al., 2000).

Conservation Status: Not evaluated.

***Takifugu reticularis* (Tian, Cheng & Wang, 1975)**

Common Name(s): Reticulate puffer.

Habitat: Marine; demersal; nearshore, surfzone environments with sandy substrates.

Global Distribution: Subtropical; Northwest Pacific: Yellow Sea and East China Sea.

Description: In this species, dark bands are ascending to its cheek and snout. It is also known for its least depth of caudal peduncle. The diet of this species consists mainly of polychaetes, but also other food items such as gammaridean amphipods and juvenile fishes are taken. It reaches a maximum standard length of 29 cm.

Food Value: It is a poisonous species and is not to be eaten (FishBase). All the organs of this fish are considered to be toxic (http://self.gutenberg.org/articles/japanese_pufferfish).

Aquarium Value: The suitability of this fish for aquarium is unknown.

Toxicity: The internal organs and blood are toxic. Hence it does not appear to be utilized (Shao et al., 2014b).

Conservation Status: Not evaluated.

***Takifugu snyderi* (Abe, 1988)**

Common Name(s): Not designated.

Habitat: Marine; demersal; juveniles have been recorded from nearshore surf zones.

Global Distribution: Subtropical; Western Pacific: Japan, Yellow Sea and South China Sea.

Description: This species is diagnosed by its total soft rays (10–13) and pectoral soft rays (14–16). Laterally its body shape is short and/or deep. Caudal fin is more or less truncate and normal. It grows to a maximum standard length of 30 cm.

Food Value: It is a poisonous species and is not to be eaten (FishBase). All the organs of this fish are considered to be toxic. It is however, commercially targeted for the consumptive pufferfish trade

Aquarium Value: Though this species is used as a component in saltwater aquarium, much of its aquarium parameters are unknown.

Suitable Size of Fish: under 30 cm

Tank Type: marine tank

Toxicity: Ovaries and liver are extremely toxic; skin and intestine are highly toxic; flesh is innocuous or slightly toxic, and testis is innocuous (FishBase).

Conservation Status: Not evaluated.

***Takifugu stictonotus* (Temminck & Schlegel, 1850)**

Common Name(s): Not designated.

Habitat: Marine; demersal; lower mouths of rivers.

Global Distribution: Temperate; Northwest Pacific: southern Hokkaido, Japan to the East China and Yellow seas.

Description: This species is diagnosed by its 15–18 dorsal soft rays and 13–16 anal soft rays. Lateral body shape is short and/or deep. Body is covered with prickles. Caudal fin is more or less truncated and normal. Many small dark blue spots are seen dorsally. Pectoral and anal fins

are yellow. Dorsal and caudal fins are blackish-blue. This species has the maximum standard length of 35 cm.

Food Value: It is a poisonous species and is not to be eaten (FishBase). However, it is reported that the TTX toxicity of the muscle, skin, and testis of this species is at acceptable level and these organs are fit for human consumption (http://society.kisti.re.kr/sv/SV_svpsbs03VR.do?method=detail&cn2=KSSHBC_2007_v40n5_276). Anraku et al. (2013) reported that the muscle of this species contains TTX at 6.52 μg/g. This suggests that the muscle of this species is within the safe level (less than 10 MU or 2 μg) and is safe for human consumption.

Aquarium Value: The suitability of this fish for aquarium is unknown.

Toxicity: It has been reported that the liver, gallbladder, and ovary of this species showed a toxicity of 12–136 MU/g (http://society.kisti.re.kr/sv/SV_svpsbs03VR.do?method=detail&cn2=KSSHBC_2007_v40n5_276). Anraku et al. (2013) reported that the ovary of this species contains TTX at 74.8 μg/g.

Conservation Status: Not evaluated.

***Takifugu xanthopterus* (Temminck & Schlegel, 1850)**

Common Name(s): Yellowfin puffer, striped puffer.

Habitat: Marine; demersal; sublittoral zone and estuaries; on rock bottoms; at depths ranging from zero to 100 m.

Global Distribution: Temperate; Northwest Pacific: southern Japan and East China Sea.

Description: This species is diagnosed by its 16–18 dorsal soft rays and 14–16 anal soft rays. Body is covered with prickles. Body is bluish black dorsally with 4 wide curved black bands. Two anterior bands extend from pectoral fin. Two posterior ones are almost parallel to dorsal body

profile. There is a large black patch at base of dorsal fin and all fins are yellowish. It grows to a maximum standard length of 50 cm.

Food Value: It is a poisonous species and is not to be eaten (FishBase). Nagashima et al. (2001) however, reported that this species is non-toxic and suggested that the non- toxic puffer fish contains non- toxic tetrodotoxin derivatives as precursors or metabolites of tetrodotoxin. It is however, reported that the TTX toxicity of the muscle, skin, and testis of this species is at acceptable level and these organs are fit for human consumption (http://society.kisti.re.kr/sv/SV_svpsbs03VR.do?method=detail&cn2=KSSHBC_2007_v40n5_276). This species is commercially targeted for the consumptive pufferfish trade, and is among the top four fugu species. Despite a ban on the sale of toxic pufferfish in fish markets, this species may sometimes be found in processed fish products in Taiwan (Lyczkowski-Shultz et al., 2014).

Aquarium Value: This species is used as a component in saltwater aquarium and its aquarium parameters are given below.

Suitable Size of Fish: under 50 cm
Minimal Tank Volume: 1000 liters (264 US gal)
Water Conditions:
Temperature: 18°C (64.4°F)–25°C (77°F)
pH: 7.5–8.5
Water Hardness: 5–15 °dKH
Floor Water Column: entire water column
Behavior: aggressive
Care Level: very difficult
Feeding: carnivore

Toxicity: This species is known to bio-accumulate tetrodotoxin (TTX) in moderate concentration in the liver and ovaries. The ovaries and liver are highly toxic, the intestine is slightly toxic, and the flesh, skin and testes are innocuous. This species has also been found to contain a non-toxic derivative of TTX in its liver, which is thought to be a precursor or metabolite of TTX (Lyczkowski-Shultz, 2014). In another study, this species showed the highest toxin levels of toxin in the liver, gallbladder, and ovary and the values were found to exceed 1,000 MU/g (1,275–1,910 MU/g) (Kim et al., 2007; http://society.kisti.re.kr/sv/SV_svpsbs03VR.do?method=detail&cn2=KSSHBC_2007_v40n5_276).

Conservation Status: Data deficient.

***Torquigener hicksi* (Hardy, 1983)**

Common Name(s): Hick's toadfish.

Habitat: Marine; demersal; coastal waters.

Global Distribution: Tropical; Eastern Indian Ocean: Indonesia and northwestern Australia.

Description: Body of this species is elongated, rounded dorsally and flattened ventrally. It is tapering into a narrow caudal peduncle. Mouth is small and terminal with numerous short papillae. Chin is moderately prominent. Eye is moderate, slightly elongated and dorsally adnate. Dorsal spines are relatively sparse. Pectoral fins are dorsally elongated and rounded. Ventrolateral skinfold is not obvious. Lateral line is distinct with a few, small associated papillae. Dorsal base color is brownish-grey with pale spots and dots extending from level of eyes onto caudal peduncle. Belly is white. Pectoral, dorsal and caudal fins are greyish. Anal fin is pale. This species grows to a maximum total length of 13 cm. There is little other information available for this species, as it is known only from the holotype.

Food Value: This species is venomous (FishBase) and it is not utilized.

Aquarium Value: The suitability of this fish for aquarium is unknown.

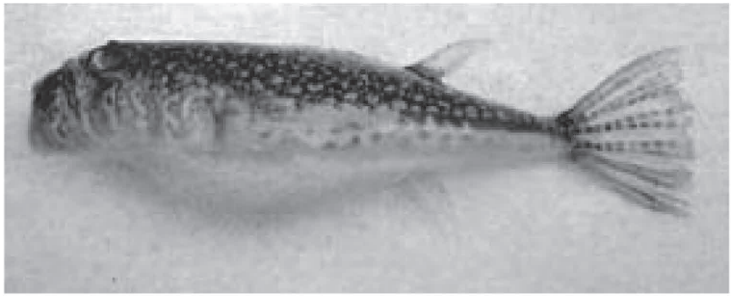
Toxicity: Unknown.

Conservation Status: Not evaluated.

3.1.2 LESS TOXIC (HARMLESS) MARINE PUFFERFISH

Kingdom: Animalia
Phylum: Chordata
Subphylum: Vertebrata
Class: Actinopterygii
Order: Tetraodontiformes
Family: Tetraodontidae

***Amblyrhynchotes rufopunctatus* (Li, 1962)**
(=*Amblyrhynchotes hypselogenion; Tetraodon hypselogenion, Sphoeroides hypselogeneion*)



Common Name(s): Orange-spotted toadfish, dwarf blowfish, dwarf blaasop, cheek-barred toadfish.

Habitat: Marine; demersal; shallow coastal sand flats and in estuaries; seagrass beds or sandy bottoms shallower than 40 m.

Global Distribution: Tropical; Western Central Pacific: South China Sea.

Description: In this species, eye is superiorly placed and is without free orbital margin. Chin is prominent. Prickles are seen from interorbital space to back, on sides of head, sides of body and belly. These pricklets are, however, not reaching anal fin. There is no raised keel on caudal peduncle. Color of the body is dark brown above. Three dark vertical bands are seen on head. It feeds mainly on molluscs, fishes, crustaceans and it grows to a maximum size of 175 mm.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic; and internal organs (such as liver, ovary and intestine) and skin may be toxic. This species, however, is not utilized.

Aquarium Value: It is used in marine aquarium where the sea water temperature is maintained between 23°C and 26°C. Other aquarium parameters are unknown.

Toxicity: This species is contaminated by tetrodotoxin-secreting bacteria such as *Vibrio* or *Pseudomonas* (Yin et al., 2005).

Conservation Status: Not evaluated.

***Arothron caeruleopunctatus* (Matsuura, 1994)**

Common Name(s): Blue spotted puffer, toadfish, blowfish.

Habitat: Found singly in shallow lagoons and seaward reefs over mixed coral, sand, rubble and weedy bottoms; depth: 2–50 m.

Global Distribution: Tropical and temperate waters; Indo-West Pacific: Reunion and Maldives, eastward through Indonesia and Papua New Guinea to the Coral Sea, and northward to Japan.

Description: Body of this species is oval and relatively elongated. Skin is not covered with scales. It has no pelvic fin and no lateral line. Dorsal and anal fins are small, symmetric and located at the end of the body. Its snout is short with two pairs of nostrils and its mouth is terminal with four strong teeth. This species is recognized by its coloration. It is yellow or brown dorsally and pale below. There are numerous small dark-edged blue spots on the body and median fins. Eyes are surrounded by blue and brown rings. They feed on crustaceans, sea urchins, sponges, coral and algae.

Also this puffer feeds on the crown -of -thorns starfish. It grows to a maximum size of 80 cm. and its lifespan is 15 years.

Food Value: This species is utilized as it's muscle is harmless (FishBase). However, according to Taiwan Fish database, it is a poisonous fish and is not fit for human consumption (http://fishdb.sinica.edu.tw/eng/species.php?id=3832600).

Aquarium Value: This species is a component of the marine aquarium trade. This is a huge fish that is not ideal for the home aquarium. However, it may be considered in extremely large set ups. The marine aquarium for this species should satisfy the following parameters:

Minimum Tank Size: 120 cm; 2000 liters

Specific Gravity of Sea Water: 1.020–1.025

pH: 8.1–8.5

Temperature: 22.2–23.9°C (72–75°F)
Water Hardness: 8–12 °d
Stocking Ratio: 1:1 M:F
Diet: Carnivore

Toxicity: Its internal organs (such as liver, ovary and intestine) are toxic. The body of this pufferfish is covered in a toxic mucus. If the skin is consumed, it may be fatal to humans (http://www.whatsthatfish.com/fish/bluespotted-puffer/1478).

Fisheries status: There is no interest for its fisheries.

Conservation Status: Not evaluated.

***Arothron carduus* (Cantor, 1849)**

Common Name(s): Thick-striped pufferfish.

Habitat: Marine; demersal; inner reefs of coral reef areas in very shallow water at depths of up to 10 m.

Global Distribution: Tropical; Sea of Penang off Malaysia, the Ryukyu Islands between Taiwan and Japan, and the Izu Islands in Southeastern Japan,

Description: Body of this species is elongated and is slightly compressed. Dorsal profile is gently arched. Snout is short and blunt. Mouth is terminal and is surrounded by thin lips. Interorbital space is flattened. Head and body are covered with small spinules except on posterior of caudal peduncle, and around mouth, eye, gill opening, and dorsal and anal fin bases. Caudal peduncle is compressed. Dorsal and anal fins are rounded. Origin of dorsal is anterior to that of anal. Pectoral and caudal fins are rounded. A single lateral line is passing along body from caudal fin base to above gill opening, where it branches into two lines. Color of fresh speci-

men: lateral and dorsal sides of head and body are white with many black lines. Several small black spots are found scattered on ventrolateral part between pectoral and anal fins. Ventral side of head and body are yellow. Pectoral fin is dusky yellow. Dorsal and anal fins are yellowish-brown. Caudal fin is white with many irregular longitudinal black lines and black spots (Matsuura and Okuno, 1991).

Food Value: It is a harmless species (FishBase) as its internal organs (such as liver, ovary and intestine) and skin are toxic; and muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 µg/g tissue).

Aquarium Value: This species may be found in the curio trade, where it is dried and sold as ornamental product. It is also occasionally found in the marine aquarium trade (Shao et al., 2014b).

Toxicity: Its toxicity is currently unknown (Shao et al., 2014b).

Conservation Status: Not evaluated.

***Arothron diadematus* (Rüppell, 1829)**

Lateral view

Frontal view

Common Name(s): Masked puffer, panda puffer.

Habitat: Marine; coral-rich fringing reef-associated; at depths ranging from 5 to 30 m.

Global Distribution: Tropical; Western Indian Ocean: Red Sea.

Description: Panda puffer derives its name due to its similarity with the Panda Bear. Body shape of this species is orbicular with short obtuse snout. Small spinules are present on body excluding the snout and caudal peduncle. Caudal fin is rounded. Body color is tan to brown with distinct dark banding around eyes resembling a mask. Dark spots or splotches sometimes occur on the body. Fins which are without spines are typically darker in color. A single short dorsal fin sits far back on the body. A short anal fin is seen under the dorsal fin. There are no pelvic fins. It is an omnivore feeding on coral tips, some crustaceans, and molluscs. This species grows to a maximum size of 30 cm total length.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (less than 10 MU/g tissue - i.e., 2 μg/g tissue).

Aquarium Value: It is suitable for marine aquarium with the following parameters.

Minimum Tank Size: 400 liters (with plenty of places to hide and swim).

Temperature: 72–78ºF

Specific Gravity: 1.020–1.025

pH: 8.1–8.4

Behavior: Semi-aggressive.

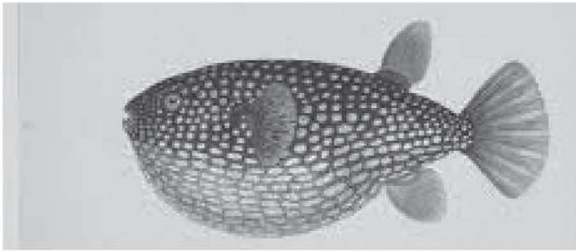
Diet: Shellfish, crustaceans and hard-shelled foods such as snails; all kinds of live and frozen meaty foods like prawn, crabs/crabs legs, bloodworms, blackworms, silversides, and mussels. It may graze on algae also.

Toxicity: Its internal organs (such as liver, ovary and intestine) and skin are toxic and are not edible.

Fisheries Status: It is fished for only marine ornamental fish trade.

Conservation Status: Not evaluated.

***Arothron gillbanksii* (Clarke, 1897) (= *Tetraodon gillbanksii*)**



Common Name(s): Fat puffer.

Habitat: Marine; demersal.

Global Distribution: Temperate; Southwest Pacific: New Zealand.

Description: Body of this species is oblong in profile and is laterally compressed. Dorsal profile is arched. Anal fin origin is slightly behind dorsal fin origin. Mouth is terminal and is directed forward. Sharp 4-rooted spines cover most of body. Color of preserved specimens is medium brown to dark brown dorsally with pale spots and pale ventrally usually without spots.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 μg/g tissue).

Aquarium Value: The suitability of this fish for aquarium is unknown.

Toxicity: Unknown.

Conservation Status: Not evaluated.

***Arothron leopardus* (Day, 1878)**

Common Name(s): Banded leopard blowfish.

Habitat: Marine; demersal; no species-specific habitat and ecology information available.

Global Distribution: Tropical; Indian Ocean: Seas of India.

Description: This species is olive superiorly, extending two-thirds of the distance down the sides, with an interrupted black network surrounding white spots. There are three black cross bands, one over the head, with a V-shaped light interorbital band posterior to it; the second, above the pectoral fin and the posterior one from the base of the dorsal fin. Reticulated narrow black lines enclosing large white spots are seen on the caudal and dorsal fins, The dorsal fin has also a narrow black basal band. It grows to a mean length of 6 cm.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 µg/g tissue). However, it is unlikely to be utilized. Further, there is no use and trade information available for this species.

Aquarium Value: Though it is used in the marine aquarium, much of the aquarium parameters are unknown.

Water Type: Seawater

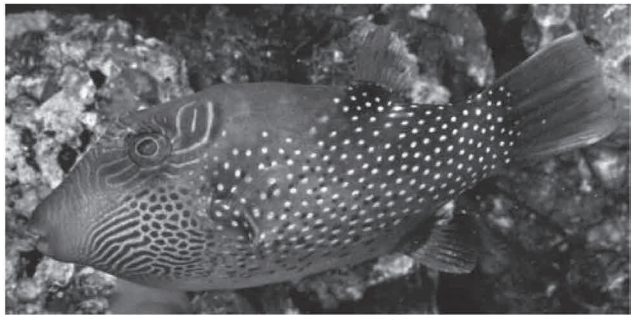
Temperature: 23–26°C

Toxicity: Unknown.

Fisheries Status: This species forms a significant share of trawl fishery and is used as an ornamental fish in the marine aquarium (Sajeevan and Somvanshi, 2013).

Conservation Status: Not evaluated.

***Canthigaster amboinensis* (Bleeker, 1864)**



Common Name(s): Spider-eye puffer, sharpnose pufferfish, Ambon toby, Ambon pufferfish, spotted toby.

Habitat: Marine; reef-associated; inhabit shallow water, often subjected to surge; juveniles remain in holes of outer reef flat and reef margin;

adults on shallow reef flats in high energy zones to about 10 meters depth; benthopelagic; depth range 1–16 m.

Global Distribution: Tropical; Indo-Pacific: East Africa to the Galapagos Islands, north to southern Japan and Hawaii, south to the Great Barrier Reef and the Society Islands.

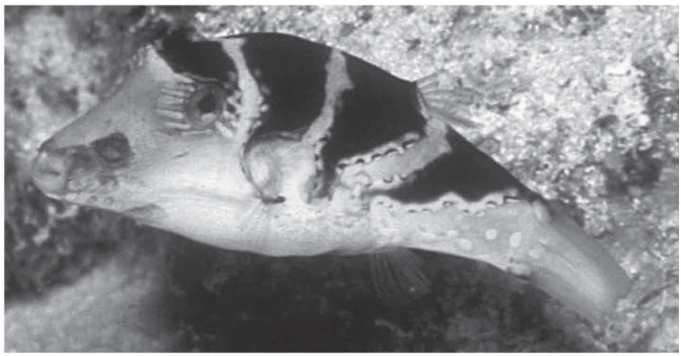
Description: It is a medium-sized sharpnosed puffer species. A ridge of skin is seen mid-dorsally. Snout is conical and attenuate. Caudal fin is slightly rounded. Color (in alcohol) is generally brown. Head and sides are with numerous pale spots with dark centres. Snout is crossed by several dark lines. Eye has several dark lines radiating from the posterior edge and arching dorsally, not joining those of opposite side. Cheeks have parallel rows of small blackish dots forming lines which curve ventrally towards throat. Dorsal, anal, and pectoral fins are blackish at base and pale brown or reddish above. Caudal fin is brown. It is omnivorous feeding mainly on algae, but also takes polychaetes, sea urchins, brittle stars, molluscs, tunicates, corals, crustaceans and sponges. Spawning in this species occurs during the day and involves the preparation of an algal nest on the substratum by the females into which eggs are deposited and fertilized by the male, and spawning occurs in multiple bouts, with no parental care after the last bout. This is consistent with field observations of spawning, social organization, and sexual dimorphism in other *Canthigaster* species. It grows to a maximum total length of 15 cm.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 µg/g tissue)

Aquarium Value: It is a component of the marine aquarium trade. This species is used in saltwater aquarium and the suitable aquarium parameters are given below.

Tank: 109.99 gal (~ 500L)
Size: up to 15 cm
Temperature: 68–82.4°F (20–28°C)
Feeding: Algae, clams, crabs, krill, zoobenthos
Degree of Difficulty: not for beginners.
Toxicity: Unknown.
Fisheries Status: It has no commercial fishery.
Conservation Status: Not evaluated.

***Canthigaster axiologus* (Whitley, 1931)**



Common Name(s): Pacific crown toby.

Habitat: Marine; sheltered habitat, often on open sand and rubble bottom near reef; depth range 10–80 m.

Global Distribution: Tropical; Pacific: Japan to New South Wales, east to the Marshall Islands and Tonga; with records from Western Australia, from Exmouth Gulf northwards.

Description: This species is a globular fish, but more laterally compressed than other species of pufferfish and can reach 10 cm in length. Body is white with a black area connecting the two eyes. There are 3 saddle-like, dark brown bars on body. The first is pointed at the pectoral fins, the second is just in front of the dorsal fin and down peak mid-flanks and the last is on the caudal fin. A black area is present on the upper and lower portions of the caudal peduncle. Many small orange spots are present on the sides, on the snout and with a larger size on the caudal peduncle. There are also some blue spots on the body. Muzzle is well marked with a small terminal mouth and a pair of nostrils. Mouth looks like a small bird's beak formed by the merger of four teeth on each jaw. Eyes radiate some blue and orange lines. Iris is yellow. On the cheeks, there is an orange curved line from the base of the nose and ends at the height of the pectoral fins. Dorsal fin is small, located in the posterior third of the back. Pelvic fins are absent, and anal fin is small, located at the same height as the backbone. Caudal can be yellow and/or orange punctuated with points. Skin is naked, without scales but with very small spines directed backwards.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 µg/g tissue).

Aquarium Value: It is a popular aquarium species and the suitable aquarium parameters are given below.

Tank Type: marine tank
Minimal Tank Volume: 200 liters (53 US gal)
Size: under 11.9 cm
pH Tolerance: 8–8.6
Water Hardness Tolerance: 17–18 °dKH
Feeding: carnivore – live food
Lifespan: 8 years
Care Level: moderately difficult
Toxicity: Unknown.
Conservation Status: Not evaluated.

***Canthigaster bennetti* (Bleeker, 1854)**

Common Name(s): Bennett's sharpnose puffer, brownback toby, Bennett's toby, Bennett's pufferfish, exquisite toby.

Habitat: Marine; reef-associated (inner reef flats and sheltered lagoons); inshore species with algal or silty reefs and among attached *Sargassum* on shallow rubble flats; depth range 1–15 m.

Global Distribution: Tropical; Indo-Pacific: East Africa south to Port Alfred, South Africa and east to Tuamoto Islands, north to southern Taiwan, south to New South Wales. Reported from Tanabe Bay, Japan and Southeast Atlantic.

Description: This species has a small mouth and a long, conical snout. It has a moderately compressed body with short-based dorsal and anal fins. Color (in alcohol) is generally brownish dorsally, pale tan ventrally. Head, back, and sides are with numerous small brown and white spots. Indistinct dark blotch or ocellus is located at base of dorsal fin. Upper part of caudal peduncle has one to several indistinct dark stripes (sometimes broken). Eye is with radiating brown lines, those from opposite side not meeting over snout or interorbital. Several broken vertical brown lines are present on cheek just posterior to mouth. Faint brown stripe is seen on ventral mid-line from chin to anus. Dorsal, anal, and pectoral fins are pale with dark-edged fin rays. Caudal fin is mostly pale, sometimes brownish basally. It is a monogamous species feeding mainly on filamentous green algae and to a lesser extent on fleshy and coralline red algae and on benthic invertebrates. It grows to a maximum length of 10 cm and its lifespan is 5–8 years.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 µg/g tissue).

Aquarium Value: It is a component of the marine aquarium trade. The suitable aquarium parameters are given below.

Minimum Tank Size: 50 gallons

Water Conditions:

Temperature: 72–78°F

dKH:8–12

pH: 8.1–8.4

Specific Gravity (SG): 1.020–1.025

Stocking Ratio: 1:1 M:F

Diet: Omnivore.

Care Level: Moderate.

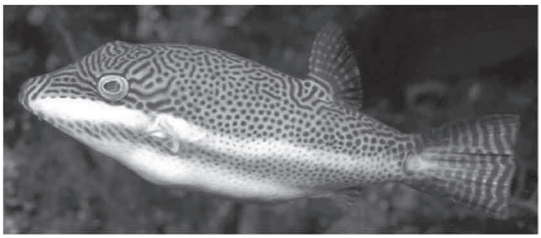
Temperament: Peaceful

Others: Aquascaped with live rock and rubble with easy access to large open areas.

Toxicity: Unknown.

Conservation Status: Not evaluated.

***Canthigaster callisterna* (Ogilby, 1889)**



Lateral view

Frontal view

Common Name(s): Clown toado, clown toby.

Habitat: Marine; demersal; depth up to 250 m.

Global Distribution: Temperate; Southwest Pacific: Australia, including Lord Howe and Norfolk Islands and New Zealand, including Kermadec Islands; New Caledonia.

Description: The clown toado is a small deep-bodied plump species with a distinct sharp nose. Color of body (in alcohol) is reddish brown dorsally and whitish ventrally. Dorsal portion of body (above eye level) is covered with small dark spots, connecting to form maze of broken lines on mid-dorsal surface. Head is usually with about 12 brownish lines radiating from eye. Snout and predorsal region have numerous irregular dark lines; cheeks are with series of oblique dark lines and whitish ventral region is overlaid with light brown spots. Many specimens (all sub-adults below

about 50–60 mm SL) show whitish longitudinal band (with spots) on middle of sides, about equal to eye diameter in width, extending from snout to base of caudal fin. Dorsal, anal, and pectoral fins are pale. Caudal fin is pale with series of faint bars and upper and lower margins of fin are dark brown. It eats a variety of encrusting animals like sponges, bryozoans, ascidians and small crustaceans. This species grows to a maximum length of 25 cm.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 μg/g tissue). Some reports however, have designated this species as highly poisonous (http://en.wikipedia.org/wiki/Clown_toado).

Aquarium Value: Though this species is in the aquarium trade, it does not appear to be common. The following are the aquarium parameters.

Water Type: Seawater
Tank: 219.98 gal (~ 1000L)
Temperature: 73.4–80.6°F (23–27°C)
Feeding: Clams, shrimp, snails.
Degree of Difficulty: Only for advanced aquarists.
Toxicity: Unknown.
Conservation Status: Not evaluated.

***Canthigaster capistrata* (Lowe, 1839)**

Common Name(s): Macaronesian sharpnose-puffer, sharpnose puffer.

Habitat: Marine; associated with rocky reefs consisting of boulders, vertical walls, platform and outcroppings which are often colonized by various algae; and also associated with artificial reefs.

Global Distribution: Tropical; Eastern Central Atlantic: known from oceanic islands.

Description: This species is gray to light brown on the back until the first horizontal black line. Lower part of the body is traversed by a second white dark brown horizontal line. These two dark lines extend to the tail fin and black to brown tint wane in adults. Small blue dots are spread at the head and on the ventral part. Placed high on the head, her big eyes are yellow gold surrounded by a broken blue line. Its fins are translucent. This species frequently preys on *Diadema antillarum* and other echinoderms and is important in regulating the populations of herbivorous urchins in sublittoral rocky reefs. It grows to 8 cm only.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 μg/g tissue).

Aquarium Value: It is a potential aquarium species and the suitable aquarium parameters are given below.

Aquarium Tank: ~ 700 liter

Size of Fish: up to 25 cm

Temperature: 23–26°C

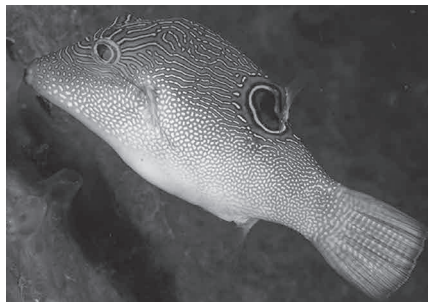
Food: Algae, frozen food (large sort), shrimp feed, crabs, krill, crustaceans, mysids, snails, sponges, sea urchins, starfish, worms.

Difficulty: No beginner's fish.

Toxicity: Unknown.

Conservation Status: Not evaluated.

***Canthigaster compressa* (Marion de Procé, 1822)**



Common Name(s): Compressed toby, fingerprint sharpnose puffer, fine-spotted pufferfish, fingerprint toby.

Habitat: Marine; brackish; reef-associated; seagrass beds and sandy areas of shallow lagoons and channels; silty bays or harbors around wharf pilings; non-migratory; depth range 2–25 m.

Global Distribution: Tropical; Western Pacific: Philippines to the Solomon Islands, north to Ryukyu Islands and southern Marianas, south to Vanuatu.

Description: Eyes of this species are slightly projecting from the top of the head. The latter is emerging in a pronounced muzzle. Pectoral, dorsal and anal fins are translucent. Dorsal and anal fins are placed behind the body. Tail, appears rectangular. Body color is gray-brown. Upper part of the body of the fish is decorated with a pattern consisting of fine lines, and the lower part consists of dots. A ocellated black spot is seen on the dorsal fine base. It feeds on benthic invertebrates and sponges, as well as algae. It grows to a size of 11 cm only.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 µg/g tissue).

Aquarium Value: It is a component of the marine aquarium trade and the suitable aquarium parameters are given below.

Aquarium: ~ 500 liters.

Size of Fish: Up to 12 cm.

Temperature: 23–25°C

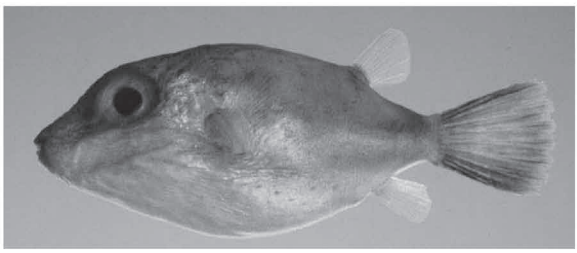
Food: Frozen food (large sort), shrimp feed.

Toxicity: Unknown.

Fisheries Status: It has no commercial fishery.

Conservation Status: Not evaluated.; Least Concern.

***Canthigaster cyanetron* (Randall & Cea-Egaña, 1989)**



Common Name(s): Bluebelly toby.

Habitat: Marine; demersal; ledges, under large coral heads and in caves; depth range 12–40 m.

Global Distribution: Subtropical; Southeast Pacific: endemic to Easter Island.

Description: The fishes of this species are laterally compressed, taller than wide in cross section and have limited inflation capabilities. They possess elongated, pointed snouts. Pelvic fins are absent. They grow to a maximum size of 7.1 cm.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 µg/g tissue). There is no use and trade information available for this species and it is unlikely to be utilized.

Aquarium Value: The suitability of this fish for aquarium is unknown.

Toxicity: Unknown.

Conservation Status: Not evaluated.

***Canthigaster cyanospilota* (Randall, Williams & Rocha, 2008)**

Common Name(s): Blue-spotted toby.

Habitat: Marine; demersal; Inhabits seaward reefs on sand-rubble bottoms; depth range 10–80 m.

Global Distribution: Subtropical; Indian Ocean to the Red Sea and Gulf of Aqaba.

Description: Color of body (in alcohol) of this species is pale grey to pale tan with three oblique, saddle-like, brown bars on body, not extending below level of upper end of gill opening. A broad dark brown band is seen

across posterior interorbital and anterior occiput. Dark brown dots and short lines are also seen on head and body. Dark lines are present on snout behind mouth. A dark brown spot is seen below base of pectoral fin and a mid ventral brown line is on head and abdomen. Fins are pale yellowish. In life, the dark dots and lines are bright blue. Caudal fin is conspicuously marked with longitudinal blue lines or rows of small blue spots and short lines. Snout is often green dorsally. Skin is with numerous small spinules that are directed posteriorly, each fitting into a longitudinal groove. Skin is smooth when stroked posteriorly, but spinules are apparent when stroked anteriorly. Very few spinules are seen on flat ventral part of body between anal and caudal fins. Small dark brown spots and short lines of preserved specimens are bright blue in life, and there are no yellow spots. Brown saddle-like bars may be yellowish along the edges. It grows to a maximum length of 10.4 cm.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 µg/g tissue).

Aquarium Value: The suitability of this fish for aquarium is unknown.

Toxicity: Unknown.

Conservation Status: Not evaluated.

***Canthigaster epilampra* (Jenkins, 1903)**

Common Name(s): Lantern toby.

Habitat: Marine; reef-associated; inhabits outer reef slopes; depth range 6–60 m.

Global Distribution: Tropical; Indo-Pacific: Christmas Island in the eastern Indian Ocean to the Hawaiian and Society islands, north to the Ryukyu Islands, south to Tonga and Rarotonga.

Description: Color of body (in alcohol) of this species is mostly pale except brownish on dorsal portion of head and body. Prominent dark

brown blotch about two to three times size of eye is usually present at base of dorsal fin. Numerous small brown dots are covering side of head and body. A faint brown stripe is seen on ventral midline from chin to anus. Several diagonal brown lines are emanating from mouth, about equal to eye diameter in length. 7 to 12 brown lines are radiating from eye, those from opposite side not meeting over snout or interorbital. Several horizontal bands are seen at caudal base slanting towards middle of fin. Dorsal, anal, pectoral, and caudal fins are pale. It feeds on molluscs, echinoderms, crabs and filamentous algae. The species grows to 12 cm in length.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 μg/g tissue). This species however, has been designated as poisonous (http://fishdb.sinica.edu.tw/eng/species.php?id=3833100).

Aquarium Value: This species is used in saltwater aquarium and the suitable aquarium parameters are given below.

Aquarium Size: ~ 400 liters

Temperature: 24–26°C

Diet: Algae, frozen food (large sort) shrimp feed, shrimp live food, mussel meat, crustaceans, molluscs, sea urchins.

Mature Size: 12.5 cm.

Care Level: Intermediate.

Temperament: Semi-aggressive.

Difficulty: Experienced aquarists.

Toxicity: Unknown.

Conservation Status: Not evaluated.

***Canthigaster figueiredoi* (Moura & Castro, 2002)**

Common Name(s): Southern Atlantic sharpnose-puffer.

Habitat: Marine; coral-rich as well as coral-poor areas, and areas with rocky bottoms; depth range 1–35 m.

Global Distribution: Tropical; Western Atlantic: southern Caribbean to Santa Catarina, Brazil, including the oceanic islands of Atol das Rocas and Fernando de Noronha.

Description: This species has a long anterior extension of the lower horizontal dark stripe on the flank (composed of irregular horizontal and diagonal bars and originating as a solid stripe on the ventral caudal fin margin). This stripe reaches the pectoral fin base. A dark caudal-fin margin is present. Vertically oriented bars are absent on the caudal fin. Further, it has fewer stripes and spots on body especially on the dorsum. It feeds on vegetation, sponges, crustaceans, and molluscs. It grows to a maximum length of 12 cm.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 µg/g tissue).

Aquarium Value: It is a component of commercial aquarium. However, the aquarium parameters of this species are unknown.

Toxicity: Unknown.

Conservation Status: Not evaluated.

***Canthigaster flavoreticulata* (Matsuura, 1986)**

Common Name(s): Sharpnose puffer.

Habitat: Marine; associated with rocky reefs; depth range 98–111 m.

Global Distribution: Tropical; Pacific Ocean: Tonga Submarine Ridge.

Description: Body of this species is moderately compressed and is covered with scattered prickles. Snout is long and conical. A raised skin fold is

seen on back extending from above posterior edge of eye to dorsa origin. A single nostril is located on each side of snout, surrounded with an elevated rim. Interorbital space is flattened. Caudal peduncle is greatly compressed, slightly tapering toward caudal fin base. Dorsal and anal fins are slightly rounded. Pectoral fin is broad and short. Caudal fin is slightly rounded. It is a small species with a total length of 11 cm.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 µg/g tissue). However, it is unlikely to be utilized.

Aquarium Value: This species is used in saltwater aquarium and some of the aquarium parameters known are given below.

Water Conditions:

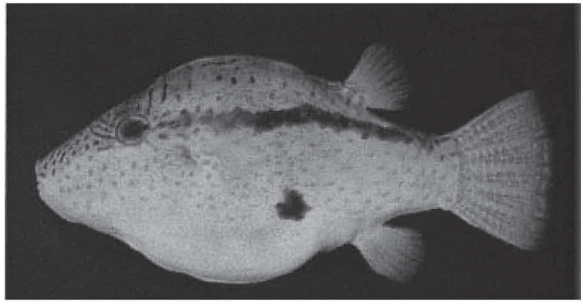
pH in the Water: 8.0 to 8.3

dH (Hardness): 12 to 25

Toxicity: Unknown.

Conservation Status: Not evaluated.

***Canthigaster inframacula* (Allen & Randall, 1977)**



Common Name(s): Not designated.

Habitat: Marine coral reef joint; rock and sand substrates; depth range 124–274 m.

Global Distribution: Tropical; Eastern Central Pacific: Oahu Island, Hawaiian Islands. Northwest Pacific: Japan.

Description: Head and body of this species are light olivaceous grey dorsally, shading to whitish on lower sides and abdomen. A slightly irregular blackish stripe is seen from eye to upper base of caudal fin (diffused just behind eye). There is an irregular roundish black spot larger than eye

on lower side between pectoral base and origin of anal fin. Head and body except thorax and abdomen are with well-separated small brownish to blackish spots, most numerous dorsally on snout. Brownish lines are radiating anteriorly, dorsally, and posteriorly from eye. A few brownish lines are also present dorsally at front of snout, on nape, back, and dorsally on caudal peduncle. Dorsal, anal, and pectoral fins are translucent and slightly yellowish. Dorsal and anal base are with brownish lines and small brown spots. Caudal fin is pale with faint brownish spots arranged in approximately vertical rows. Black spot present on the lower side is the chief diagnostic feature of this species. It can reach 7.6 cm in overall length.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 µg/g tissue).

Aquarium Value: The suitability of this fish for aquarium is unknown.

Toxicity: Unknown.

Conservation Status: Least Concern.

Canthigaster investigatoris (Annandale & Jenkins, 1910)

Inage not available

Common Name(s): Sharpnosed puffer.

Habitat: Marine; demersal; depth up to 101 m.

Global Distribution: Tropical; Indo-West Pacific: Indonesia.

Description: This species is diagnosed by its dorsal rays (9 or 10), anal rays (10) and pectoral rays (15). Color of body (in alcohol) is uniformly tan with several narrow brown lines crossing snout and interorbital. About two to three similar lines are extending horizontally from upper caudal peduncle and dorsal fin base to pectoral region. Fins are tan, probably translucent in life. The color pattern in combination with the low pectoral ray count are the distinctive characters.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 µg/g tissue).

Aquarium Value: This species is used in saltwater aquarium and some of the aquarium parameters known are given below.

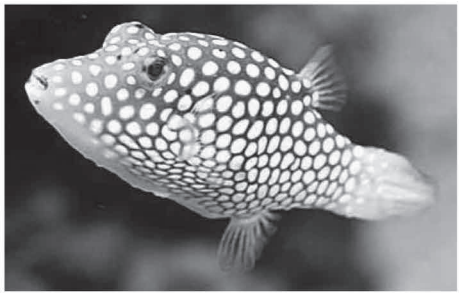
Water Type: Seawater.

Temperature: 23–26 °C.

Toxicity: Unknown.

Conservation Status: Not evaluated.

***Canthigaster jactator* (Jenkins, 1901)**



Common Name(s): Hawaiian white-spotted toby, white-spotted puffer.

Habitat: Marine; reef-associated; lagoon and seaward reefs over coral, rock, rubble, and sand; depth range 1–30 m.

Global Distribution: Tropical; Pacific Ocean: Hawaiian Islands.

Description: This species is diagnosed by its dorsal rays (9 or 10), anal rays 9 or 10 and pectoral rays (16 to 18). Color of body (in alcohol) is brown with numerous white spots on sides of head and body. Ventral portion of body from anus to lower jaw is usually tan with absence of spots. Caudal fin is uniformly tan to brownish and remainder of fins is translucent with rays thinly outlined with dark pigment. It feeds on sponges, algae, detritus, tunicates, polychaetes, bryozoans, sea urchins, brittle stars, crabs, peanut worms, shrimps, zoanthids, fishes, amphipods and foraminiferans. It grows to a maximum length of 9 cm. It is also known to be a carnivorous cleaner of the green sea turtle, *Chelonia mydas*. Fish with severely distended bellies are infected by nematode worms, *Philometra* sp., which eventually cause mortality.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 µg/g tissue).

Aquarium Value: It is a component of commercial, saltwater aquarium and the suitable aquarium parameters are given below.

Minimum Tank Size: 50 gallons

Care Level: Moderate.

Temperament: Peaceful.

Water Conditions:

Temperature: 72–78°F.

dKH: 8–12.
pH: 8.1–8.4.
Specific Gravity (SG): 1.020–1.025.
Diet: Omnivore.
Toxicity: Unknown.
Conservation Status: Not evaluated.

Canthigaster jamestyleri (Moura & Castro, 2002)

Common Name(s): Goldface toby.

Habitat: Marine; reef-associated; deep rocky outcroppings and hard bottoms with gorgonians; depth range 90–100 m.

Global Distribution: Subtropical; Western Atlantic: off the southeast coast of the USA and the Gulf of Mexico.

Description: Snout of this species is relatively long and very acute. Nostril is single and is surrounded by a fleshy rim. Interorbital region is concave. Eye is located slightly above dorsal margin of head. Gill opening is arch-shaped and is located just to pectoral fin base, and about half the length of pectoral fin base. Pectoral fin has 15 or 16 rays. Dorsal fin is anterior to and larger than anal fin and has 9 rays. Caudal fin is truncate to slightly convex. Small spinules are located on lower part of head and abdomen and have two lateral roots did fold into small sockets. Color is tan, darker dorsally than ventrally, with roundish spots and irregular diagonal lines ventral to pectoral fin base. Side of head and snout are marked with horizontal lines, and two stripes run along body. It is an epibenthic browser, mainly preying on sessile invertebrates It reaches a maximum length of 8.5 cm.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 μg/g tissue). There is no use and trade information available for this species. It is unlikely to be utilized.

Aquarium Value: This species is used in saltwater aquarium and some of the aquarium parameters known are given below.

Water Type: Seawater.

Aquarium: 500 liter.

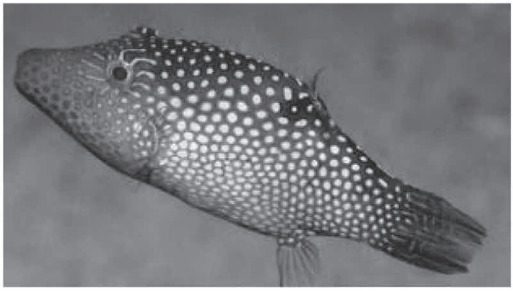
Temperature: 23–26°C.

Food/Feed: Crustaceans and other shellfish.

Toxicity: Unknown.

Conservation Status: Not evaluated.

***Canthigaster janthinopterus* (Bleeker, 1855)**



Common Name(s): Honeycomb toby, spotted pufferfish, spotted puffer, spotted toby, white-spotted pufferfish.

Habitat: Marine; clear lagoon and seaward reefs; with sponges; prefers sheltered areas in the form of holes in dead and living corals; depth range 1–30 m.

Global Distribution: Tropical; Indo-Pacific: East Africa south to Transkei, South Africa and east to the Line, Marquesan, and Oeno islands, north to southern Japan, south to Lord Howe Island. Southeast Atlantic.

Description: This species is diagnosed by its dorsal rays (9 or 10), anal rays (9 or 10), pectoral rays (16 or 18). Color of body (in alcohol) is brownish with numerous white spots on sides of head and body. Ventral portion of body from anus to lower jaw is usually tan without spots. Head is usually with spoke-like lines radiating from eye. Dark blotch or ocellus is sometimes present (sometimes poorly developed) at base of dorsal fin. Caudal fin is uniformly tan to brownish. Remainder of fins is translucent with rays thinly outlined with dark pigment. Orange stripes are seen on the side of the head in some adult specimens. It feeds on sponges, polychaetes, filamentous algae and on

smaller quantities of tunicates, crustaceans, echinoderms and corals. It grows to a maximum length of 9 cm.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 µg/g tissue).

Aquarium Value: It is a component of the marine aquarium trade and the suitable aquarium parameters are given below.

Aquarium Tank Size: From 100 liters.

Water Conditions:

Temperature: 24–28°C.

pH: 8.1 to 8.4.

Water Hardness: 5–15 ° dKH.

Food: omnivore – Both live and frozen.

Lifespan: 5 years.

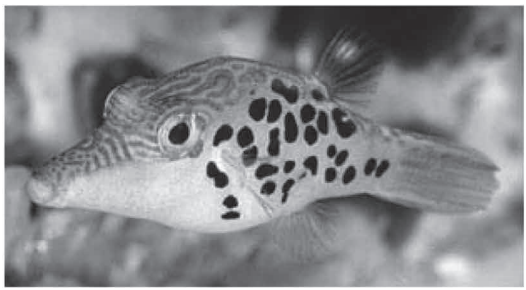
Behavior: Aggressive towards their own kind.

Breeding: Moderately difficult.

Toxicity: Unknown.

Conservation Status: Not evaluated.

***Canthigaster leoparda* (Lubbock & Allen, 1979)**



Common Name(s): Leopard sharp-nose puffer, leopard pufferfish, leopard toby.

Habitat: Marine; reef-associated; deep water habitats, usually along deep drop-offs in caves; depth range 30–50 m.

Global Distribution: Tropical; Eastern Indian Ocean: Christmas Island. Western Pacific: Philippines, Ambon, and Guam.'

Description: This species is diagnosed by its 8 to 9 dorsal soft rays, and 9 anal soft rays. Top-side of face and body of this species are yellow with blue lines. Sides and underside are white with blue spots. Sides are

with several clusters of brown blotches. Fins, except caudal fin are clear. It needs a varied diet of meaty foods including: squid, krill, clams, and shrimp to help wear down its ever-growing teeth. It reaches a maximum adult size of 7.5 cm.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 µg/g tissue).

Aquarium Value: It. is relatively new to the marine aquarium trade and the suitable aquarium parameters are given below.

Minimum Tank Size: 30 gallons

Water Conditions:

Temperature: 72–78°F

dKH: 8–12

pH: 8.1–8.4

Specific Gravity (SG): 1.020–1.025

Diet: Omnivore.

Lifespan: 5–8 years.

Care Level: Moderate.

Temperament: Peaceful.

Aquarium Set Up and Care: Natural habitat has to be created within the aquarium in order to ease their acclimation. Aquarium should have plenty of deep caves and rock crevices with enough depth to allow the fish to escape the bright aquarium lighting. Ideally the rock work within the aquarium should re-create the steep rocky reef slope of this species native environment, which should include plenty of caves, crevices and areas of reduced or diffused lighting. There should also be areas of reduced water flow in middle to lower areas within the aquarium, and increased water flow near the aquarium surface. Tank mates should consist of similarly sized semi-aggressive fish species that are not too boisterous for the relatively passive nature of the leopard pufferfish.

Diet: It should include marine based meaty foods like: krill, shrimp, squid, mussels, clams, quality frozen preparations and pellet foods designed for marine carnivores. This fish should be fed daily 1 to 2 times per day.

Toxicity: Unknown.

Conservation Status: Least Concern.

***Canthigaster margaritata* (Rüppell, 1829)**

Common Name(s): Margaritata puffer, Red Sea toby, ray-finned fish.

Habitat: Marine; tidal pools, lagoons and sheltered reefs from 1 to 30 m; depth range 0–10 m.

Global Distribution: Tropical; Indo-West Pacific: Red Sea, Inhaca Island in Mozambique, Sri Lanka, and Ogasawara Islands.

Description: This species is diagnosed by its 8 or 9 dorsal and anal rays and 16 to 18 pectoral rays. Color of body (in alcohol) is reddish-brown with numerous whitish to greyish spots about size of pupil or smaller. Ventral surface is tan or light brown without spots. Ocellus at base of dorsal fin is weakly developed. Head is usually with about 6 to 10 dark lines radiating from eye. Interorbital and tip of snout are usually with combination of thin dark cross-bands and small brownish dots (difficult to detect in some preserved material). Tip of snout is tan. Dorsal, anal, and pectoral rays are light brown or dusky with fine dark borders. Caudal fin is reddish-brown with pale spots. It feeds on small invertebrates and algae. This species is a facultative corallivore, feeding mainly on soft corals. It reaches a maximum size of 31.2 cm.

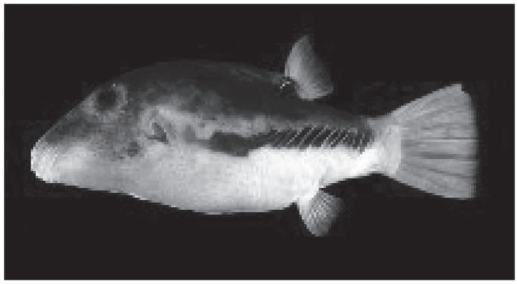
Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 µg/g tissue).

Aquarium Value: This species is used in saltwater aquarium and some of the aquarium parameters known are given below.

Tank: 260 gal (approx)

Temperature: 71.6–80.6°F (22–27°C)
Feeding: Sea urchins.
Degree of Difficulty: Only for advanced aquarists.
Toxicity: Unknown.
Fisheries Status: It has no commercial fisheries.
Conservation Status: Not evaluated.

***Canthigaster marquesensis* (Allen & Randall, 1977)**



Common Name(s): Sharpnosed puffer.
Habitat: Marine; reef-associated; depth range 15–42 m.
Global Distribution: Tropical; Eastern Central Pacific: Nuku Hiva, Marquesas Islands.
Description: This species is diagnosed by its 10 dorsal rays, 9 anal rays and 17 pectoral rays. Head and body of this species are generally brownish dorsally and tan ventrally. Prominent dark brown longitudinal band, about equal to eye diameter in width, is seen extending from pectoral fin axil to caudal peduncle. Dorsal portion of body is with network of dark irregular blotches. Dark spots (eye sized) are seen at base of dorsal fin. A dark blotch about size of pupil is located anterior to and slightly below pectoral fin base. Area surrounding mouth is whitish with brownish zebra-like stripes. Perimeter of eye is narrowly whitish, intersected by brownish spokes, those of the opposite side are not meeting over snout or interorbital. A series of approximately 15 to 20 narrow, parallel pale lines are seen on posteroventral region of body (lower caudal peduncle for the most part), extending diagonally in anteroventral to posterodorsal direction, intersecting prominent longitudinal band. Five to six brownish horizontal bands are seen at caudal base, slanting towards middle of fin.

Dorsal, anal, pectoral, and caudal fins are pale. It feeds on filamentous algae and small invertebrates. It reaches a maximum size of 7.1 cm.

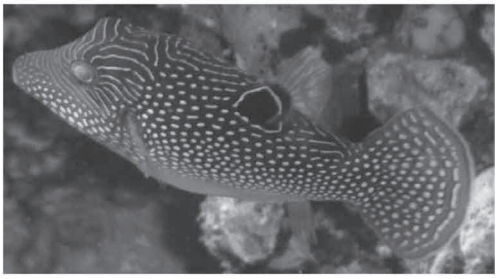
Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 µg/g tissue). There is no use and trade information for this species.

Aquarium Value: The suitability of this fish for aquarium is unknown.

Toxicity: Unknown.

Conservation Status: Not evaluated.

***Canthigaster natalensis* (Günther, 1870)**



Common Name(s): Natal toby.

Habitat: Coral reef associated; demersal; shallow water species; tidepools; depth range 0–15 m.

Global Distribution: Subtropical; Western Indian Ocean: Mozambique and South Africa to Reunion and Mauritius.

Description: This species is diagnosed by its 11 dorsal rays, 10 anal rays and 16 or 17 pectoral rays. Color of body (in alcohol) is generally brown and lighter on ventral surface. Numerous white spots, about 1/3 to 1/2 pupil size are seen on side and also faintly visible on basal half of caudal fin. Small dark spots of similar size are found widely scattered among pale spots, but not particularly apparent due to brown ground color. Side of snout is with series of 4–7 dark bars joining those from opposite side on dorsal surface. 2–3 similar lines are sometimes joined to former, but perpendicular to them in orientation, on lower part of head extending from lower jaw to level of gill opening. Dark blotch or lines are usually present on chin. Dark stripe (sometimes broken) are present on mid-ventral line from posterior part of head to anus. Edge of eye is with several dark lines radiating in all directions, those on dorsal part meeting opposite members

on interorbital. Cheeks are with patch of small white spots, sometimes coalesced to form irregular broken lines. Dorsal, anal, and pectoral fins are whitish with dark-edged rays. Caudal fin is dusky to brownish. It feeds on calcareous algae, benthic invertebrates and sometimes corals. This species reaches a maximum size of 8.6 cm.

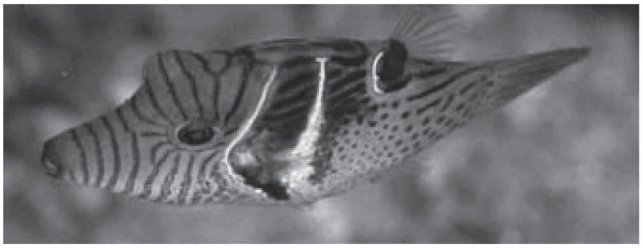
Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 μg/g tissue). This species does not appear to be utilized.

Aquarium Value: The suitability of this fish for aquarium is unknown.

Toxicity: Unknown.

Conservation Status: Not evaluated.

***Canthigaster ocellicincta* (Allen & Randall, 1977)**



Common Name(s): Shy toby, circle-barred toby, circle-barred pufferfish, circle-barred puffer.

Habitat: Marine; inhabits invertebrate-rich inshore reef to outer reef walls where usually in caves; depth range 10–53 m.

Global Distribution: Tropical; Western Pacific: Philippines and eastern Indonesia to Fiji, north to the Ryukyu Islands, south to the Great Barrier Reef and New Caledonia, Tonga.

Description: This species is diagnosed by its 9 dorsal rays, 9 anal rays and 16 pectoral rays. Ground color (in alcohol) of head and body is tan. Side of head is with a series of 8–9 faint stripes (blue in life), those on snout forming narrow lines confluent dorsally with those of opposite side. Six narrow brown lines are seen across interorbital. Two brownish bars with intermediate whitish area are seen between posterior portion of head and level of dorsal fin origin. Narrow whitish margin is seen on front of anterior most bar. Two pale brown stripes are found extending obliquely downwards from base of uppermost caudal rays to level of posterior most dorsal ray. Posterior portion

of body and caudal peduncle are with 5–6 horizontal rows of faint (bluish in life) spots. Dark brown ocellus is located at base of dorsal fin. There is a diffuse brown mid-ventral stripe from anus to level of pectoral base. Fins are translucent with rays thinly outlined with dark pigment. It feeds on algae and small invertebrates. This species has a maximum standard length of 7.5 cm.

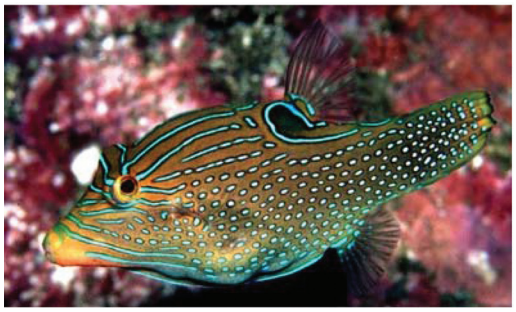
Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level), less than 10 MU/g tissue (i.e., 2 μg/g tissue). There is no use and trade information available for this species.

Aquarium Value: It is of interest to marine aquarists, however it appears to be rarely encountered in the trade. Its aquarium parameters are also not known.

Toxicity: Unknown.

Conservation Status: Not evaluated.

***Canthigaster papua* (Bleeker, 1848)**



Common Name(s): Papuan toby, false-eyed pufferfish, spotted sharp-nose.

Habitat: Coastal to outer reef habitats from silty to pristine reefs; clear, coral-rich areas of lagoon and seaward reefs; juveniles in shallow estuaries. Depth range is 1–50 m.

Global Distribution: Tropical; Indo-West Pacific: Maldives to eastern New Guinea, north to the Philippines and Palau, south to the Great Barrier Reef and New Caledonia.

Description: This species gets its name from the black spot at the base of the dorsal fin which looks like an eye. It can be recognized by its coloration. It is brown to orange with numerous small blue-green spots on the body and caudal fin. Black-edged blue-green lines radiate from the eye and a black spot is present below the dorsal fin. This species is an

omnivorous benthic forager. It feeds on squid, krill, clams, and shrimp. Larvae of this species were found to settle on moorings and artificial structures. It reaches a size of 10.2 cm.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 µg/g tissue).

Aquarium Value: This species is used in saltwater aquarium and some of the aquarium parameters known are given below.

Minimum Tank Size: 50 gallons
Water Conditions:
Specific Gravity (SG): 1.020–1.025
Hardness: dKH 8–12
pH: 8.1–8.5
Temperature: 23.3–26.7°C (74–80°F)
Stocking Ratio: 1:1 (male: female)
Diet: Omnivore.
Lifespan: 8–15 years.
Care Level: Moderate.
Temperament: Semi-aggressive
Toxicity: Unknown.
Conservation Status: Not evaluated.

***Canthigaster petersii* (Bianconi, 1854)**

Common Name(s): Peter's toby.

Habitat: Marine; reef-associated; muddy bottoms, mixed rock and coral, and along sandy beaches; depth range 1–25 m.

Global Distribution: Tropical; Indian Ocean: from Oman and East Africa to the Andaman Sea.

Description: This species is characterized by 8–10 dorsal rays, 8–10 anal rays and 16–18 pectoral rays. It has a slightly rounded caudal fin. Body is brown with numerous white spots on snout, side of body and caudal fin. Bluish-white lines are seen mainly around eye region and on upper back. A prominent white-edged black spot is found below dorsal-fin base and belly is white. This species is sexually dimorphic. It grows to a maximum size of 9 cm.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 μg/g tissue).

Aquarium Value: It is a component of the international marine aquarium trade. However, its aquarium parameters are unknown.

Toxicity: Unknown.

Conservation Status: Not evaluated.

Canthigaster punctata (Matsuura, 1992)

Image not available

Common Name(s): Not designated.

Habitat: Marine; reef-associated; depth up to 92 m.

Global Distribution: Tropical; Western Indian Ocean: Mascarene Submarine Ridge.

Description: This species is diagnosed by its dorsal fin with 10 soft rays, anal fin with 10 soft rays and pectoral fin with 15 soft rays. There is a large number of brown point on the back side of the body. A horseshoe-shaped brown line is found extended to the side. There is a brown point on the back side and the ventral side of the base of the caudal fin. Caudal fin has a dark line of several semi-transparent runs up and down. It is a small species with a length 9 cm.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 μg/g tissue). There is no use and trade information available for this species.

Aquarium Value: The suitability of this fish for aquarium is unknown.

Toxicity: Unknown.
Conservation Status: Not evaluated.

***Canthigaster punctatissima* (Günther, 1870)**

Common Name(s): Spotted sharp-nosed puffer.
Habitat: Marine; reef-associated; hides in shaded, protected recesses in rocky reefs, boulder strewn slopes and along walls; intertidal pools; sandy substrata; depth range 3–21 m.
Global Distribution: Tropical; Eastern Central Pacific: Guaymas, Mexico to Panama and the Galapagos Islands.
Description: This species has a robust, slightly compressed body. Head is large and blunt. Snout is long and pointed. 1 pair of small hole-like nostrils are present. Nape is with crest between eyes and dorsal fin. Eyes are at high on sides of head. Jaws are a beak composed of 4 fused heavy powerful teeth with a central suture on each jaw. A slit-like gill opening is in front of the pectoral fin base. A single short- based dorsal fin is present at rear of body. A similar-shaped anal fin is present below the dorsal fin. Dorsal, anal rays and pectoral fins have 8–10, 8–10 and 15–18 rays, respectively. There are no pelvic fins and spines are absent in the fins. Tail fin is rounded, with 10 main rays. Tough scaleless skin is seen. Head and body are with scattered tiny spinules and there is no fleshy skin flaps. Color of body (in alcohol) is brown with numerous white spots on sides of head and body. Ventral portion of body from anus to lower jaw is usually tan without spots. Caudal fin is tan to brownish with small pale spots (may be faded in preserved specimens), particularly apparent on basal portion of fin. Remainder of fins is translucent with rays thinly outlined with dark pigment. This monogamous species grows to a size of 9 cm in total length.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 μg/g tissue).

Aquarium Value: The suitability of this fish for aquarium is unknown.

Toxicity: Nunez-Vazquez et al. (2000) reported that the values of TTX toxicity of mucous, liver, intestine and gonad of this species were 1.1 μg/g, 0.68 μg/g, 0.51 μg/g and 3.9 μg/g, respectively.

Conservation Status: Least Concern.

***Canthigaster pygmaea* (Allen & Randall, 1977)**

Common Name(s): Pygmy toby.

Habitat: Marine; reef-associated; found hidden in holes; depth range 2–30 m.

Global Distribution: Tropical; Western Indian Ocean: Red Sea.

Description: This species is diagnosed by its dorsal rays (8 to 10); anal rays (9 or 10) and pectoral rays 5 (14 to 16). Head and body are generally grey-brown, slightly lighter on ventral surface. Numerous small round spots are on side, those over most of body faintly grey with dark dot in centre, those on ventral surface and lowermost portion of side are prominently dark. A dark brown spot, about size of eye or slightly smaller is seen at base of dorsal fin. Most of eye except anterior edge is broadly rimmed with dark brown. Side of snout and cheek are with 9 narrow grey bars with dark outlines, not joining those from opposite side across dorsal surface of snout. Fins are pale with dark-edged rays. It grows to a maximum length of 5.6 cm only.

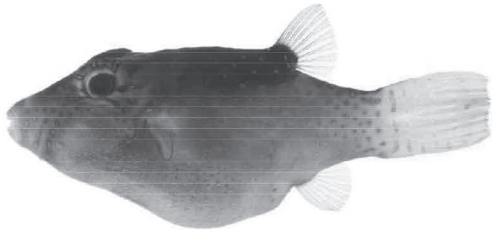
Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 μg/g tissue).

Aquarium Value: It is occasionally found in the marine aquarium trade. However, its aquarium parameters are unknown.

Toxicity: Unknown.

Conservation Status: Not evaluated.

***Canthigaster rapaensis* (Allen & Randall, 1977)**



Common Name(s): Currently unavailable.

Habitat: Marine; coral reef-associated; areas of high live coral cover in areas with few anthropogenic disturbance; non-migratory.

Global Distribution: Tropical; Central Pacific: French Polynesia.

Description: This species is diagnosed by its dorsal rays (10 or 11); anal rays (9 or 10) and pectoral rays (16 to 18). Head and body are generally pale brow. Numerous small brown spots are seen on sides of head and body. A diffuse blackish patch which is larger than eye is found at base of dorsal fin. Predorsal region including dorsal portion of snout and upper rim of orbits possess dark brown coloration. A dark brown stripe is on ventral midline extending from chin to anus. Several spoke-like dark lines are radiating from eye, those from opposite side not meeting over snout or interorbital. Several short brown stripes (sometimes broken) are also seen on side of cheek. Dorsal, anal, and pectoral fins are translucent with dark-edged rays. Each fin ray of caudal is with three to five brown bands and membranous portion of fin is pale. It grows to a maximum standard length of 7.8 cm.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 µg/g tissue). There is no use and trade information available for this species. It is unlikely to be utilized.

Aquarium Value: The suitability of this fish for aquarium is unknown.

Toxicity: Unknown.

Conservation Status: Vulnerable.

Canthigaster rivulata (Temminck & Schlegel, 1850)

Common Name(s): Brown-lined puffer, rivulated toby, maze toby, doubleline toby, tail-barred pufferfish.

Habitat: Marine; reef-associated; rocky and coral reefs; seagrass beds; depth range 0–350 m.

Global Distribution: Tropical; Indo-Pacific: East Africa south to Natal, South Africa and east to Hawaii; north to southern Japan, south to northwestern Australia; Kermadec Island.

Description: This species is diagnosed by its dorsal rays (9 or 10), anal rays (9 or 10) and pectoral rays (16 to 18). Color of body (in alcohol) is generally pale tan. Side of body is with two longitudinal and parallel dark bands, usually less than eye diameter in width, extending from pectoral region to caudal peduncle. Bands are joining each other, forming an arc in front of gill opening. Lower band may be faint or absent on some specimens. Dorsal portion of body (above uppermost band) is with brownish vermiculated pattern. Small dots or broken lines are present sometimes on sides of head and body. Faint spoke-like lines are sometimes radiating from eye. A dark blotch is found at base of dorsal fin. A dark spot is also seen on pectoral base. Dorsal, anal, pectoral, and caudal fins are pale. This species has been observed to spawn in aquaria. It feeds upon benthic invertebrates, sponges and algae. It grows to a maximum length of 18 cm.

Food Value: It is a venomous species. (FishBase). However, it has been reported to be harmless as the muscle of this species has been reported to contain TTX at 0.25 μg/g. This suggests that the muscle of this species is within the safe level (less than 10 MU or 2 μg) and is safe for human consumption (Anraku et al., 2013).

Aquarium Value: It is a component of the marine aquarium trade and there is no report on its aquarium parameters.

Diet: Omnivore; It requires an enriched meaty diet with some vegetable matter, e.g., brine shrimp, earthworms, tubifex worms, finely chopped fish and shrimp flesh, and fresh greens.

Aquarium Suitability: Fish-only aquariums.

Toxicity: Unknown.

Fisheries Status: It has no commercial fishery.

Conservation Status: Not evaluated.

***Canthigaster rostrata* (Bloch, 1786)**

Common Name(s): Caribbean sharpnose-puffer, sharpnose pufferfish.

Habitat: Marine; reef-associated; inhabits reefs and marginal habitats such as seagrass beds; depth range 1–40 m.

Global Distribution: Tropical; Western Central Atlantic: South Carolina, USA and Bermuda to Tobago and the Lesser Antilles.

Description: A small, roughly football-shaped fish with a large pointed snout, small fins at the rear of the body, and a prominent tail. This species is distinguished from all other Atlantic species by a short upper dark longitudinal stripe, presence of few spots on flank and dorsum, and absence of a conspicuous (larger than eye) spot on the dorsum. An upper dark longitudinal stripe extends from caudal-fin dorsal margin to the vertical through dorsal-fin base. Although a horizontal line of dark spots extends anterior to the anterior portion of the horizontal dark stripe in some specimens, and sometimes even surpasses the dorsal fin base, this line of spots never forms a continuous stripe. It is also distinguished by the absence of vertically oriented bars on the caudal fin and by the presence of bars on the snout. Sides of the body vary from pale yellow to white with bright blue spots, while the edges of the tail fin have thick, dark borders that distinguish this species from similar

puffers. Back is typically brown in females and grey in mature males. It is omnivorous feeding on seagrass, sponges, crabs and other crustaceans, molluscs, polychaete worms, sea urchins, starfishes, hydroids and algae. This monogamous species grows to a maximum length of 12 cm.

Reproduction: Sharpnose puffers reproduce sexually by laying demersal eggs and do not undergo sex change during reproductive development. Males regularly visit the female members of their harem throughout the day to reinforce their bond. During the breeding season, these visits often result in spawning when they occur in the early morning hours. Males enter a female's territory, spread their fins and present their flank. Females respond and the pair spends a few minutes feeding side by side. If the female is ready to spawn, she will search the substrate for a patch of algae to use as a nest and will spend some time cleaning it while the male encourages her by nudging her repeatedly with his snout. If the female stops preparing the nest, or attempts to leave, the male often becomes aggressive and may display or even bite to urge her on. Once the nest is ready, the couple swim side by side just above it. The female lays her eggs into the nest and the male fertilizes them immediately. Once the eggs are laid, the two-sharpnose puffers return to their daily activities and the nest is left uncared for until the eggs hatch and disperse into the plankton. Sharpnose puffers have been observed mating in the spring, but the full extent of their breeding season is currently unknown (http://www.oceana.org).

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 µg/g tissue). This puffer is not caught as a food fish.

Aquarium Value: Because of its small size and bright colors, it is widely collected for the marine aquarium trade and the suitable aquarium parameters are given below.

Minimum Tank Size: 113.6 liters (30 US G.)
Size: 10.2–12.7 cm
Water Conditions:
Specific Gravity (SG): 1.020–1.025
pH: 8.1–8.5
Temperature: 23.3–26.7°C (74–80°F)
Water Hardness: 8–12 dH
Stocking Ratio: 1:1 M:F

Diet: Carnivore.

Lifespan: 8–15 years.

Difficulty: Challenging.

Toxicity: These fish, like other puffers, possess tetrodotoxin which makes them poisonous to eat. As such, most reef predators avoid them. However, they are still occasionally consumed by groupers, snappers, barracuda and eels.

Conservation Status: Not evaluated.

***Canthigaster sanctaehelenae* (Günther, 1870)**

Common Name(s): St. Helena sharpnose pufferfish, bottlefish, bastard hogfish.

Habitat: Marine; reef-associated; tide pools and rocky areas; depth range 0–50 m.

Global Distribution: Tropical; Southeast Atlantic: known only from St. Helena and Ascension islands.

Description: This species is diagnosed by its 10 dorsal fin rays. Head and body are provided with blue, darker-edged spots. Blue lines radiate from eye. Caudal fin has 6 to 7 bluish vertical bands. This species is different from all Atlantic *Canthigaster* species (except *C. supramacula*) by the absence of longitudinal dark stripes on the side of the body or caudal peduncle. It is also distinguished from *C. supramacula* by the absence of a conspicuous dark spot on the dorsum. It feeds mainly on filamentous red and green algae and coralline red algae but also on corals. It grows to a maximum standard length of 13 cm.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 µg/g tissue). There is

no use and trade information available for this species. It is unlikely to be utilized.

Aquarium Value: This species is used in saltwater aquarium and some of the aquarium parameters known are given below.

Aquarium: ~ 1000 liters

Temperature: 23–26°C

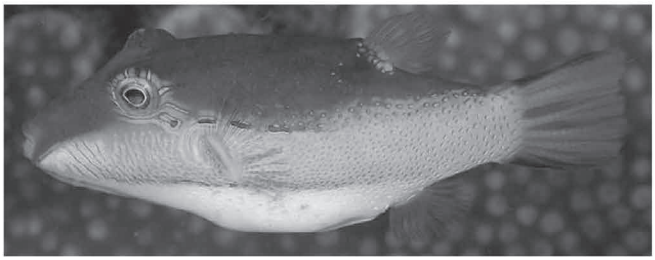
Diet: Artemia, frozen food (large sort), live food, mussel meat, mysids.

Difficulty: Experienced aquarists reserved.

Toxicity: Unknown.

Conservation Status: Not evaluated.

***Canthigaster smithae* (Allen & Randall, 1977)**



Common Name(s): Bicolored toby, Smith's pufferfish.

Habitat: Marine; reef-associated; outer reef slopes; clear inner reefs, slopes near bases of steep walls with mixed rubble and boulders; depth range 20–40 m.

Global Distribution: Tropical; Western Indian Ocean: Agalega Islands, Mauritius to Durban, South Africa. Also Maldives.

Description: This species is diagnosed by its dorsal rays (10) anal rays (9) and pectoral rays (17). It has a form of irregular body, black back, white belly and chin with two orange longitudinal lines. Iris is bright yellow. Head and body are generally whitish, but abruptly more or less uniform brown on dorsal surface above level of lower boundary of eye. Pale portion is covered with numerous small brown spots, becoming lighter on ventral surface. Spots on region below lower jaw are joining to form series of thin concentric curved lines with open side directed antero-ventrally. A dark stripe is sometimes present on mid-ventral line. A series of spoke-like dark brown lines are found radiating from eye, those from opposite

side not meeting over snout or interorbital, spaces between these lines white. 4–5 irregular and elongate dark-rimmed white markings are seen extending from just below and slightly behind eye to position on sides level with distal tips of middle pectoral rays. Dorsal, anal, and pectoral fins are translucent with dark-edged rays, outer portion of caudal slightly dusky. A prominent dark margin is found on dorsal and ventral edge of caudal fin. This monogamous species feeds on algae, invertebrates and corals. It grows to a maximum length of 13 cm.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 μg/g tissue).

Aquarium Value: This species is occasionally found in the marine aquarium trade, although it does not appear to be regularly available. Some of its aquarium parameters are given below.

Tank: 109.99 gal (~ 500L)

Temperature: 73.4–78.8°F (23–26°C)

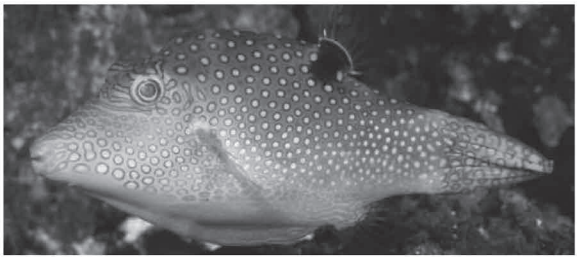
Feeding: Clams, mysids, shrimp.

Degree of Difficulty: Only for advanced aquarists.

Toxicity: It is a poisonous species to its predators due to the presence of tetrodotoxin in the skin and certain organs.

Conservation Status: Not evaluated.

***Canthigaster solandri* (Richardson, 1845)**



Common Name(s): Spotted sharpnose, false-eye toby, netted pufferfish, sharpbacked puffer, jewel pufferfish, spotted sharpnose puffer, spotted toby.

Habitat: Marine; reef-associated; sheltered rocky reefs; intertidal reef flats, lagoon and seaward reefs; open barren areas, also among corals and under ledges; benthopelagic; depth range 10–36 m.

Global Distribution: Tropical; Indo-Pacific: East Africa to the Line and Tuamoto Islands, north to Ryukyu Islands, south to New Caledonia and Tonga; strays to the Hawaiian Islands.

Description: This species is diagnosed by its dorsal rays (8 to 10), anal rays (8 to 10) and pectoral rays (15 to 18). Color of body (in alcohol) is reddish brown with numerous blue-white to greyish spots. A darkish blotch or ocellus is usually present at base of dorsal fin. Ventral surface of body is tan to pale brown without spots. Head is usually with about 8 to 10 dark lines radiating from eye, the continuations of which usually form cross-bands on the interorbital and upper portion of snout. Lower portion of side of head is with bluish to grey spots about equal to or smaller than pupil size in diameter. Area immediately below eye is sometimes with fine brown speckling which grades into larger spots below, tip of snout whitish. Dorsal, anal, and pectoral rays are with fine dark borders and remainder of ray and fin membranes are transparent or yellowish. Caudal fin is red-brown to tan with bluish or reddish spots, the outer rows of which may be fused into irregular bars. This monogamous species feeds mainly on filamentous red and green algae and coralline red algae but also on corals, tunicates, molluscs, echinoderms, polychaetes, crustaceans and bryozoans. This species grows to a maximum total length of 11.5 cm.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 μg/g tissue)

Aquarium Value: It is a component of commercial, marine aquarium and its aquarium parameters are given below.

Minimum Tank Size: 50 gallons.

Water Conditions:

Temperature: 72–78°F

dKH: 8–12

pH: 8.1–8.4

Specific Gravity (SG): 1.020–1.025

Diet: Microalgae (e.g., Spirulina), macroalgea (e.g., seaweed/nori), small crustaceans (krill, mysids, artemia). It should be fed two times a day.

Care Level: Moderate.

Temperament: A peaceful fish. In aquarium, it is aggressive to its own species.

Aquarium Care: Only one fish of this species should be kept in a tank. These fish should not suck in air when they are being fed or transported, as they have difficulties expelling it again. It may be a threat to many invertebrates as this species eats shrimps, crayfish, crabs, small bivalves, sea urchins, snails, etc. These fish require food which helps to prevent overgrowing teeth., for example, clams. If their teeth grow too much, it might necessitate grinding them down, however this is a very stressful procedure. These fish should be kept in a well-run aquarium where they can "graze" algae from rocks and stones. If there are insufficient algae on the rocks, it is important to feed more frequently and supplement with algae rich food, for example, Spirulina. This species can live as a pair (male and female).

Toxicity: This species has a toxin in its skin, which it releases when highly stressed or dying. This poison can kill all the aquatic life in the aquarium.

Conservation Status: Not evaluated.

***Canthigaster supramacula* (Moura & Castro, 2002)**

Common Name(s): West African sharpnose-puffer.

Habitat: Marine; reef-associated.

Global Distribution: Tropical; Eastern Central Atlantic: known only from off Côte d'Ivoire and Ghana. May be more widespread along the tropical African coast.

Description: This species is characterized by the presence of a conspicuous dark spot resembling an ocellus on the dorsal portion of the trunk anteroventral to origin of dorsal fin. Dorsal portion of this spot is found extending to the dorsal fin origin. It lacks conspicuous dark stripes along the sides of the body, bearing only two to four irregular lines that extend from the caudal peduncle to about a vertical through the dorsal fin base. It feeds on artemia, copepods, bryozoans, molluscs, cladocerans,

worms, starfish, and other zoobenthos. This species grows to a maximum standard length of 3.9 cm.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 µg/g tissue)

Aquarium Value: This species is used in saltwater aquarium and some of the aquarium parameters known are given below.

Aquarium: ~ 100 liter

Temperature: About 27°C

Diet: Invertebrates.

Difficulty: No beginner's animal.

Toxicity: Unknown.

Conservation Status: Not evaluated.

***Canthigaster tyleri* (Allen & Randall, 1977)**

Common Name(s): Tyler's toby.

Habitat: Marine; reef-associated; clear lagoon and seaward reefs; secretive, often in holes or under ledges; depth range 1–40 m.

Global Distribution: Tropical; Indian Ocean: Mauritius, Comoros, Maldives, and Seychelles.

Description: This species diagnosed by its dorsal rays (9), anal rays (9) and pectoral rays (16).It possesses a globular body while being also a bit compressed laterally. Its snout is elongated with a small terminal mouth. Back ground coloration is whitish. Sides are covered with red spots and back is yellow to green with a network of blue lines from the caudal fin to the tip of the snout. Blue lines are seen parallel on the top of the snout. A white circle not closed on its top surrounds the eye. Belly is white and fins are translucent. Its diet is based on different kinds of algae, sponge and other small invertebrates**.** It grows to a maximum length of only 9 cm.

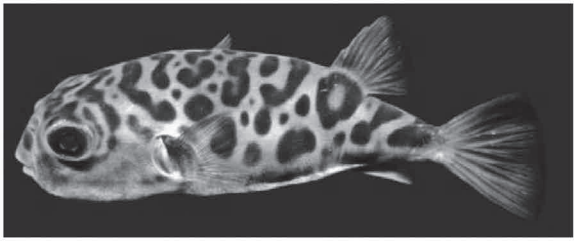
Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 μg/g tissue).

Aquarium Value: In the saltwater aquariums, these smaller puffers will not harm stony or soft corals but will consume tiny motile crustaceans. If they are not well fed, they may eventually try and go after larger crustaceans as well (shrimp/crabs). Though it is a component of aquarium its aquarium parameters are unknown.

Toxicity: Unknown.

Conservation Status: Not evaluated.

***Contusus richei* (Fréminville, 1813)**



Common Name(s): Prickly toadfish, barred toadfish, globefish, toado.

Habitat: Marine; demersal; clear, coastal waters; mud and shell/sand substrates in natural harbors as well as in vegetated habitats and rocky-reefs dominated by algae; depth range 1–50 m.

Global Distribution: Temperate; Eastern Indian Ocean: southern Australia. Southwest Pacific: New Zealand.

Description: Body of this species is robust, rounded, elongate and is, tapering to a short, narrow caudal peduncle. Head and mouth are small though the fused teeth are very sharp. Snout is short. Lower border of eye level is with dorsal part of pectoral fin base. Dorsal and anal fins are ending well short of caudal fin base. Sides of body are with brownish-grey spots, joining dorsally to form a series of irregular, transverse bars over length of dorsum. Skin is rough. It eats crustaceans and molluscs. This species has a maximum standard length of 25.4 cm and reaches sexual maturity at age two. Its lifespan is 7 years.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 μg/g tissue).

Aquarium Value: It is a component of commercial, saltwater aquarium and its aquarium parameters are given below.

Suitable Size for Tank: under 25 cm.

Minimal Tank Volume: 300 liters (79 US gal).

Water Conditions:

Temperature: 23°C (73.4°F)–26°C (78.8°F)

pH: 7.5–8.5

Water Hardness: 5–15 °dKH

Floor Water Column: Entire water column

Behavior: Aggressive.

Care Level: Moderately difficult.

Feeding: Carnivore.

Toxicity: Unknown

Conservation Status: Not evaluated.

***Guentheridia formosa* (Günther, 1870)**

Common Name(s): Spotted puffer.

Habitat: Marine; demersal; coastal species found on soft bottom.

Global Distribution: Tropical; Eastern Central Pacific: Costa Rica to Ecuador.

Description: Body of this species is elongate, and oval. Head is low and broad and notably wider than deep. Snout is short. Eyes are high on sides of head. Jaws are a beak composed of 4 fused, heavy powerful teeth with a central suture on each jaw. A slit-like gill opening is seen in front of the pectoral fin base. A single short-based dorsal fin is present at rear body. A similar shaped anal fin is seen below dorsal. There are no pelvic fins. No spines are seen in fins. Tail fin is bluntly straight. Skin is tough and scalelsss. Body is with small spinules. There are no fleshy skin folds. Upper half of head and body are dark and paler below with variable yel-

lowish markings. Body is with spots in various patterns. Back and upper sides are with variably sized dark spots. Other fins are greenish. It is carnivorous feeding on a variety of invertebrates. It reaches a maximum total length of 26 cm.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 µg/g tissue).

Aquarium Value: The suitability of this fish for aquarium is unknown.

Toxicity: Unknown.

Conservation Status: Least Concern.

***Javichthys kailolae* (Hardy, 1985)**

Common Name(s): Not designated.

Habitat: Marine; benthopelagic; depth range 62–85 m.

Global Distribution: Tropical; Indian Ocean: Serpent Bank, Bali Strait, Java, Indonesia.

Description: This species belongs to a monotypic genus of tetraodontid fishes, with the following combination of characters: nasal organ is with two small, almost equally sized openings; eye rim is adnate only dorsally; top of pectoral fin base is below lower margin of eye; ventrolateral skin fold is absent; spines are moderately sparse, on dorsum, ventrum and sides; and frontals are narrow over interorbit. Mouth is small and terminal. Lips are moderately thick, covered with numerous, short papillae. Chin is lacking. Nasal organ is short with 2 small, widely separated opening. Eye is somewhat elongate and moderate in size. Anterior margin of gill opening is smooth. Body spines are short, 2-rooted and are sparsely scattered on dorsum from snout to dorsal fin; on ventrum from behind chin to vent, and on cheeks and flanks to just before dorsal fin. Dorsum is uniformly brownish-grey, extending two thirds down cheek, and half-way down sides, thereafter abruptly white. Lips and belly are white, with small grey specks on chin and

ventral surface of caudal peduncle. Caudal and dorsal fins are greyish and are darkening distally. Other fins are colorless. (Hardy, 1985).

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 μg/g tissue). This species is not utilized.

Aquarium Value: The suitability of this fish for aquarium is unknown. This new species was described only in 1985 and little else is known about it (http://www.snipview.com/q/Javichthys_kailolae).

Toxicity: Unknown

Conservation Status: Not evaluated.

Lagocephalus guentheri (Miranda Ribeiro, 1915)

Common Name(s): Diamondback puffer.

Habitat: Marine; demersal; continental shelf; over sandy or muddy bottoms; mangroves; intertidal zone over muddy substrates.

Global Distribution: Subtropical; Indo-West Pacific: Persian Gulf, southern Oman, India, Indonesia, northwestern Australia and the South China Sea. Reported from Japan; Southwest Atlantic: Brazil.

Description: In this species, longitudinal skin fold is extending on the ventrolateral corner of the body from the chin to the ventral part of the caudal peduncle. Lateral line system comprises ventral and lateral elements, the ventral element coursing along the skin fold and the lateral element extending along the mid-lateral side of the body from the region dorsal to the gill opening to the caudal-fin base with the anterior extension coursing from ventral to the eye to the snout region. There are two openings in the nasal organ and are broad. Ventral surface of the head and belly are covered with spinules, extending just posterior to the lower jaw to slightly before the anus. Spinules on the back are forming a rhomboidal or elliptical patch. Caudal fin is slightly lunate and the middle rays are slightly produced posteriorly. Dorsal and ventral tips of the caudal fin are

produced posteriorly. Dorsal side of the body is brown with several dark bands crossing over the back. First band is between the eyes; second is above the gill opening; third is above the posterior part of the pectoral fin; and fourth is encircling the dorsal-fin base. A couple of small dark markings is seen on the dorsal side of the caudal peduncle. A silver-white band is running on the side of the body. Dorsal fin is dusky. Caudal fin is dark brown or almost black with the dorsal and ventral white tips. Pectoral and anal fins are pale. It has a maximum total length of 26 cm.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 μg/g tissue).

Aquarium Value: The suitability of this fish for aquarium is unknown.

Toxicity: Unknown

Fisheries Status: it is a component of artisanal fisheries in some countries; it is not considered a commercial species.

Conservation Status: Not evaluated.

***Lagocephalus suezensis* (Clark & Gohar, 1953)**

Common Name(s): Suez puffer.

Habitat: Marine; demersal; variety of coastal and offshore habitats, including offshore reefs; rocky bottom covered with algae; depth range up to 25 m.

Global Distribution: Temperate; Western Indian Ocean: Suez. Mediterranean: immigrant.

Description: There are no scales in this species. But the skin is rough on dorsal and ventral surfaces, while completely smooth on the sides. Back is brown-olive with darker brown to grey irregular spots. Sides are silvery shiny. Belly is white and the four central caudal rays are yellow. It feeds on benthic invertebrates, spawns in the summer, and its eggs and larvae are planktonic. This species has a maximum total length of 18 cm (Corsini et al., 2005).

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level), less than 10 MU/g tissue (i.e., 2 µg/g tissue). This species however, is not utilized.

Aquarium Value: The suitability of this fish for aquarium is unknown.

Toxicity: Unknown.

Conservation Status: Not evaluated.

***Lagocephalus wheeleri* (Abe, Tabeta and Kitahama, 1984)**

Common Name(s): Not designated.

Habitat: Marine; demersal.

Global Distribution: Temperate; Northwest Pacific: Japan, Taiwan, and the East China Sea.

Description: Body of this species is covered with prickles. Caudal fin is emarginate. Body is yellowish-brown or greenish-brown dorsally and silver ventrally. Pectoral and dorsal fins are yellow or white. Anal fin is white. Caudal fin is yellow, edged with white dorsally and ventrally. It has a maximum standard length of 30 cm.

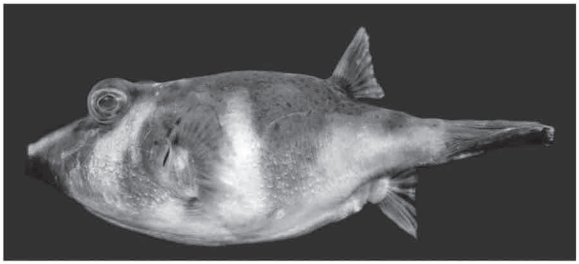
Food Value: It is a harmless, non-toxic species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 µg/g tissue).

Aquarium Value: The suitability of this fish for aquarium is unknown.

Toxicity: The muscle of this species has been reported to contain TTX at 0.35 µg/g. This suggests that the muscle of this species is within the safe level (less than 10 MU or 2 µg) and is safe for human consumption (Anraku et al., 2013). Kim et al. (2008) reported that the toxicity values of the muscle, skin, liver, intestine and gonad of this species were less than 5, 6, 7, 7, and 9 MU/g, respectively. These values of this report suggest that the muscle and the internal organs are edible as all these values are in safe level (i.e., less than 10 MU/g).

Conservation Status: Not evaluated.

***Omegophora cyanopunctata* (Hardy & Hutchins, 1981)**



Common Name(s): Bluespotted toadfish.

Habitat: Marine; reef-associated; coastal reefs, as well as anthropogenic structures including piers and jetties; shallow inshore waters at depths ranging from 5 to 15 m.

Global Distribution: Subtropical; Eastern Indian Ocean: known from the type locality, Canal Rocks, Cape Naturaliste, Western Australia.

Description: Body of this species is elongated with somewhat bulky head and pectoral region. It is rounded dorsally and flattened ventrally, tapering to the moderately thickened caudal peduncle. Mouth is small and terminal on a protruding snout. Lips are moderately thick, covered with numerous short papillae. Chin is lacking. Nasal organ is a small, simple tentacle which is slightly expanded distally. Eye is small, round and completely adnate. Pectoral fins are more or less bilobed, the median rays shorter than those above or below. Body spines are short, multi-rooted and are densely scattered over body from mid snout to dorsal fin, sometimes continuing sparsely on anterior part of caudal peduncle. Dorsal base color is brown to dark brown with numerous iridescent blue spots. Three brown to dark-brown bars extend down each side of body, first passing obliquely through eye to lower jaw, joining with corresponding bar from other side, second enveloping gill slit and pectoral base and bifurcating ventrally, and the third just posterior to pectoral fin. Interspaces on side are pale brown to cream. Ventral surface is white with ventrolateral surface lined with yellow. Adult males possess a black to brown circular blotch above pectoral base, surrounded or partly surrounded by an iridescent blue line or series of spots. Fins are yellow to orange and caudal fin is more dusky with lowermost rays blackish. It reaches a total length of 18 cm.

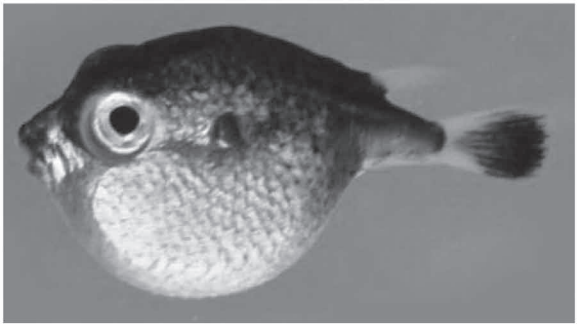
Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 µg/g tissue).

Aquarium Value: It is a component of the marine aquarium trade. However, except temperature (23–26°C) nothing is known about its aquarium requirements.

Toxicity: Unknown.

Conservation Status: Not evaluated.

***Pelagocephalus marki* (Heemstra & Smith, 1981)**



Common Name(s): Rippled blaasop.

Habitat: Marine; demersal; mid-water, pelagic environments.

Global Distribution: Temperate; Southeast Atlantic: Port Alfred to Knysna (South Africa). Southwest Pacific: New Zealand.

Description: Most of head and upper half of body of this species are medium to dark greyish-brown. Thin pale lines are forming a reticulate pattern on dorsum from head to midway between pectoral and dorsal fins. Ventrum is pale with greyish areas on chin and around vent and anal fin base. Very small black spots are fond irregularly scattered all over the body, fewest on ventrum. Dorsal, anal and pectoral fins are colorless. Caudal fin is becoming uniformly darker. Lateral line is indistinguishable. Short slightly curved, 3-rooted spines are completely encircling body from level of nasal apparatus to anterior of dorsal fin base. It reaches a total length of 12 cm.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 µg/g tissue). There is no use and trade information available for this species and it is unlikely to be utilized.

Aquarium Value: Though this species is occasionally used in saltwater aquarium, much of its aquarium parameters are unknown.

Suitable Size of Fish: Under 12 cm.

Tank Type: Marine tank.

Toxicity: Unknown.

Conservation Status: Not evaluated.

***Polyspina piosae* (Whitley, 1955)**

Common Name(s): Orange-barred puffer.

Habitat: Marine; benthopelagic; sandy bottoms in coastal waters, including surf zones and areas with sparse seagrass; on sand near reefs and in protected coastal bays.

Global Distribution: Subtropical; Eastern Indian Ocean: Western Australia.

Description: Body of this species is elongated and rounded dorsally. It is also barely flattened ventrally tapering to a short, narrow caudal peduncle. Mouth is small and terminal. Lips are thick and are covered with numerous short papillae. Chin is prominent. Eye is moderate, round and completely adnate. Pectoral fins are dorsally elongated and rounded. Caudal fin is truncated. Lateral line is very indistinct. Body spines are essentially 2-rooted. Dorsum is with many irregularly scattered white spots on a light brown background. A thin band and a somewhat broader, darker band cross dorsum at posterior of pectoral fins and at dorsal fin, respectively. Laterally a dark patch extends over opercular region. Belly and fins are uniformly pale. This species is carnivorous feeding on snails, shellfish and crustaceans. This species grows to a maximum length of 8.5 cm.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 µg/g tissue).

Aquarium Value: This species is likely a component of the South Australian specialty marine aquarium trade and some its aquarium parameters are given below.

Water Type: Seawater.

Temperature: 23–26°C

Food/Feed: Snails, shellfish and crustaceans.

Toxicity: Unknown.

Conservation Status: Not evaluated.

***Reicheltia halsteadi* (Whitley, 1957)**

Common Name(s): Halstead's toadfish.

Habitat: Marine; demersal; just beyond turbulent zone off surf beaches; sheltered bays.

Global Distribution: Subtropical; Southwest Pacific: only known from eastern central Australia.

Description: Body of this species is elongated and rounded dorsally. It is also somewhat flattened ventrally, tapering to a narrow caudal peduncle. Mouth is small and terminal. Lips are moderately thick, and are covered with numerous short papillae. It lacks chin. Eye is round, moderate in size, and rim is completely adnate, with the upper border level is with or slightly interrupting dorsal profile, and the lower border is well above level of mouth corner. Pectoral fin margins are rounded. Ground color of dorsum is pale yellowish-green with many irregular light brown or reddish-brown blotches. Darker brown bands cross dorsum at eyes, between eyes and pectoral fin base, just behind pectoral fin base and are extending down side at dorsal fin base, and at caudal fin base. Brownish blotches and yellowish-green background continue to mid-lateral region and thereafter they are replaced by small, silverish-grey flecks which are gradually merging into white belly, silverish-grey sheen obvious on cheek and lower

lateral surfaces. Silverish-grey flecks form dense band under mouth, and are scattered thinly anterior to vent on spineless region of belly, at posterior of anal fin base and on under surface of caudal peduncle (intensity and number of flecks vary according to individual). Spinose region of belly is white. All fins are pale and a reddish- brown patch is seen on anterior of pectoral fin insert. It reaches a total length of 16 cm (Hardy, 1982).

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 µg/g tissue). There is no use and trade information available for this species.

Aquarium Value: This species is likely a component of the marine aquarium trade and some its aquarium parameters are given below.

Suitable Size of Fish: Under 16 cm.

Tank Type: Marine tank.

Toxicity: Unknown.

Conservation Status: Not evaluated.

Sphoeroides andersonianus (Morrow, 1957)

Image not available.

Common name(s): Unknown.

Habitat: Marine; demersal.

Global Distribution: Tropical; Eastern Pacific.

Description: Unknown.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 µg/g tissue).

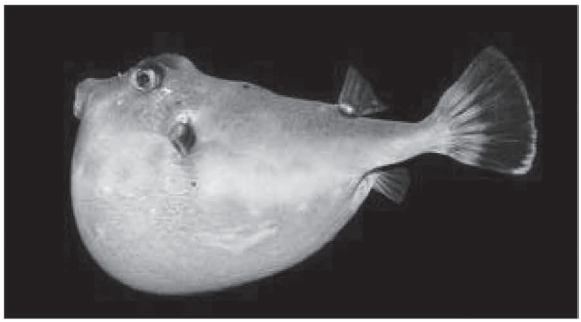
Aquarium Value: The suitability of this fish for aquarium is unknown.

Toxicity: Unknown.

Conservation Status: Not evaluated.

Sphoeroides angusticeps **(Jenyns, 1842)**

Normal fish



Inflated fish

Common Name(s): Narrow-headed puffer.

Habitat: Marine; reef-associated; hovers just above the substrate in mixed areas of sand, gravel and boulder; buries in the sand at night; depth range 5–18 m.

Global Distribution: Tropical; Eastern Pacific: endemic to the Galapagos Islands.

Description: This species is diagnosed by its 8 dorsal soft rays, 7 anal soft rays and inflatable body. Body is relatively elongated. Head is large, blunt, narrow and concave between eyes. Snout is short. Eyes are high on sides of head. Jaws are a strong beak composed of 4 fused heavy powerful teeth with a central suture on each jaw. A slit- like opening is seen in front of pectoral fin base. A single short-based dorsal fin is present at rear of body. There are no pelvic fins and spines in fins. Skin is tough and scaleless. Most of body is without small spinules. A pair of small black skin flaps is straddling midline of back. Dorsum is tan to light brown with pale mottling and belly is white. A dorsal ring is seen around eye. Iris and fins are yellowish. It reaches a maximum size of 25 cm.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 μg/g tissue).

Aquarium Value: This species is used as a component in saltwater aquarium and some of its aquarium parameters are given below.

Suitable Size of Fish: Under 25 cm.

Tank Type: Marine tank.

Toxicity: Unknown.

Conservation Status: Least Concern.

Sphoeroides georgemilleri (Shipp, 1972)

Image not Available

Common Name(s): Plaincheek puffer.

Habitat: Marine; demersal; depth range 22–22 m.

Global Distribution: Tropical; Western Central Atlantic: known from the type locality, Caribbean Sea, off Colombia.

Description: A blunt-headed species with heavy jaws forming a beak of 2 teeth in both upper and lower jaws. Dorsal and anal fins are set far back near caudal fin. Dorsal fin is with 8 soft rays (no spines); anal fin is with 7 soft rays (no spines) and pectoral fin is usually with 16 rays. Pelvic fins are absent. Prickles are present from snout to posterior margin of pectoral fin dorsally, and chin to several millimeters anterior to anus ventrally, but absent laterally. Lappets are absent. Dorsally and laterally, basal pigmentation is light grey or brown, with a few dark, poorly defined blotches. Cheeks are with uniform basal pigment, without distinct markings. Ventral surface is unpigmented.

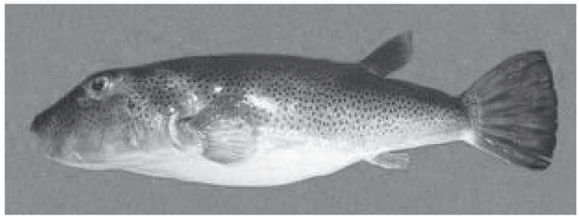
Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 µg/g tissue). There is no use and trade information available for this species, and it is unlikely to be utilized.

Aquarium Value: The suitability of this fish for aquarium is unknown.

Toxicity: Unknown.

Conservation Status: Not evaluated.

Sphoeroides kendalli (Meek & Hildebrand, 1928)



Common Name(s): Slick puffer.

Habitat: Marine; demersal; soft bottom of shallow coastal areas; occasionally found at middle regions of estuaries and in mangroves in Peru and Panama; depth range 0–20 m.

Global Distribution: Tropical; Eastern Central Pacific: Costa Rica to Talara, Peru.

Description: Body of this species is oblong, thick and inflatable. Head is compressed. Between eyes, it is slightly convex. Eyes are high on sides of head. Jaws are a strong beak composed of 4 fused heavy powerful teeth with a central suture on each jaw. A slit-like gill opening is seen in front of the pectoral fin base. A single short-based dorsal fin is at rear body. There are no pelvic fins. Fins lack spines. Skin is tough and scaleless without spines. There re no fleshy skin flaps. Coloration of body is grey to dark brown above and white below. A broad band of small dark spots is present on side above midline from snout to tail base. All fins are greenish. Outer margin of tail is dusky. It grows to a maximum total length of 18 cm.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 μg/g tissue).

Aquarium Value: Though this species is used as a component in salt-water aquarium, much of its aquarium parameters are unknown.

Suitable Size of Fish: Under 18 cm.

Tank Type: Marine tank.

Toxicity: Unknown.

Conservation Status: Least Concern.

***Sphoeroides lispus* (Walker, 1996)**

Common Name(s): Naked puffer.

Habitat: Marine; demersal; bays and over sandy bottoms; juveniles often in more open areas over cobble or rocky bottoms; depth range 5–20 m.

Global Distribution: Subtropical; Eastern Pacific: throughout the Gulf of California to Baja Magdalena.

Description: Body of this species is oblong, thick and inflatable. Head is relatively long and slender. Between eyes, it is wide and flat. Eyes are high on sides of head. Jaws are a strong beak composed of 4 fused heavy powerful teeth with a central suture on each jaw. A slit-like gill opening is in front of the pectoral fin base. A single short-based dorsal fin is at rear body. There are no pelvic fins and fins lack spines. Tough scaleless skin is without spines. There are no fleshy skin flaps. Coloration of body is light brown to grey above and paler below. Back is with 3 dark indistinct bars. Small white dots and streaks are seen on upper body. A darker bar is also seen between eyes. Dorsal and anal and pectorals are pale. It reaches a maximum total length of 35 cm.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 µg/g tissue).

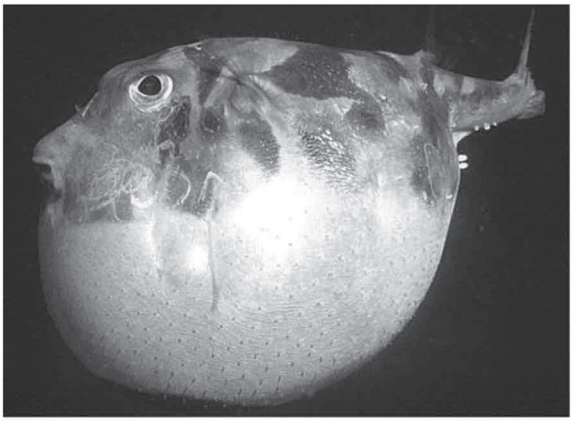
Aquarium Value: The suitability of this fish for aquarium is unknown.

Toxicity: Nunez-Vazquez et al. (2000) reported that the values of TTX toxicity of mucous, muscle, liver, intestine and gonad of this species were 5 µg/g, 2.3 µg/g, 130 µg/g, 10 µg/g and 12 µg/g, respectively.

Conservation Status: Least Concern.

***Sphoeroides marmoratus* (Lowe, 1838)**

Normal fish



Inflated fish

Common Name(s): Guinean puffer, spinyback blowfish, brown puffer.

Habitat: Marine; demersal; shallow waters; associated with rocky and artificial reefs; over sandy substrates; over soft, sandy substratum; depth range 0–100 m.

Global Distribution: Subtropical; Eastern Atlantic: Portugal to Angola.

Description: This species is dark at the top and clear with black spots on the belly part. It lacks scales and its body is covered with small spines. It feeds on molluscs and small invertebrates. This species has a maximum total length of 20 cm.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 µg/g tissue). There is no use and trade information available for this species.

Aquarium Value: This species is used as a component in saltwater aquarium and its aquarium parameters are given below.

Minimum Tank Size: 208.2 liters (55 US G.).

Suitable Size of Fish: 17.8–20.3 cm.

Water Conditions:

Specific Gravity (SG): 1.020–1.025

pH: 8.1–8.5

Temperature: 23.3–26.7°C (74–80°F)

Water Hardness: 8–12 dH

Stocking Ratio: 1:1 (male: female)
Availability: Rare.
Diet: Carnivore.
Lifespan: 8–15 years.
Difficulty: Challenging.
Toxicity: Unknown.
Conservation Status: Not evaluated.

Sphoeroides nitidus (Griffin, 1921)

Image not available.
Common Name(s): Unknown.
Habitat: Marine; demersal.
Global Distribution: Subtropical; Southwest Pacific: New Zealand.
Description: Not reported.
Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 µg/g tissue). There is no use and trade information available for this species.
Aquarium Value: The suitability of this fish for aquarium is unknown.
Toxicity: Unknown.
Conservation Status: Not evaluated.

Sphoeroides pachygaster **(Müller & Troschel, 1848)**

Common Name(s): Blunthead puffer, smooth pufferfish, balloonfish, bottlefish, blunthead blaasop.
Habitat: Marine; benthopelagic; relatively deepwater species; variety of habitats, including over the continental shelf, in submarine canyons and in association with seamounts; young are pelagic; depth range 50–480 m.

Global Distribution: Subtropical; circumglobal in tropical and temperate seas.

Description: This species is diagnosed by its typical stout and inflatable body with rounded snout, big head and skin without scales. In the mouth four large teeth (two in each jaw) form a beak. Eyes are rather big and oval in shape. A small dorsal fin is placed above the anal fin of similar size and shape. Caudal fin is slightly concave. Pelvic fin is absent. Body has smooth skin, without any scales, prickles or spines Color of the dorsal surface and the flanks is greyish to olive green with many pale dots. Ventral side is white. Diet of this species is mainly squid, cuttlefish and octopus, but also seems to include small, bony fish from time to time. It has a maximum total length of 40.5 cm and weight of 650 g. Little is known about the fecundity, spawning season or other life history aspects of this species.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 μg/g tissue).

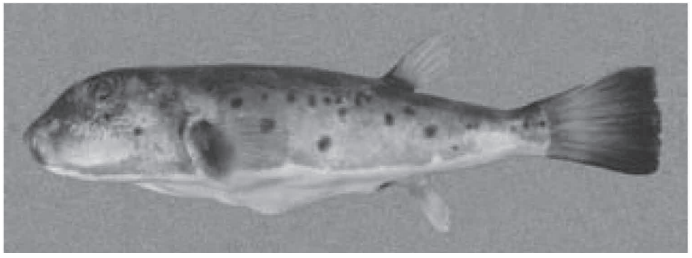
Aquarium Value: The suitability of this fish for aquarium is unknown.

Toxicity: This species is weakly toxic. In the Mediterranean, it is considered non-toxic.

Fisheries Status: This species has a commercial fisheries.

Conservation Status: Vulnerable.

***Sphoeroides sechurae* (Hildebrand, 1946)**



Common Name(s): Peruvian puffer.

Habitat: Marine; demersal; soft bottom of shallow waters; depth range 5–118 m.

Global Distribution: Tropical; Eastern Pacific: Gulf of California to Chimbote Bay, Peru.

Description: Body of this species is oblong, thick and inflatable. Head is relatively long and slender. It is wide and convex between eyes. Eyes are on high on sides of head. Jaws are a strong beak composed of 4 fused heavy powerful teeth with a central suture on each jaw. There are no pelvic fins and no spines in fins. Skin is tough and scaleless. Skin spines are seen over almost entire body and head. Skin flaps are absent. Dark olive brown above and paler below. Dark spots are seen above eye and are scattered along flank behind pectoral. Indistinct pale lines are present on upper surface. An indistinct pale oval is seen on centre top of head. Dorsal fin is with dark base. Inner one-third of tail is olive and outer two-thirds are black. Pectoral fin has a clear narrow dark bar at base. It has a maximum total length of 17 cm.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 µg/g tissue).

Aquarium Value: Though this species is used as a component in saltwater aquarium, much of its aquarium parameters are unknown.

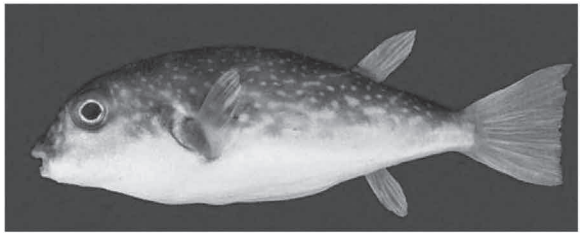
Suitable Size of Fish: Under 17 cm.

Tank Type: Marine tank.

Toxicity: Unknown.

Conservation Status: Least Concern.

***Sphoeroides trichocephalus* (Cope, 1870) (= *Tetraodon trichocephalus*)**



Common Name(s): Pygmy puffer.

Habitat: Marine; demersal; soft substrata; depth range 0–10 m.

Global Distribution: Tropical; Eastern Pacific: Costa Rica and Panama; Nicaragua and Chile.

Description: This species is diagnosed by its 8 dorsal fin rays and 7 anal fin rays. Belly of this species is spinous to near vent. Ends of the pectoral fins are spinous and those on the head are long and close set like seal bristles. Profile is suddenly descending from the prefrontal region to the premaxillary region. Caudal fin is with prominent points and is concave when closed. Anal fin is behind opposite the dorsal. Color of dorsum is yellowish. Fins are uniformly straw colored. A brown spot is seen at the base of the pectoral fin. This species grows to a maximum total length of 10.5 cm.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 μg/g tissue).

Aquarium Value: This species is used as a component in saltwater aquarium and its aquarium parameters are given below.

Suitable Size of Fish: Under 11 cm.

Minimal Tank Volume: 113 liters (30 US Gallons).

Water Conditions:

Temperature: 23°C (73.4°F) and 26°C (78.8°F)

Specific Gravity (SG): 1,020 -1,025

pH: 8.0–8.3

Behavior: Semi-aggressive.

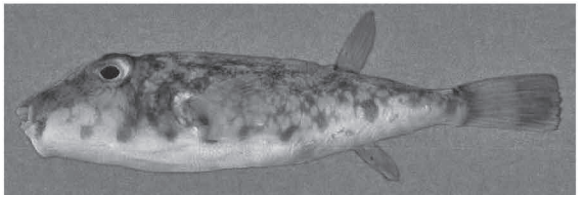
Feeding: Carnivore.

Toxicity: Unknown.

Fisheries Status: This species is not widely utilized but is likely taken as bycatch in trawl fisheries and discarded. This species is occasionally found in local markets.

Conservation Status: Least Concern.

***Sphoeroides tyleri* (Shipp, 1972)**



Common Name(s): Bearded puffer.

Habitat: Marine; demersal; sandy beaches and areas associated with sponge and shell bottoms; coastal regions influenced by river outflows; depth range 10–80 m.

Global Distribution: Tropical; Western Atlantic: Colombia to south-eastern Brazil.

Description: Body of this species is oblong, thick and inflatable. Head is blunt. Eyes are high on sides of head. Jaws are a strong beak composed of 4 fused heavy powerful teeth with a central suture on each jaw. A slit-like gill opening is seen in front of the pectoral fin base. A single short-based dorsal fin is seen at rear body. There are no pelvic fins and spines in fins. Tough scaleless skin is without spines. Skin flaps are present on side, especially on lower side. Prickles are present over most of the body before dorsal and anal fins. Grey brown above and white below. Upper body and head are with dark mottling. A row of 10 indistinct dark spots are seen along lowerside from chin to end of tail base. It feeds on crustaceans, molluscs and echinoderms. This species grows to a maximum total length of 12 cm.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 µg/g tissue). There is no use and trade information available for this species, and it is unlikely to be utilized in consumptive fisheries because it is likely to be toxic.

Aquarium Value: Though this species is used as a component in salt-water aquarium much of its aquarium parameters are unknown.

Suitable Size of Fish: Under 12 cm.

Tank Type: Marine tank.

Toxicity: Unknown.

Conservation Status: Not evaluated.

***Sphoeroides yergeri* (Shipp, 1972)**

Common Name(s): Speckled puffer.

Habitat: Marine; demersal; primarily in clear waters to depths of 60 m.

Global Distribution: Tropical; Caribbean Sea along the Central and South American coast from Belize to Colombia.

Description: Body of this species is oblong, thick and inflatable. Head is moderately blunt. Eyes are high on sides of head. Jaws are a strong beak composed of 4 fused heavy, powerful teeth with a central suture on each jaw. A slit-like gill opening is seen in front of the pectoral fin base. A single shot-based dorsal fin is present at rear of body. A similar-shaped anal fin is also present. There are no pelvic fins and spines in fins. Tail fin edge is bluntly straight. Skin is tough and scaleless. Flank is with numerous skin flaps. Prickles are present above and below on body and sometimes on sides. Brown to grey above and paler below. Upper head and body are provided with small red-brown spots. Lower sides are with many tiny black specks on a pale background. It feeds mainly on shellfish. This species has a maximum total length of 12 cm.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 µg/g tissue). There is no use and trade information available for this species, and due to its toxicity, it is unlikely to be utilized in consumptive fisheries.

Aquarium Value: The suitability of this fish for aquarium is unknown.

Toxicity: Unknown

Conservation Status: Not evaluated.

Takifugu plagiocellatus (Li, 2002)

Image not available.

Common Name(s): Unknown.

Habitat: Marine; demersal.

Global Distribution: Tropical; Northwest Pacific: China.

Description: It grows to a maximum standard length of 10.9 cm.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 µg/g tissue).

Aquarium Value: The suitability of this fish for aquarium is unknown.

Toxicity: Unknown.

Conservation Status: Endangered II class (species extinction risk is increasing).

Takifugu variomaculatus (Li & Kuang, 2002)

Image not available.

Common Name(s): Not designated.

Habitat: Marine; demersal; estuarine species.

Global Distribution: Tropical; Northwest Pacific: China.

Description: This species grows to a maximum standard length of 13.7 cm.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 μg/g tissue). There is no use and trade information available for this species.

Aquarium Value: The suitability of this fish for aquarium is unknown.

Toxicity: Unknown.

Conservation Status: Not evaluated.

Tetraodon implutus (Jenyns, 1842)

Image not available.

Common Name(s): Not designated.

Habitat: Marine; demersal. There is no available ecological information.

Global Distribution: Tropical; Indian Ocean: Cocos (Keeling) Islands.

Description: Not reported.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 μg/g tissue). There is no known information on its use since it is only known from specimens collected in the 1830s.

Aquarium Value: The suitability of this fish for aquarium is unknown.

Toxicity: Unknown.

Conservation Status: Not evaluated.

***Torquigener albomaculosus* (Matsuura, 2014)**

Common Name(s): White-spotted pufferfish.

Habitat: Marine; reef-associated; depth range 10–27 m.

Global Distribution: Tropical; Northwest Pacific: Japan, Ryukyu Is.

Description: *Torquigener albomaculosus* is referring to the many white spots on its body (albus = white; and maculatus = spotted). This species is distinguished by its 9 dorsal soft rays, 6 anal soft rays and 16 pectoral-fin rays. Dorsal-most ray of pectoral fin is nubbin-like and rudimentary. Mid-side of body (from behind pectoral- to caudal-fin base) is without the solid, dark, longitudinal stripe nor rows of dark spots. Dorsal half of head and body are with fine brown reticulations and many white spots, while ventral half is silvery white with many white spots from chin to above anal-fin origin. Dorsal rim of eye is light yellow. Head and body are with many two-rooted spinules. Males of this species construct intricate, mystery these circles as spawning nests by swimming and wriggling in the seafloor sand. These nests, used only once, are made to attract females. This species has a maximum total length of 12 cm.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 μg/g tissue).

Aquarium Value: The suitability of this fish for aquarium is unknown.

Toxicity: Unknown.

Conservation Status: Not evaluated.

***Torquigener altipinnis* (Ogilby, 1891)**

Common Name(s): Highfin toadfish.

Habitat: Marine; demersal; mouths of bays; sandy, sandy mud, and muddy substrates.

Global Distribution: Subtropical; Southwest Pacific: Australia, including the Lord Howe and Norfolk islands and New Zealand, including Kermadec Islands.

Description: This species is diagnosed by its 8–10 dorsal rays, 7–8 anal rays, 15–18 pectoral rays and 11 caudal rays. Body of this species is elongated, rounded dorsally and flattened ventrally tapering into a narrow caudal peduncle. Mouth is small and terminal. Eye is moderate and is slightly elongated. Pectoral fin is dorsally elongated and rounded. Upper surface of head is yellowish-brown. Fins are bright yellow. Dorsal spines are only moderately dense. A few spines project posteriorly from prebranchial margin, which lacks fleshy papillae. Dorsal surface is with distinct, pale to milk-white spots, which are rounded or sometimes sickle-shaped and interspersed with many smaller, pale flecks.

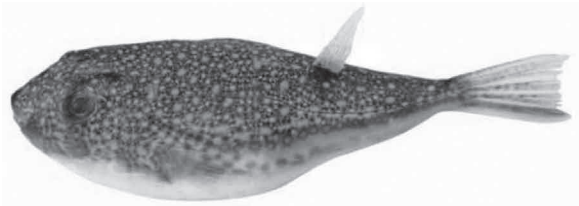
Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 µg/g tissue). This species however, is not utilized.

Aquarium Value: The suitability of this fish for aquarium is unknown.

Toxicity: Unknown.

Conservation Status: Not evaluated.

***Torquigener andersonae* (Hardy, 1983)**



Common Name(s): Anderson's toadfish.

Habitat: Marine; demersal.

Global Distribution: Subtropical; Southwest Pacific: known only from southeastern Australia.

Description: Body of this species is elongated, rounded dorsally and flattened ventrally. It is tapering to a narrow caudal peduncle. Mouth is small and terminal. Lips are thin and are covered with numerous short papillae. Chin is prominent. Eye is moderate in size, elongated, and dorsally adnate. Upper border level is with dorsal profile and lower border is well above level of mouth corner. Pectoral fins are slightly dorsally elongated and rounded. First ray of pectoral fin is very short. Dorsal fin is elongated and pointed. Anal fin is elongated and bluntly pointed. Caudal fin is truncated. Ventrolateral skinfold extends from behind chin to caudal fin. Body spines are two-rooted and are moderately developed. Dorsum is dirty brown with some indistinct pale spots and several darker brown spots behind head. Color is continued onto lateral surface, but is becoming more pale, especially on cheek. Belly is pale. All fins are brownish. A linear series of blotches are barely visible on sides of body. This species has a maximum total length of 16 cm. There is very little information concerning the habitats or ecology of this species.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 µg/g tissue). This species is not utilized.

Aquarium Value: The suitability of this fish for aquarium is unknown.

Toxicity: Unknown.

Conservation Status: Not evaluated.

***Torquigener balteus* (Hardy, 1989)** (= *Torquigener marleyi*)

Image not available.

Common Name(s): Slender blaasop.

Habitat: Marine; demersal; estuaries over sandy and rocky bottoms; depth range 365–460 m.

Global Distribution: Subtropical; Western Indian Ocean: Natal, South Africa.

Description: This species is diagnosed by its 7 anal fin-rays and 13 to 14 pectoral-fin rays. Caudal fin is more or less normal and truncated. It has fewer spinules and belly is with numerous longitudinal pleats. Coloration of body is greyish brown with small pale spots and smaller pale dots above. A white stripe is seen on posterior part of upper lateral line. Belly and fins are white. It feeds on isopods, crabs, bivalves and fish. It has a maximum total length of 9 cm.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 µg/g tissue). This species however, is not utilized for food, as it is considered highly toxic. However, it is used to poison animals such as cats (Leis, 2014).

Aquarium Value: Though this species is used as a component in saltwater aquarium, much of its aquarium parameters are unknown.

Water Type: Seawater.

Temperature: 23–26°C

Food: Carnivore- snails and shellfish.

Toxicity: Unknown.

Conservation Status: Not evaluated.

***Torquigener brevipinnis* (Regan, 1903)**

Common Name(s): Yellow-stripe toadfish, short-fin puffer.

Habitat: Marine; demersal; deep sandy coastal slopes; brackish waters; epibenthic species which mainly occurs in small loose groups on shallow coastal sand flats and in estuaries; depth range 20–100 m.

Global Distribution: Subtropical; Indo-West Pacific: Indonesia and northwestern Australia; Papua New Guinea; Japan and New Caledonia.

Description: Body of this species is elongated, rounded dorsally and flattened ventrally. Body is tapering to a narrow caudal peduncle. Mouth is small and terminal. Lips are thin and are covered with numerous short papillae. Chin is prominent. Eye is moderate in size, elongated, and dorsally adnate. Upper border level of eye is with dorsal profile and lower border is well above level of mouth corner. Pectoral fins are slightly dorsally elongated and rounded. First ray of pectoral fin is very short. Dorsal fin is elongated and pointed. Anal fin is elongate and pointed and its origin is under posterior of dorsal fin base. Caudal fin is truncated. Venterolateral skinfold extends from behind chin to caudal fin. Body spines are two-rooted, small, and are moderately sparse dorsally. Dorsum is with many small, round or oval and pale yellowish spots. They are delicately outlined by small brownish dots, which also form a reticulate network against a pale brownish background. Lateral yellowish-brown band from behind pectoral fin to caudal fin base forms lower boundary to spotted region. Lower sides and belly are creamy-white. Top of head and snout are with similar though less regular markings as dorsum. Side of head and cheek are with somewhat mottled brownish background. Three slightly oblique, narrow, creamy-white bands traverse cheek from below nostril, below anterior corner of eye, and just forward of gill opening from mid-eye level, respectively. A similar marking, in the form of an inverted U, crosses cheek beneath posterior half of eye. Dorsal, anal, and pectoral fins are colorless. Caudal fin rays are with regular dark brown blotches, producing the effect of six vertical bands. Posteroventral webbing of caudal fin is brownish grey. It often sleeps during the day by burying itself under the sand with only the eyes exposed. This species has a maximum standard length of 10 cm (Hardy, 1984).

Food Value: It is a venomous fish (FishBase). The ovaries and internal organs are reportedly toxic (Shao et al., 2014k). This species is not utilized.

Aquarium Value: The suitability of this fish for aquarium is unknown.

Toxicity: Unknown.

Conservation Status: Data deficient.

***Torquigener flavimaculosus* (Hardy & Randall, 1983)**

Common Name(s): Studded pufferfish, dwarf blaasop, Red Sea migrant fish, yellow-spotted puffer.

Habitat: Marine; reef-associated; seagrass beds; depth range 3–57 m.

Global Distribution: Tropical; Western Indian Ocean: northern Red Sea and Kenya; a recent emigrant to the Mediterranean Sea via the Suez Canal. Also reported from the Persian Gulf and Seychelles.

Description: In this species, lower margin of the eye is above the level of the mouth corner and above the top of the fin base. Mouth is terminal at level of upper end of pectoral fin. Chin is distinct. Dorsal and anal fins are elongated and pointed. Skin has numerous longitudinal pleats. Small spinules are present on the belly, on the head, on the sides and the back in a patch which does not reach the dorsal fin. Number of spines across the belly on a line between pectoral bases is 16. Lower edge of the gill opening forms a cartilaginous spur. Small spines which are irregularly distributed are present on the margin of the gill opening. Dorsal surface is brown with irregular grey-whitish spots. A mid-lateral line of well-distinguished yellow-orange spots, followed by a pale yellow zone is separating the dorsal colored surface from the white ventral surface. Vertical yellow-brown bands seen on the cheek, are separated by irregular white bands. Caudal fin is with brown spots. Dorsal is lightly spotted with white. Anal and pectoral fins are transparent. This species sometimes exhibits burrowing behaviour It feeds on marine invertebrates.

It grows to a maximum total length of 16 cm (Corsini-Foka et al., 2006; Hardy and Randall, 1983).

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 µg/g tissue).

Aquarium Value: The suitability of this fish for aquarium is unknown.

Toxicity: Unknown.

Conservation Status: Not evaluated.

***Torquigener florealis* (Cope, 1871)**

Common Name(s): Floral puffer.

Habitat: Marine; demersal; over sand bottoms; depth range 90–238 m.

Global Distribution: Temperate; Western Central Pacific: Hawaii to Japan and the East China Sea.

Description: Body is elongated, rounded dorsally and flattened ventrally. It is tapering to a narrow caudal peduncle; Mouth is small and terminal. Lips are thin, covered with numerous short papillae. Chin is prominent. Nasal organ is a short, erect papilla which is set in a low depression well forward of the eye, with 2 moderately separated openings. Posterior opening is only slightly larger than anterior. Eye is moderately sized, elongated, and dorsally adnate. Upper border interrupts dorsal profile. Lower corner is well above level of mouth corner. Dorsal and anal fins are somewhat rounded. Pectoral fins are slightly dorsally elongate and rounded. Ventrolateral skinfold extends from behind chin to caudal fin, except directly beneath pectoral fin. Lateral line is distinct, with a few small, associated papillae. Body spines are 2-rooted, small, and projecting from short, normally recessed papillae. They are moderately sparse dorsally from level of nasal organs almost to dorsal fin base. Extending laterally from cheek almost to limit of dorsal spines, extending ventrolaterally and ventrally from behind chin to anterior of vent, the ventral spines are dense. Many small whitish spots are seen on dorsum and are delineated by rosette of

smaller brown spots. A lateral band of brownish-orange blotches is also seen. Cheek is with small yellowish-brown spots. This species grows to a maximum standard length of 18.5 cm.

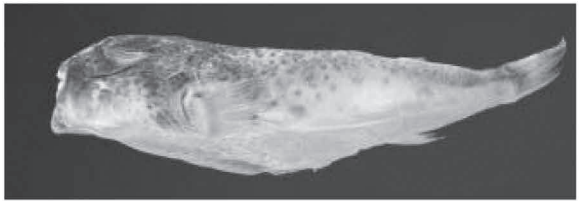
Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 μg/g tissue). This species however, is not utilized.

Aquarium Value: The suitability of this fish for aquarium is unknown.

Toxicity: Unknown.

Conservation Status: Not evaluated.

***Torquigener gloerfelti* (Hardy, 1984)**



Common Name(s): Not designated.

Habitat: Marine; demersal; depth range 50–60 m.

Global Distribution: Tropical; Western Central Pacific: Bali Strait, Indonesia.

Description: Body of this species is elongated, rounded dorsally and flattened ventrally. It is tapering to a narrow caudal peduncle. Mouth is small and terminal. Lips are thin and are covered with numerous short papillae. Chin is prominent. Nasal organ is a short, erect papilla and is set in a low depression well forward of the eye. It is with two moderately separated openings. Of these openings, posterior opening is equal in size or slightly larger than anterior one. Eye is moderately sized, elongated and dorsally adnate. Pectoral fins are slightly dorsally elongated and rounded. First ray of these fins is very short. Dorsal fin is elongated and somewhat rounded. Its origin is just posterior to vent. Anal fin is elongated and pointed and its origin is under posterior of dorsal fin base. Caudal fin is truncated. Ventrolateral skinfold extends from behind chin to caudal fin, except directly beneath pectoral fin. Body spines are two-rooted, small and are moderately sparse dorsally. Spines are extending laterally from cheek almost to limit of dorsal spines and are extending ventrally from behind chin to anterior of vent. Ventral spines are moderately

dense. Dorsum is with a dense pattern of irregularly shaped, open-sided, medium brown circles and ovals, on a pale yellowish-white background. Pattern is especially dense on head and is interspersed with small, solid, brownish dots. Background color extends to ventrolateral skin fold and chin. Sides and cheek are with irregularly spaced yellowish-brown blotches. Belly and lips are creamy-white. Caudal fin is greyish distally. All other fins and proximal portion of caudal fin are colorless (Hardy, 1984).

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 µg/g tissue). This species, however, is not utilized.

Aquarium Value: The suitability of this fish for aquarium is unknown.

Toxicity: Ha et al. (2012) reported on the toxicity of the internal organs of this species. According to them, the skin, meat, intestine, liver, and reproductive organ of this species showed the following range of toxicity.

Skin: 0.5–53.9 MU/g
Meat: 0–14.7 MU/g
Intestine: 0.3–54.5 MU/g
Liver: 6.1–782.3 MU/g
Reproductive Organ: 0–977.9 MU/g

Conservation Status: Not evaluated.

***Torquigener randalli* (Hardy, 1983)**

Common Name(s): Randall's puffer.

Habitat: Marine; demersal; sandy bottom habitat; depth range 15–132 m.

Global Distribution: Tropical; Eastern Central Pacific: known only from off Oahu, Hawaii.

Description: Body of this species is elongated, rounded dorsally and flattened ventrally. It is tapering to a narrow caudal peduncle. Mouth is small and terminal. Lips are thin and are covered with numerous short

papillae. Chin is prominent. Nasal organ is a short, erect papilla and is set in a low depression well forward of the eye, with 2 moderately separated openings. Eye is in moderate size, elongate, and dorsally adnate. Eye's upper border level is with dorsal profile and lower border well is above level of mouth corner. Pectoral fins are slightly dorsally elongated and rounded. Ventrolateral skinfold extends from behind chin to caudal fin, except directly beneath pectoral fin. Lateral line is distinct, with a few small, associated papillae. Mid-dorsal branch of lateral line is above pectoral fin base and is not meeting in midline. Second lateral line may be somewhat indistinct and it drops from behind mouth corner. Body spines are 2-rooted, small and are projecting from short, normally recessed papillae. Spines are moderately sparse dorsally from level of nasal organs almost to dorsal fin base, extending laterally from cheek almost to limit of dorsal spines, extending ventrolaterally and ventrally from behind chin to anterior of vent. Ventral spines are dense. Dorsum is with a scattering of small, distinctly edged, pale spots on a darker greyish-brown background. A lateral, dark brown band is extending from above pectoral fin base to base of caudal fin. A number of small brown flecks are seen below band, from posterior to pectoral fin base to base of dorsal fin. A darker brown smudge is seen immediately under eye to halfway down cheek. Further, smudges are found immediately behind mouth corner and anterior to gill opening. Rest of cheek is speckled with brown, fewer specks ventrally. Belly and chin are whitish. Caudal rays are with a series of brown specks and remaining fins are colorless. This species has a maximum standard length of 12.7 cm.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 μg/g tissue). This species however, is not utilized.

Aquarium Value: Though this species is used as a component in saltwater aquarium, much of its aquarium parameters are unknown.

Size of Fish for Tank: Under 12.7 cm.

Tank Type: Marine tank.

Toxicity: Unknown.

Conservation Status: Not evaluated.

***Torquigener tuberculiferus* (Ogilby, 1912)**

Common Name(s): Fringe-gill toadfish.

Habitat: Marine; demersal; depth range 53–80 m.

Global Distribution: Tropical; Indo-West Pacific: Indonesia. Recently recorded from the Chesterfield Islands

Description: Body of this species is elongated, rounded dorsally and flattened ventrally. It is tapering to a narrow caudal peduncle. Mouth is small and terminal. Lips are thin and are covered with numerous short papillae. Chin is prominent. Eye is moderate, elongate and dorsally adnate. Pectoral fin is dorsally elongated and rounded. Dorsal fin is elongated, bluntly pointed, and is based above vent. Ventrolateral skinfold extends from behind chin to caudal fin except directly beneath pectoral fin. Base color of body is pale brown. Dorsum is heavily speckled with small, irregular, darker brown spots which are becoming larger posteriorly. A narrow brownish band crosses over caudal peduncle midway between dorsal and caudal fins. Laterally, moderately-sized brown spots extend from cheek to behind pectoral fin. Remaining lateral surface is with larger brown spots on a pale background. Belly is pale with diffuse light brown markings between chin and vent. All fin rays are brown. It has the ability to inflate itself, either with air or water, as a deterrent to predators. It has a maximum standard length of 9.5 cm.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 µg/g tissue).

Aquarium Value: The suitability of this fish for aquarium is unknown.

Toxicity: Unknown.

Fisheries Status: It has no commercial fisheries.

Conservation Status: Least Concern.

***Torquigener vicinus* (Whitley, 1930) (=*Torquigener tuberculiferus* subspecies *vicinus*)**

Common Name(s): Orange spotted puffer.

Habitat: Marine; demersal.

Global Distribution: Subtropical; Eastern Indian Ocean: Western Australia.

Description: Body of this species is elongated, rounded dorsally and flattened ventrally. It is tapering to a narrow caudal peduncle. Mouth is small and terminal. Lips are thin and are covered with numerous short papillae. Chin is prominent. Eye is moderate, elongate and dorsally adnate. Pectoral fins are dorsally elongated and rounded. Dorsal and anal fins are elongated and bluntly pointed. Ventrolateral skinfold extends from behind chin to caudal fin except directly behind pectoral fin. Lateral line is distinct with a few small associated papillae. Second lateral line is sometimes indistinct. Dorsum is generally medium brown with irregular pale markings. Brown spotting is more distinct on dorsal surface of caudal peduncle and on sides. Lower lateral surface and and belly are brownish. Chin is slightly darker. All fins are brownish. Caudal fin darkens distally. It has a maximum standard length of 17.4 cm.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 μg/g tissue). It is not utilized.

Aquarium Value: The suitability of this fish for aquarium is unknown.

Toxicity: Unknown.

Conservation Status: Not evaluated.

***Torquigener whitleyi* (Paradice, 1927)**

Common Name(s): Whitley's toadfish.

Habitat: Marine; demersal.

Global Distribution: Tropical; Indo-West Pacific: northwestern Australia; Papua New Guinea.

Description: Body of this species is elongated, rounded dorsally and flattened ventrally. It is tapering to a narrow caudal peduncle. Mouth is small and terminal. Lips are thin and are covered with numerous short papillae. Chin is prominent. Eye is moderate, elongate and dorsally adnate. Pectoral fins are dorsally elongated and rounded. Dorsal fin is elongated and bluntly pointed. Anal fin is elongated, bluntly pointed and is based behind anterior of dorsal fin. Caudal fin is truncated. Ventrolateral skin fold extends from behind pectoral fin margin to caudal fin. Lateral line is distinct with a few small associated papillae. Dorsum is chocolate-brown with irregular, scattered, pale greyish-brown blotches and bands on dorsal and dorsolateral surfaces. Pale dorsal bands are seen above pectoral fins and are directed postero-medially towards dorsal fin base. Several moderate chocolate-brown spots are seen along sides from above pectoral fin base to base of caudal fin and also on lower surface of cheek. A few pale brown spots are present on ventrolateral region below dorsal fin. Remainder of sides is white. Mottled dark brown band is seen around chin. Lips are white. Pectoral fins are with yellowish tinge. Dorsal and caudal fins are slightly darker. It grows to a total length of 9.8 cm.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 μg/g tissue).

Aquarium Value: The suitability of this fish for aquarium is unknown.

Toxicity: Unknown.

Conservation Status: Not evaluated.

***Tylerius spinosissimus* (Regan, 1908)**

Common Name(s): Spiny blaasop, fine-spine pufferfish.

Habitat: Marine; bathydemersal; deep-water; in its occupation of shallower depths, over sandy and muddy bottoms; depth range 250–435 m.

Global Distribution: Indo-West Pacific: South Africa to northwestern Australia; northward to South China Sea; Southeast Atlantic: southeast coast of South Africa; Mediterranean.

Description: This fish is the only species in the genus. It has a round body and head with blunt snout. Head measures 45.6% standard length (SL), predorsal 71.1% (SL), preanal 73.7%(SL), and caudal peduncle 7.3% (SL). Mouth is small and is not reaching anterior vertical of eye. There are two large teeth in each jaw with a median suture. Anterior tip upper teeth are curved downward and anterior tip of lower teeth curved upwards. It has large eye (30.6%) and narrow interorbital (15.3%), all in head length. Small slit-like gill opening is seen in front of pectoral fin. Small wide- based pectoral fin is with 13 rays. Caudal fin is relatively long and truncated to slightly rounded. Body is covered with delicate spines extending to the middle of the dorsal fin base. A single spine is seen at the midpoint between tip of snout and eye origin. Dorsal surface to mid-body is dark grey with small light grey patches. Belly and ventral surface of caudal peduncle are white. Dorsal and anal fins are transparent while caudal fin is with grey rays and transparent membrane. It feeds on molluscs and crustaceans. It reaches a total length of 12 cm (Golani et al., 2011).

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 µg/g tissue). This species is not utilized.

Aquarium Value: The suitability of this fish for aquarium is unknown.

Toxicity: Unknown.

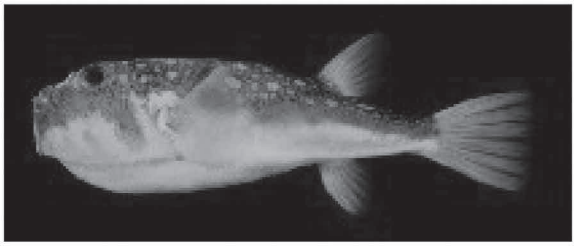
Conservation Status: Not evaluated.

3.2 BRACKISH WATER PUFFERFISH

3.2.1 TOXIC (POISONOUS TO EAT) BRACKISH WATER PUFFERFISH

Kingdom: Animalia
Phylum: Chordata
Subphylum: Vertebrata
Class: Actinopterygii
Order: Tetraodontiformes
Family: Tetraodontidae

***Amblyrhynchotes honckenii* (Bloch, 1785)** (= *Torquigener marleyi, Sphoeroidae honckenii, Tetrodon honckenii*)



Common Name(s): Evileye blaasop, evileye pufferfish.

Habitat: Estuaries, seagrass beds, sandy and rocky area to depths of 400 m; Juveniles are occasionally seen in tidal pools.

Global Distribution: Tropical; Indo-West Pacific: South Africa to China. Marshall Islands in Micronesia.

Description: This species has blackish brown with yellowish white spots above, sides yellow and white below. Dorsal, pectoral and caudal fins are dusky with a yellow tinge. Males are with white anal fins which are yellow in breeding females. It feeds on crabs, isopods and other small fishes. As this fish is highly toxic, it is to be handled with gloves. The flesh should not be eaten or fed to pets. This species grows to a maximum length of 30 cm.

Food Value: It is a poisonous species and is not to be eaten (FishBase). All organs of this fish are considered to be toxic

Aquarium Value: This species is used in marine aquarium. The suitable aquarium parameters of this species are given below.

Suitable Size of Fish: under 30 cm.

Maximum age of fish: Unknown.

Minimal tank volume *(minimum size aquarium):* 400 liter.

Floor Water Column: Entire water column.

Temperature: 23–26°C

pH Tolerance: 7,5–8,5

KH *(water hardness):* 7–12

Salinity: 1015–1024

Character *(behavior):* Very aggressive against conspecifics and other species.

Activity: Active hunter, moderately active swimmer lies mainly with danger and rests buried in the soil.

Care: It is extremely sensitive to nitrite and ammonia, and must be introduced in a completely screwed aquarium. Because of the messy eating behavior, it deserves a big filter (skimmer) with excess capacity and a lot of live rock is preferable.

Care Level: moderately difficult.

Food: Carnivore -live and frozen food (no fish): snails, shrimp, bloodworms, mussels, clams and other shellfish.

Propagation: It is unknown. There are no confirmed reproduction registered in captivity.

Toxicity: This species is toxic. Liver contains the highest concentrations of the potent neurotoxin viz. tetrodotoxin (TTX). Much lower toxicity of the gonads may be due to seasonal variations in TTX concentrations (Liu et al., 2014). It is not touched by other fishes and sea birds. Hands should be washed after handling this fish. The flesh should not be fed to pets.

Fisheries Status: There are no fisheries for this species.

Conservation Status: Not evaluated; least Concern.

***Arothron immaculatus* (Bloch & Schneider, 1801)**

Common Name(s): Immaculatus puffer, blackedged blaasop, immaculate blow fish, immaculate pufferfish, narrow-lined toadfish, yellow-eye puffer.

Habitat: Marine; brackish; freshwater; silt bottoms near coral reefs, shallow estuaries, mangroves, and seagrass beds; depth range 3–30 m.

Global Distribution: Tropical; Indo-West Pacific, from the Red Sea and East and South Africa to the Seychelles, Madagascar and Mascarenes east to Philippines, western Indonesia.

Description: Body of this species is round in cross-section. Nasal organs of two tentacles join at the base. Body except posterior part of tail, base of anal and snout is covered with slender spines. Eyes are yellow. Teeth are fused into bony plates. Coloration of body is brownish above and lighter below. Upper and lower edge and margin of caudal fin are blackish. No markings are seen on body except dark blotch at pectoral fin base. These puffers are carnivores and require a diet that is rich in meaty foods. Foods like mysids and brine shrimp as well as high quality meaty frozen foods will keep juveniles healthy. Though it is primarily carnivorous, it also feeds on seagrasses and mangrove plants. It grows to a maximum length of 30 cm.

Food Value: It is a poisonous species and is not to be eaten (FishBase). All the organs of this fish are considered to be toxic.

Aquarium Value: It is currently sold commercially in the aquarium trade (Shao et al., 2014t). The aquarium parameters of this species are:

Tank Size: 150 Gallons.

Water Conditions: 74–82°F, SG 1.020–1.027, pH 7.9–8.5

Temperament: Semi-aggressive.

Experience Level: Beginner.

The ideal setup should be an established aquarium with good filtration and a protein skimmer. Aquascape should be with live rock and other materials to create an environment rich with nooks and crannies, caves and overhangs while preserving easy access to large open areas.

Toxicity: It produces powerful toxins in its tissues, especially in the liver and in the ovaries. Eating of these fishes has resulted in serious illness and sometimes death. Toxicity studies made in the fishes of this species of the Malaysian waters have shown that the TTX concentration of liver and muscle was at 444 µg/g and 107 µg/g, respectively (Azman et al., 2014). The TTX of this species when injected intra-peritoneally at concentrations of 0.1, 0.2 and 0.3 ml/g to the tilapia *Oreochromis mossambica*, it proved to be lethal triggering a sudden body color change and paralysis followed by death. The introduction of ovary extract was more fatal and the average time for color change was observed at 5.4, 3.1, 1.4 seconds

and the average time of death at 93, 72, 70 seconds, respectively in the above concentrations. Whereas, the intra-peritoneal introduction of liver extract was more lethal as the average time of color change was found to be 77, 87 and 59 seconds and average time of death occurred after 10.22, 4.03, 3.18 minutes, respectively (Saha et al., 2015).

Fisheries Status: This species has minor commercial fishery.

Conservation Status: Not evaluated.

***Arothron stellatus* (Anonymous, 1798)**

Common Name(s): Stellate puffer, star blaasop, star puffer, starry pufferfish, starry toadfish, staring blow fish.

Habitat: Marine; brackish; reef-associated; juveniles occur in sandy and weedy inner reefs, adults on clear lagoons and seaward reefs; depth range 3–58 m.

Global Distribution: Tropical; Indo-Pacific: Red Sea and East Africa to the Tuamoto Islands, north to southern Japan, south to Lord Howe Island. Southeast Atlantic: south coast of South Africa.

Description: Body of this species is covered with prickles. Juveniles are with dark stripes on belly; becoming spots with growth. Adults are with or without spots on fin. They have diagonal black bands crossing the abdomen. *Arothron stellatus* feeds on sea urchins (crown-of-thorns starfish, *Acanthagaster planci*), sponges, crabs, coral and algae. This species grows to a maximum length of 120 cm.

Food Value: It is a poisonous species and is not to be eaten (FishBase). All the organs of this fish are considered to be toxic. This species is not sold in the local markets, but it is dried, stretched and utilized by local fishermen of certain countries (Shao et al. (2014q).

Aquarium Value: It is a component of the marine aquarium trade. The aquarium parameters of this species are:

Minimum Tank Size: 300 gallons (Very large aquariums are preferred)
Water conditions

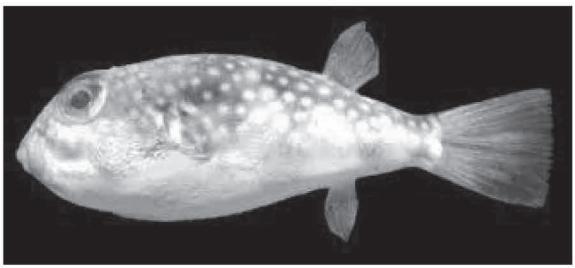
Temperature: 23–26°C (73.4–78.8°F).
dKH: 8–12,
pH: 8.1–8.4,
Specific Gravity (SG): 1.020–1.025

Toxicity: It possesses TTX in the muscle, intestine, liver and gonads. The liver and skin are toxic, the ovaries are extremely toxic (Shao, et al., 2014q). It also contains considerable amounts of Paralytic shellfish poison (PSP toxins) (Egmond et al., 2004).Toxicity studies made in the fishes of this species of the Malaysian waters have shown that the TTX concentration of liver and skin was at 11.2 µg/g and 0.44 µg/g, respectively (Azman et al., 2014).

Fisheries Status: There is no commercial fishery for this species.

Conservation Status: Not evaluated.

***Chelonodon patoca* (Hamilton, 1822)**



Common Name(s): Milkspotted puffer, Gangetic blow fish, marbled toad, Gangetic pufferfish, milkspotted toadfish,

Habitat: Marine; freshwater; brackish; reef-associated; anadromous; primarily marine species and occasionally from freshwater streams; inhabits coastal waters and enters the lower reaches of rivers and lagoons; sand and mudflats, around the mouths of rivers or in brackish mangrove estuaries; sometimes penetrates fresh water, but is never found more than a few kilometers from the sea; depth range 1–5 m.

Global Distribution: Tropical; Indo-Pacific: East Africa to the Admiralty Islands, New Britain and Trobiand Islands, north to China, south to northern Australia.

Description: This species is diagnosed by its dorsal fin rays (9–11); anal fin rays (8–10) and pectoral fin rays (16–19). Body of this species is relatively short and ovoid in cross section. Head is broad, with length 3.6 times standard length. Eyes are large, in dorsolateral position and situated about middle of length of head. Nostrils are round, situated very close to eye. Predorsal distance is 1.4 times standard length and is covered with spiny patches. Dorsal fin is round, originating opposite to vent and is inserted in posterior region of body. Anal fin is round, originating 3 mm from vent. Caudal fin is 4.6 times total length. Dorsal surface is black. Back and sides are covered with many small, round, fluorescent yellowish spots and round blotches. Spots and blotches are very variable in size and form. Spot are also extending up to caudal fin. Lower part is yellowish-white. At smaller sizes, this species feeds predominantly on detritus, later transitioning to a diet of benthic invertebrates. This species has a maximum total length of 38 cm.

Food Value: It is a poisonous species and is not to be eaten (FishBase). All the organs of this fish are considered to be toxic. However, it is considered a delicacy in Japan. (http://www.wildsingapore.com/wildfacts/vertebrates/fish/tetraodontidae/patoca.htm).

Aquarium Value: This species is used as a component in brackish water aquarium and its aquarium parameters are given below.

Minimum Tank Size: 100 US Gallons (380 liters).

Water Parameters: Not known.

Diet: Likely live and frozen foods (not fish), freeze-dried krill, frozen shrimp, squid, clams and other molluscs and crustaceans.

Sexual Dimorphism: Not known.

Breeding: Not known.

Social Behavior/Temperament: Aggressive.

Activity: Not known.

Care: Marine species, but can be kept in brackish conditions. Due to size, tanks of 100–250+ gallons are recommended

Estimated Lifespan: Not known.

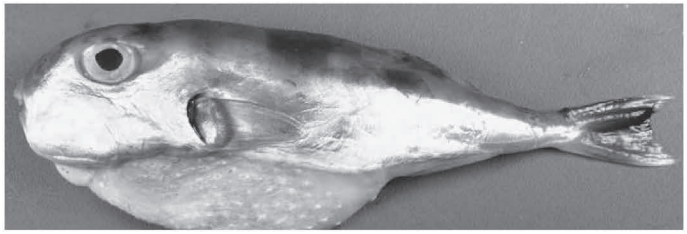
Toxicity: Among the tissues of this species tested, toxicity in the skin ranged from 60 to 6,700 MU/g, in the ovary from 25 to 670 MU/g, in the testis from 45 to 550 MU/g, in the muscle from 2 to 390 MU/g, and in the liver from 5 to 380 MU/g. The liver, which is known as one of the most

toxic organs in Japanese marine puffer in general, showed lower toxicity in this species. *C. patoca* toxin has been characterized as tetrodotoxin (TTX), 4-epi-TTX and anhydro-TTX (Mahmud et al., 2001). Ghosh et al. (2004) reported that toxicity in the liver and ovary of this species was 18.5 MU/g and 136.0 MU/g, respectively. Toxicity studies made in the fishes of this species of the Malaysian waters have shown that the TTX concentration of liver and muscle was at 246 µg/g, and 277 µg/g, respectively (Azman et al., 2014).

Fisheries Status: This species has minor commercial fishery.

Conservation Status: Not evaluated.

***Lagocephalus laevigatus* (Linnaeus, 1766)**



Common Name(s): Smooth puffer.

Habitat: Marine; brackish; pelagic-neritic; inshore and near-shore areas, including estuaries and mangroves; over sand, soft or mud bottoms; usually found alone or in small, loose aggregates; adults are pelagic, but near continental margins; young are commonly found on coastal and offshore banks; depth range 10–180 m.

Global Distribution: Subtropical; Western Atlantic: New England, USA and Bermuda to Argentina. Eastern Atlantic: Mauritania to Namibia.

Description: Body of this species is elongated and globular with loose lower skin. Color of body is greenish above; silvery on sides, and white below. Jaws form a beak with 2 teeth in upper jaw and 2 in lower jaw. There are no pelvic fins. Small spiny projections (prickles) are seen on belly and no prickles on head or back. Diet of this species consists mainly of, in order of frequency of occurrence, the sea whip *Leptogorgia setacea*, followed by various crustaceans, teleosts and amphipods. Lesser utilized food options for *Lagocephalus laev-*

igatus include polychaetes, bivalves, algae, gastropods and isopods, all of which comprise very small volumes in the puffer diet (polychaetes, bivalves, algae, gastropods and isopods comprise >5% in their total food intake). Maximum total length and weight of this species are 100 cm and 4.9 kg respectively.

Food Value: It is a poisonous species and is not to be eaten (FishBase). However, in Senegal, this species is the most commonly consumed tetraodontid in households, and is often prepared in rice-based dishes (Shao et al., 2014w).

Aquarium Value: This species is used as a component in brackish water aquarium and its aquarium parameters are given below.

Suitable Fish Size: Under 100 cm.

Minimal Tank Volume: 3000 liters (793 US gal).

Water Conditions:

Temperature: 23°C (73.4°F)–26°C (78.8°F)

pH: 7.8–8.8

Water Hardness: 5–15 °dKH

Floor Water Column: Entire water column.

Behavior: Aggressive

Care Level: Very difficult.

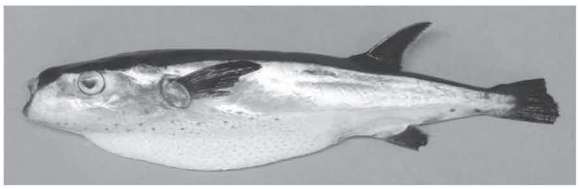
Feeding: Carnivore.

Toxicity: The toxicity of this species may be derived by the cnidarians that it ingests (Shao et al., 2014w). Muscle and skin plus viscera extracts of this species have shown very low levels of toxicity (1.7 MU/g) (Oliveira et al., 2003).

Fisheries Status: It is harvested by small-scale artisanal fisheries in parts of its range.

Conservation Status: Not evaluated.

***Lagocephalus lagocephalus* (Linnaeus, 1758)**



Common Name(s): Oceanic puffer.

Habitat: Marine; benthopelagic; oceanodromous; primarily an oceanic, pelagic species but may enter estuaries; depth range 10–476 m.

Global Distribution: All tropical and subtropical oceans.

Description: This species is diagnosed by its dorsal fin with 13–15 rays, anal fin with 11–13 rays and pectoral fin with 13–16 rays. Body is smooth except for well developed spinules on belly from chin to anus. In adults lower caudal fin lobe is longer than upper lobe. Caudal fin is emarginate. Adults are dark green, brownish grey, or blue dorsally and white below. Juveniles to about 18 cm have 9 uniform bars on back from eye to dorsal fin. Dark spots are seen in front and middle of belly and on side near pectoral base in fish less than 33 cm. It feeds on crustaceans and squids. Maximum length and weight of this species are 61 cm and 3.2 kg, respectively.

Food Value: It is suspected responsible for fatal poisoning and it should not be eaten (Bianchi et al., 1999). In Senegal, this species is commonly consumed in rice-based dishes (Hardy et al., 2014b).

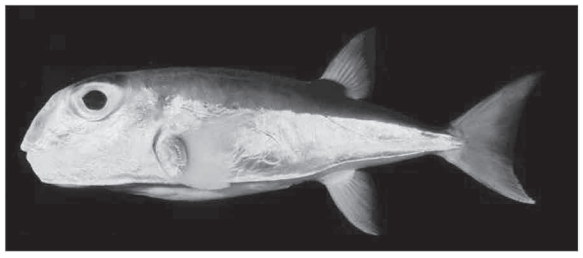
Aquarium Value: The suitability of this fish for aquarium is unknown.

Toxicity: It is a highly poisonous fish and is thought to have been responsible for some cases of fatal fish poisoning in Maldives in the past.

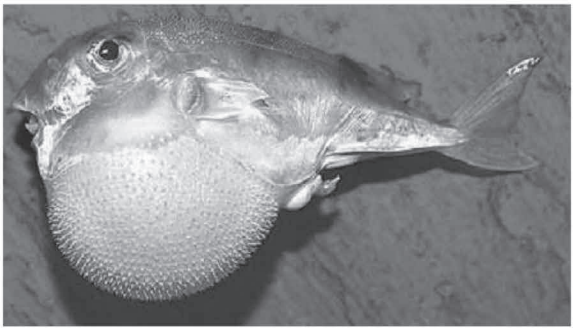
Fisheries Status: In the Persian Gulf, this species is of commercial importance to the fisheries industry as a game fish. Further, it is harvested by small-scale artisanal fisheries in parts of its range.

Conservation Status: Not evaluated.

***Lagocephalus lunaris* (Bloch & Schneider, 1801)**



Normal fish



Inflated fish

Common Name(s): Lunartail puffer, green rough-backed puffer, moontail puffer, green toadfish.

Habitat: Marine; brackish; demersal; oceanodromous; mainly marine, occasionally enters estuaries; associated with mangroves, mudflats, seagrass beds, and sandy beaches; depths ranging from 5 to 150 m.

Global Distribution: Tropical; Indo-West Pacific: Red Sea and Persian Gulf to South Africa, east along the continental shores to western Pacific, from Japan to Australia; Southeast Atlantic: south coast of South Africa.

Description: This species is diagnosed by their caudal, dorsal, pectoral and anal fin rays which are ranging from 5 to 12, 7 to 11, 9 to 12 and 7 to 17, respectively. It has an elongated body which is covered with prickles. Prickles on back are extending from nape to caudal peduncle. Back and sides are golden colored and belly is white. Tail is lunate. A patch of small bristles is seen on back between snout and dorsal fin. This fish is a carnivore preying on crabs, prawns, small fish and squids. It grows to a maximum standard length of 45 cm (Mohamad and Isa, 2013).

Reproduction: The size at first maturity was found to be 141 mm total length for females of *L. lunar*is. A scale of six stages of maturity of gonads has been identified in these females. Spawning takes place throughout the year with peak during April to June and September to December. Gonadosomatic index has been found to be high during January, April, June, September and December in females. Fecundity varied from 103355 to 298795 ova (Sirisha et al., 2013).

Food Value: It is a poisonous species and is not to be eaten (FishBase). All the organs of this fish are considered to be toxic. However, this fish is processed and sold as dried fillets. There is interest in breeding this species in artificial seawater environments in China. Additionally, this species is processed into feed for more desirable aquacultured fish species (Shao et al., 2014y).

Aquarium Value: It is commercially collected for use in the brackish aquarium trade and its aquarium parameters are given below.

Aquarium Tank: ~ 2000 liters.

Suitable Size of Fish: Up to 45 cm

Water Conditions:

Temperature: 20–27°C

Specific Gravity (SG): 1,020–1,025

pH: 8.0- 8.3

Food: Frozen food (large sort) insects, small fish, krill, bloodworms, mussel meat and snails.

Behavior: Semi-aggressive.

Difficulty: Only by experienced aquarists.

Toxicity: Small intestine, skin, testis and muscle of this species are highly toxic. The toxicity in the liver and ovary of this species has been found to be 7.2 MU/g and 23.2 MU/g, respectively (Ghosh et al., 2004). This species is unique in its distribution of tetrodotoxin in the body, with the highest concentrations reported from the muscle. However, the reported toxicity of this species appears to be highly variable. Of 363 specimens of *L. lunaris* collected off the coast of Thailand, 50 were found to have dangerous concentrations of TTX (Shao et al., 2014). In 2008 to 2009, food poisoning due to ingesting *L. lunaris* has occurred in Western Japan. Comparing the maximum toxicity in tissues of this species, ovary contained the most toxin (1810 mouse units [MU]/g), followed by liver (341 MU/g), muscle (135 MU/g), skin (79 MU/g), and intestine (72 MU/g) (Nagashima et al., 2011). Toxicity studies made in the fishes of this species of the Malaysian waters have shown that the TTX concentration of liver, muscle and skin was at 6.64 µg/g, 4.96 µg/g and 3.15 µg/g, respectively (Azman et al., 2014). Mandal et al. (2013) reported that *L. lunaris* collected from Southeast Indian coast is toxic, particularly, the muscle and therefore, it is not fit for consumption. Kim et al. (2008) reported that

the toxicity values of the muscle, skin, liver, intestine, and gonad of this species were less than 5, 5, 6, 8, and 75 MU/g, respectively. The muscle toxicity of this report however, reflects the harmless nature of this species.

Fisheries Status: There is no commercial fishery for this species.

Conservation Status: Not evaluated.

***Sphoeroides annulatus* (Jenyns, 1842)**

Common Name(s): Bullseye puffer, gulf puffer, concentric puffer.

Habitat: Marine; brackish; rocky reefs (including tide pools) and adjacent sand patches; mid-water high off the bottom or at the surface; depth range 10–105 m.

Global Distribution: Subtropical; Eastern Pacific: California, USA to Pisco, Peru and the Galapagos Islands.

Description: This species has moderately elongated body with a depth of about 30% of standard length. Back is olive-brown and its unusually flat ventral side is white. Head and back have narrow yellowish lines, bars, and oblique bands and three narrow bands just behind the eyes. There is a double concentric oval on their back after which this fish is named. Head, sides, and upper back are covered with numerous small dark spots. Fins are spotless. Iris of eyes is yellow. Head is large, projecting, and blunt and the gap between their elevated eyes is wide and convex. It's anal and dorsal fins are small and similarly shaped, have short bases, and are found well back on their body with the anal fin being slightly behind the dorsal fin. Caudal fin is bluntly convex. Head and body are covered with small spines and skin is scaleless. It grows to a maximum total length of 44 cm.

Reproduction: The reproduction in this species has been reported to be highly seasonal, with an intense spawning period during the spring-summer, when the sea surface temperature is 22.5–30.9°C and

a 11–14 h photoperiod. It is also suggested that the timing of spawning is synchronized by a semi-lunar cycle together with the rise of the average tide level. Size at first maturation was similar for females (28.2 cm TL) and males (28.6 cm TL). However, some specimens start their gonad maturation when they are as small as 19 cm TL (Sánchez-Cárdenas et al., 2011).

Food Value: It is a poisonous species and is not to be eaten (FishBase). All the organs of this fish are considered to be toxic.

Aquarium Value: This species is used as a component in brackish water aquarium and its aquarium parameters are given below (https://www.theaquariumwiki.com/Sphoeroides_annulatus).

Minimum Tank Size: 567.8 liters (150 US G.)

Size of Fish: 30.5–43.2 cm

Water Conditions:

Specific Gravity (SG): 1.015–1.025

pH: 8.1–8.5

Temperature: 23.3–26.7°C (74–80°F)

Water Hardness: 8–12 dKH

Stocking Ratio: 1:1 M:F (male: fmale)

Diet: Carnivore.

Behavior: Peaceful; but they may bite fins of their tankmates occasionally.

Lifespan: 8–15 years.

Difficulty: Challenging.

Toxicity: Nunez-Vazquez et al. (2000) reported that the values of TTX toxicity of liver, intestine and gonad of this species were 22 µg/g, 0.42 µg/g and 0.46 µg/g, respectively. The cultured fish of this species however has shown slight toxicity. Only the muscle of juveniles, the viscera of pre-adults, and muscle, liver, and gonad of adult specimens of this species have been reported to be less toxic [<1 MU, where MU is the mouse unit (equivalent to 0.2 µg of TTX/g)] (Nuñez-Vazquez et al., 2012).

Fisheries Status: It is an important target species for the artisanal fishing fleets of NW Mexico.

Conservation Status: Least Concern.

***Sphoeroides spengleri* (Bloch, 1785)**

Common Name(s): Bandtail puffer.

Habitat: Marine; brackish; all inshore habitats where there is adequate cover, such as seagrass beds and reef flats; depth range 2–70 m.

Global Distribution: Subtropical; Western Atlantic: Massachusetts, USA to Santa Catarina, Brazil.

Description: In this species, spines are present on upper and lower parts of body. There are 8–9 dorsal fin rays and 7–8 anal fin rays. Caudal fin is truncated or slightly rounded. Dorsal part of body is dark green to yellowish-brown with black spots. A row of 12–14 round, black spots is seen on the lower side of head and body. There are 2 dusky bars are present on caudal fin. It feeds on crustaceans, echinoderms, molluscs, polychaetes and plants. It has a maximum standard length of 30 cm. There is no data on the reproduction of this fish.

Food Value: It is a poisonous species and is not to be eaten (FishBase). All the organs of this fish are considered to be toxic

Aquarium Value: It is traded as an aquarium fish at Ceará, Brazil. This species is used as a component in brackish water aquarium and its aquarium parameters are given below.

Suitable Size of Fish: Under 18 cm.

Minimal Tank Volume: 200 liters (53 US gal).

Water Conditions:

Temperature: 18 °C (64.4°F)–25 °C (77°F)

pH: 7.5–9

Water Hardness: 5–20 dKH

Floor Water Column: Entire water column.

Behavior: Aggressive.

Care Level: Very difficult.

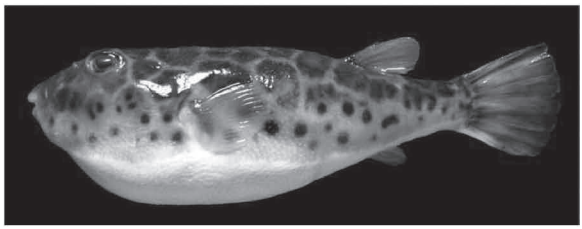
Feeding: Carnivore.

Toxicity: Muscle and skin plus viscera extracts of this species have shown high TTX toxicity up to 946 MU/g (Oliveira et al., 2013). The STX concentration of the skin of *Sphoeroides spengleri* was at 620 µg STX-equiv./100 g (Abbott et al., 2009).

Fisheries Status: There are no commercial fisheries for this species.

Conservation Status: Not evaluated.

***Sphoeroides testudineus* (Linnaeus, 1758)**



Common Name(s): Checkered puffer.

Habitat: Marine; brackish; bays, seagrass beds, tidal creeks, mangrove swamps, and into freshwater areas; no school formation; form huge aggregations; hides in the sand when frightened; depth range up to 48 m.

Global Distribution: Subtropical; Western Atlantic: Rhode Island, USA to southeastern Brazil.

Description: This species has no spinous dorsal fin and scales are absent or reduced. Sandpapery denticles are seen on various areas of the body. A reduced gill opening is seen. This species is pale tan to yellowish with a polygonal or square network of lines centered around a bulls-eye pattern on the midback in front of the dorsal fin. Lines are dark gray to olive, with small, dark brown spots on cheeks and lower sides. Abdomen is whitish and unmarked. Dark bands are present on the caudal fin. It feeds mainly on bivalves, gastropods, foraminiferans and several other benthic invertebrates specially crustaceans, which it crushes with its powerful teeth. To ward off predators, it inflates itself like a balloon. It has a maximum total length of 38.8 cm and weight of 400 g. Information on the reproductive biology and embryological development; maximum age and average lifespan of this species is lacking.

Food Value: It is a poisonous species (FishBase) and is not known to be used for human consumption, as its muscle and internal organs are highly toxic.

Aquarium Value: The suitability of this fish for aquarium is unknown.

Toxicity: The STX concentration of this species has been found to be below the action limit in all tissues and hence this species is considered as nontoxic as far as the STX is concerned (Abbott et al., 2009).

Fisheries Status: It is caught using seines, traps, and hook and line for the purposes of poison for the control of mammalian pests, such as cats, dogs, etc.

Conservation Status: Not evaluated.

***Takifugu oblongus* (Bloch, 1786)**

Common Name(s): Lattice blaasop.

Habitat: Marine; brackish; demersal; shallow coastal waters, but enters brackish waters; mangrove areas and cleared areas.

Global Distribution: Tropical; Indo-West Pacific: South Africa to Indonesia, north to Japan, south to Australia.

Description: Body of this species is naked. Spinules cover all body except the snout and caudal peduncle. Interorbital space is longer than snout length. Nostrils are covered by membrane. Triangular shaped dorsal and anal fins are present. There are two lateral lines. Body is light brownish- green dorsally. Many white dots are seen on anterior head and dorsal body. 10 or more vertical brownish green bands are seen on the dorsal side reaching the lateral side. Polychaetes dominate the diet of this species. This species has a maximum total length of 40 cm.

Food Value: It is a poisonous species and is not to be eaten (FishBase). All the organs of this fish are considered to be toxic (http://self.gutenberg.org/articles/japanese_pufferfish). However, the toxicity of this species is doubtful (FishBase). Despite a ban on the sale of toxic pufferfish in fish

markets, this species may sometimes be found in processed fish products in Taiwan.

Aquarium Value: This species is used as a component in brackish water aquarium and its aquarium parameters are given below.

Minimum Tank Size: 567.8 liters (150 US G.)

Size of Fish: 30.5–40.6 cm.

Water Conditions:

Specific Gravity (SG): 1.020–1.025

pH: 8.1–8.5

Temperature: 23.3–26.7°C (74–80°F)

Water Hardness: 8–12 dKH

Stocking Ratio: 1:1 M:F (male: female)

Availability: Rare.

Diet: Carnivore.

Lifespan: 8–15 years.

Difficulty: Challenging.

Toxicity: This species bio-accumulates tetrodotoxin, and its roe has been implicated in the poisoning deaths of humans, although the toxicity of the particular organs in unknown. It also bio-accumulates saxitoxin, a paralytic shellfish toxin (Shao et al., 2014f). The toxicity in the liver and ovary of this species has been found to be 12.0 MU/g and 24.5 MU/g, respectively (Ghosh et al., 2004). Ha et al. (2012) reported on the toxicity of the internal organs of this species. According to them, the skin, meat, intestine, liver and reproductive organ of this species showed the following range of toxicity.

Skin: 0–40.1 MU/g;

Meat: 0–22.1 MU/g;

Intestine: 0–221.8 MU/g;

Liver: 0–702.4 MU/g;

Reproductive Organ: 0–333.9 MU/g.

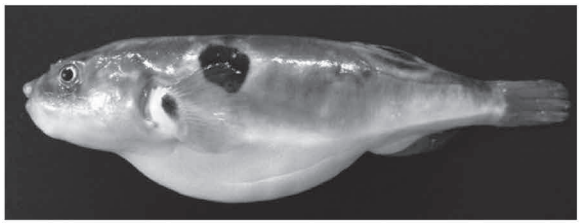
Ahmed (2006) reported on the TTX poisoning of this species and associated high levels of its toxicity in this species. High levels of toxicity, expressed as mouse units (MU), were measured by him in the gonads (2–132 MU/g), with comparatively low levels in other tissues such as the skin, muscle and liver (<2.0–31.3 MU/g). Ngy et al. (2009) reported that the TTX toxicities in this species ranged from 10 to 132 mouse units

(MU/g), much higher than the regulatory limit for human consumption (10 MU/g). The skin, muscle, liver, viscera and testis toxicities were all below 20 MU/g. Toxic principles in this species were identified as tetrodotoxin (TTX) as the main component and saxitoxin (STX) as a minor. It was confirmed that this species is a hazardous species that is unsafe for human consumption.

Fisheries Status: There are no commercial fisheries for this species.

Conservation Status: Not evaluated.

***Takifugu obscurus* (Abe, 1949)**



Common Name(s): Obscure pufferfish.

Habitat: Marine; freshwater; brackish; bottom layer of inshore and inland waters; anadromous; euryhaline species; adults migrate to freshwater to spawn.

Global Distribution: Subtropical; Western Pacific: East China Sea and the South China Sea. Found in rivers in China and the Korean Peninsula.

Description: Body of this species is covered with prickles. A large black blotch is seen on side beneath pectoral fin and on base of dorsal fin. Body color of this species is dark brown above and white below. Yellow broad bands are seen on the side of the body. Dorsal and anal fins are tan and pectoral and caudal fins are yellow. It feeds on fish and shellfish (especially shrimp). It grows to a maximum standard length of 40 cm. A parasite or symbiotic bacterium viz. *Aeromonas* strain (Ne-1) was isolated from the ovary of this species and was shown to produce tetrodotoxin (Yang et al., 2010). This is a species of interest for intensive aquaculture in China.

Food Value: It is a poisonous species and is not to be eaten (FishBase). All the organs of this fish are considered to be toxic. It is, however, a popular food fish in China and fetches a premium price owing to its high quality meat.

Aquarium Value: This species is used as a component in brackish water aquarium and its aquarium parameters are given below.

Suitable Size of Fish: under 40 cm.

Minimal Tank Volume: 700 liters (185 US gal).

Water Conditions:

Temperature: 23°C (73.4°F)–26°C (78.8°F)

pH: 8–9

Water Hardness: 5–20 dKH

Floor Water Column: Entire water column.

Behavior: Aggressive.

Care Level: Very difficult.

Feeding: Carnivore.

Toxicity: The ovaries and blood are extremely toxic, while the liver, skin, and intestine are highly toxic. The flesh and testes are innocuous (Hardy et al., 2014). The cultured fish of this species in Korea and China however, has shown slight toxicity (<1 MU and <10 MU respectively (Nuñez-Vazquez et al., 2012).

Conservation Status: Least Concern.

***Takifugu ocellatus* (Linnaeus, 1758)**

Common Name(s): Ocellated puffer, orange saddle fugu puffer, saddleback puffer.

Habitat: Marine; freshwater; brackish; demersal; anadromous (migrating into freshwater rivers for reproduction during the spawning season); coastal areas and large estuaries; juveniles are found in brackish and fresh waters, but adults need marine conditions; depth range 1–25 m.

Global Distribution: Subtropical; Asia: China and Viet Nam.

Description: This species has an olive green back, a white belly and orange eyes. Just above and behind the pectoral fins, there are two thick black dots outlined in orange to yellow that are connected to each other by a thin line over the back. There is also a black dot outlined with orange to yellow about the dorsal fin of the fish. Gender differentiation is difficult to impossible but during breeding season, the bellies of the female are larger than the males. This species grows to a maximum total length of 15 cm.

Food Value: It is a deadly poisonous fish to eat (FishBase). This species however, is a popular food fish in China and fetches a premium price owing to its high quality meat (Hardy et al., 2014).

Aquarium Value: This species is found in the ornamental aquarium trade. This species is used as a component in brackish water aquarium and its aquarium parameters are given below.

Minimum Tank Size: 208.2 liters (55 US G.)

Suitable Size of Fish: 12.7–15.2 cm

Water Conditions:

Aquarium Hardiness: Moderately hardy.

Salinity (SG): 1.010–1.024 (later in life seawater).

pH: 7.8–8.5

Temperature: 23.3–26.7°C (74 -80°F)

Water Hardness: 8–12 dKH

Stocking Ratio: 1:1 M:F (male: female)

Availability: Rare.

Diet: Carnivore- live and frozen foods such as krill, snails, shrimp, scallops, mussels,bloodworms, clams and other shellfish.

Temperament: Aggressive.

Compatibility: Single species tank.

Care Level: Moderate.

Lifespan: 8–15 years.

Difficulty: Challenging.

Aquarist Experience Level: Advanced.

Aquarium Care: This species requires a large, heavily brackish to salt water aquarium with a fine sandy substrate and some rockwork, preferably live rock and plenty of swimming space. They enjoy burrowing into the sand where they can easily hide and ambush their prey. As they are fast swimmers and easily startled, they need plenty of swimming space.

Orange forms are extremely sensitive to ammonia and nitrites and they should only be introduced into a completely cycled aquarium. As these fishes are messy eaters, they should have an overcapacity filter on their tank along with a protein skimmer to remove unwanted pollutants and ensure water quality. This species has been successfully bred in captivity also.

Toxicity: Unknown.

Conservation Status: Not evaluated.

***Takifugu poecilonotus* (Temminck & Schlegel, 1850)**

Common Name(s): Finepatterned puffer.

Habitat: Marine; freshwater; brackish; demersal; euryhaline; near shore on rock bottoms; surf zone of sandy beaches; at depths ranging from 1 to 20 m.

Global Distribution: Temperate; Northwest Pacific: Japan and the southern Korean Peninsula; Taiwan.

Description: This species is diagnosed by its 10–13 anal soft rays, 14–17 pectoral soft rays and 12–15 dorsal soft rays. Body of this species is oblong and is covered with prickles. Brown with many irregular pale spots dorsally and white ventrally. It feeds mainly on mysids and gammaridean amphipods. This species grows to a maximum standard length of 20 cm.

Food Value: It is a poisonous species and is not to be eaten (FishBase). This species is incidentally harvested for food but is not targeted. Although it is sometimes marketed as "Komon-fugu" in Japan, this species displays a frequent occurrence of considerably high levels of TTX in its muscle tissue, and its preparation and consumption has been cited as a public concern. Despite a ban on the sale of toxic pufferfish in fish markets, this species may sometimes be found in processed fish products in Taiwan (Shao et al., 2014x).

Aquarium Value: This species is used as a component in brackish water aquarium and some of its aquarium parameters are given below.

Water Type: Brackish water.

Tank Size: 500 liters.

Temperature: 23–28°C

Food/Feed: Molluscs and crustaceans.

Toxicity: The ovaries and liver are extremely toxic, while the testes, skin, and intestine are highly toxic. The flesh is slightly toxic. In this species, the proportion of toxic specimens containing mouse units (MU) per gram exceeded 95% for the skin, liver, ovary, and fin, and approximately 30% for the testis and muscles. In each of the organs, the highest toxin levels were 79 MU/g in the muscle, hundreds (158–365) of MU per gram in the fin, intestine, testis, and gallbladder, but thousands (1,147–2,406) of MU per gram in the skin, liver, and ovary. These results suggest that the toxicity of muscle and skin of this species is significantly high, and special attention may be required when the fish is intended for human consumption (Kim et al., 2009). The relationship between toxicity and maturation was also investigated in this species based on changes in the gonadosomatic index: December-March in females and November-March in males, the 'maturation period'; April, 'just after spawning'; and the other months, the 'ordinary period'. Toxicity of both sexes was high throughout the year, but sharply declined just after the period of spawning. In all tissues examined (skin, liver, and ovary) other than testis, toxicity exceeded 1000 MU/g or 10,000 MU/individual in many individuals. Seasonal profiles of tissue toxicity differed markedly between sexes. In females, liver toxicity was high during the ordinary period, and ovary toxicity was high during the maturation period. In males, little maturation-associated change in the toxin distribution was observed (Ikeda et al., 2010). Saxitoxin, a paralytic shellfish toxin, was found in the livers, ovaries and digestive tracts of this species. This species is assumed to accumulate saxitoxin by feeding on bivalves that have ingested a toxic dinoflagellate *Protogonyaulax tamarensis*. Another toxic component is present in the liver of *T. poecilonotus,* but its structural relationship to tetrodotoxin or saxitoxin is questionable (Nakamura et al., 1984).

Conservation Status: Data deficient.

***Takifugu rubripes* (Temminck & Schlegel, 1850)**

Common Name(s): Japanese puffer, tiger puffer, ocellate pufferfish.

Habitat: Marine; freshwater; brackish; demersal; non-migratory; adults in inlet waters, occasionally entering brackish waters; fingerlings in brackish river mouths and move offshore with growth; juveniles tolerate salinities ranging from 25%–100% of that of seawater; depths of 100 to 135 meters and above on the continental shelf.

Global Distribution: Temperate; Northwest Pacific: western part of the Sea of Japan and the East China and Yellow seas northward to Muroran, Hokkaido, Japan.

Description: This species has an egg-shaped body and is covered with small spines starting from the middle of forehead to the beginning point of dorsal fin, and from the bottom of nostrils to the front of anus in the belly. Other part is smooth. Dorsal and anal fins are close to triangular shape and the end part is round. Edge of pectoral and caudal fins end is vertical-shaped and slightly convex. Jaw teeth look like birds' beak. Color of back is deep black and, belly is white. There are large black spots surrounded by white in upper end of pectoral fin and bottom of dorsal fin. Further, small, irregular-shaped black spots are also seen behind large spots located backside of pectoral fin. Dorsal, pectoral, and caudal fins are black while anal fin is white. This species grows to a maximum total length of 80 cm.

Food Value: It is a poisonous species and is not to be eaten (FishBase). However, the muscle of this species has been reported to contain TTX at 0.25 μg/g. This suggests that the muscle of this species is within the safe level (less than 10 MU or 2 μg) and is safe for human

consumption (Anraku et al., 2013). It commands a high price in Japan where it is the most desirable of all Fugu (Shao et al., 2014p).

Aquarium Value: This species is used as a component in brackish water aquarium and its aquarium parameters are given below.

Minimum Tank Size: 946.4 liters (250 US G.).

Suitable Size of Fish: 61–78.7 cm.

Water Conditions:

Specific Gravity (SG): 1.015–1.025

pH: 8.1–8.5

Temperature: 23.3–26.7°C (74–80°F)

Water Hardness: 8–12 dKH

Stocking ratio: 1:1 M:F (male: female)

Availability: Rare.

Diet: Carnivore.

Lifespan: 8–15 years.

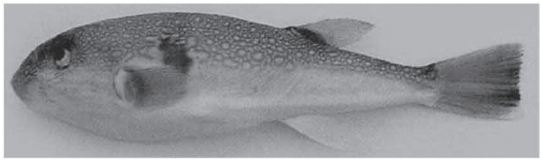
Difficulty: Challenging.

Toxicity: According to Shao et al. (2014p), the liver and ovaries of this fish are highly toxic, the intestines are slightly toxic and the flesh, skin and testes are innocuous. This species has been reported to accumulate 55.3 µg TTX per g. and 6.3 µg paralytic shellfish toxin (saxitoxin) per g. (Matsumoto et al., 2005). The cultured fish of this species however, has shown toxicity at 0.1 MU – 624 MU (Japan); and <1 MU - 125 MU (Korea and China) (Nuñez- Vazquez et al., 2012). In this species, the proportion of toxic specimens was 25.0% for the ovary, 15.8% for the liver, 11.1% for the gallbladder, and 5.3% for the fin and intestine. No toxicity was however, detected in the muscle, skin, or testis. Among the organs, the highest toxin levels were 228 MU/g in the ovary, followed by 112 MU/g in the liver, 28 MU/g in the gallbladder, 18 MU/g in the intestine, 11 MU/g in the fin, and 8 MU/g in the skin. An acceptable toxin levels in the edible muscle and skin of *T. rubripes* suggests that this species is harmless (Kim et al., 2006).

Fisheries Status: This species has commercial fisheries. It is cultured in a large scale in Japan, China and Thailand in floating cages and in land-based facilities.

Conservation Status: Not evaluated.

***Takifugu vermicularis* (Temminck & Schlegel, 1850)** (= *Takifugu vermicularis radiatus, Fugu vermicularis radiatus*)



Common Name(s): Purple puffer, pear puffer.

Habitat: Marine; demersal; nearshore waters (including semi-enclosed sea areas), creeks and estuaries; undergoes seasonal migrations.

Global Distribution: Temperate; Northwest Pacific: Japan to the East China Sea.

Description: Body of this species is without prickles. Brown vermiculations are seen dorsally and white ventrally. Pectoral and dorsal fins are yellow. Anal fin is white. Caudal fin is yellow with dark rays. This species grows to a maximum standard length of 30 cm.

Food Value: It is a poisonous species and is not to be eaten (FishBase). Anraku et al. (2013) however, reported that the TTX toxicity of the muscle of this species is at 8.43 μg/g and is within the safe level (less than 10 MU or 2 μg) for human consumption (Anraku et al. (2013). It is a highly valued food fish in Japan. This species is sold dried as a food fish. Despite a ban on the sale of toxic pufferfish in fish markets, *T. vermicularis* may sometimes be found in processed fish products in Taiwan.

Aquarium Value: Though this species is used as a component in brackish water aquarium, much of its aquarium parameters are unknown.

Suitable ***Size of Fish:*** Under 30 cm.

Tank Type*:* Marine tank.

Toxicity: The skin and intestine are highly toxic, and the ovaries and liver are extremely toxic. The flesh and testes are believed to be edible although they are slightly toxic, and sometimes highly toxic. This species also bioaccumulates saxitoxin, a paralytic shellfish toxin (Shao et al., 2014g). In this species, the proportions of toxic specimens were 100% for the gallbladder, and 56–68% for the skin, fin, liver, and intestine. However, no toxic muscle specimens were noted. The highest toxin scores were below 10 mouse units (MU) per gram in the muscle, 20–94 MU/g in the skin and fin, 319 MU/g in the intestine, and thousands (1,548–4,624) of MU per gram in the liver,

gonad, and gallbladder. The toxicity in the muscle of *T. vermicularis* was deemed acceptable for human consumption. These results suggest that the toxicity of the skin of this species is significantly high and special attention may be required when the fish is intended for human consumption (Kim et al., 2009). Further, in another study the ovary, testis, liver and muscle *Takifugu vermicularis radiatus* showed very strong toxicity, and intestine and skin had moderate toxicity. Their average toxicities were moderately toxic in all. Moreover, the toxicities of liver and intestine were stronger in Spring than Autumn. Judging from the results, *T. vermicularis radiatus* is considered to be very harmful fish. Consequently, it is necessary to take a proper preventive step against food poisoning by pufferfish ingestion (Jeon and Yoo, 1995). Saxitoxin, a paralytic shellfish toxin, was found in the livers, ovaries and digestive tracts of this species. This species is assumed to accumulate saxitoxin by feeding on bivalves that have ingested a toxic dinoflagellate *Protogonyaulax tamarensis*. Another toxic component is present in the liver of *T. poecilonotus*, but its structural relationship to tetrodotoxin or saxitoxin is questionable (Nakamura et al., 1984).

Fisheries Status: It has commercial fisheries.

Conservation Status: Not evaluated.

***Tetractenos glaber* (Fréminville, 1813)**

Common Name(s): Smooth toadfish.

Habitat: Marine; freshwater; brackish; demersal; coastal bays, often in very large schools, entering fresh water in estuaries; sandy and muddy bottoms; seagrass beds; depth range 0–20 m.

Global Distribution: Subtropical; Indo-West Pacific: southern Australia.

Description: Body of this species is moderately long and robust and is covered in minute embedded spines. Dorsal fin has 9 to 11 rays. Pectoral fin has 15 to 18 rays, the first of which is very short. It arises well below the level of the eye. Anal fin has 7–9 rays and caudal fin has 11. A distinct

skin-fold is seen along the lower sides, and body is tapering to a slender tail base. It is a small pale yellowish to greenish pufferfish, with dark brown irregular spots and blotches overlain with four darker bands and a white belly. The spots are elongated and become fewer on the lower sides. It feeds on molluscs and crustaceans of sand and mud. This species grows to a maximum total length of 16 cm.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 µg/g tissue). However, according to other reports, its flesh is highly poisonous and unfit for human consumption (Wikipedia).

Aquarium Value: This species is used as a component in brackish water aquarium and its aquarium parameters are given below.

Suitable Size of Fish: Under 15 cm.

Minimal Tank Volume: 200 liters (53 US gal).

Water Conditions:

Temperature: 23°C (73.4°F)–26 °C (78.8°F)

pH: 7.5–8.5

Water Hardness: 5–20 dKH

Floor Water Column: Entire water column.

Behavior: Aggressive.

Care Level: Moderately difficult.

Feeding: Carnivore.

Toxicity: Its toxicity is due to tetrodotoxin, which is concentrated particularly in the liver, ovaries, intestines and skin. Even leaving the fish where pets can eat it can be hazardous (Wikipedia).

Conservation Status: Not evaluated.

***Tetraodon fluviatilis* (Hamilton, 1822)**

Common Name(s): Green pufferfish.

Habitat: Freshwater; brackish; demersal; usually in slow-moving rivers, estuaries and the upper reaches of backwaters; prefers shady, marginal areas; potamodromous.

Global Distribution: Tropical; Asia: India, Sri Lanka, Bangladesh, Myanmar and Borneo; Mekong delta.

Description: Body of this species is oblong and is compressed laterally except in fleshy specimens. Dorsal profile is arched and is highest at midst of back. Interorbital is convex, without a groove. Lateral line system is distinct. Body spines are small. Sometimes they are very distinctly two-based and sometimes they are partly or wholly indistinct. These spines are covering back, sides, and belly between eyes and origin of dorsal fin. Origin of anal fin is situated beneath anterior half of dorsal fin base. Mouth is terminal and is directed forward. Lower border of eye is slightly above or below level of mouth corner and upper border is not interfering with dorsal profile. Nasal organ is a tentacle, more than distal half of which is divided in two flattened and broadened lobes. Ground colors of upper parts are tan and belly is yellowish white. Three large yellowish encircled dark patches are seen on back between eyes and dorsal fin. Anterior patch is on posterior half of head, middle patch is between pectoral fins and posterior patch is in front of dorsal fin. Middle dorsal patch is occasionally broken up into two smaller patches. Anterior half of head is variably colored, often it is irregularly dark. Sides are with 5–28 rounded, mostly ocellated, dark spots. Belly is uniformly yellowish white or with same but confluent spots as on sides. Crossbars are seen on caudal fin. Sometimes a small dark spot may be seen on interior side of pectoral fin base. Other fins are plain. It feeds on molluscs, crustaceans and other invertebrates as well as vascular plants and detritus. Occasionally it feeds on fish scales and fins. It lays 200 eggs which are attached to a hard, flat submerged surface in shallow water. A parent guards the eggs until hatching. Adults have been observed tending schools of fry. It grows to a total length of 17 cm.

Food Value: It is a poisonous species and is not to be eaten (FishBase). All the organs of this fish are considered to be toxic

Aquarium Value: This species is used as a component in commercial, brackish water aquarium and its aquarium parameters are given here.

Aquarium Size: 120 cm x 30 cm x 30 cm – 110 liters.

Water Conditions:

Temperature: 75–82°F (24–28°C)

pH: 7.8–9.0

Hardness: 10–30°H

Specific Gravity (SG): 1.005–1.010

Diet: It relishes all kinds of shellfish, as well as worms and other live and frozen foods. It should be fed snails and unshelled shellfish (such as crab legs, mussels, etc.) regularly, in order to maintain its sharp teeth. As with other puffers, these grow continuously and become a problem for the fish if they are not kept ground down.

Usual Place in the Tank: Bottom levels.

Temperament to Its Own Species: Aggressive/territorial.

Temperament Toward Other Fish Species: Aggressive/territorial.

Maintenance: This species requires brackish water, although it can also tolerate full marine conditions. Some cover in the form of rocks and pieces of driftwood should be provided, along with a sandy substrate. It also enjoys plant cover, and tough species such as java fern may survive in mildly saline water. Plastic plants also make a fine alternative. It is very sensitive to deteriorating water conditions, so regular partial water changes are essential.

Behavior and Compatibility: It is a somewhat intolerant species and is not a particularly good community fish. It will often harass and nip the fins of tank mates. In a large aquarium, possible choices include robust, active species such as scats, archerfish, and Arius catfish (http://www.seriouslyfish.com/species/tetraodon-fluviatilis/). It is not a good idea to keep more than one of these per tank unless a lot of space is available, as they are usually aggressive toward conspecifics.

Sexual Dimorphism: Unknown.

Reproduction: This species has been spawned in aquaria, but little information is available. The female lays her eggs on a flat surface, and these are then guarded by the male until they hatch.

Toxicity: The muscular tissue and viscera of this species are extremely toxic.

Fisheries Status: There are no commercial fisheries for this purpose.

Conservation Status: Not evaluated.

***Tetraodon mbu* (Boulenger, 1899)**

Common Name(s): Mbu puffer, giant puffer, or giant freshwater puffer, freshwater pufferfish.

Habitat: Freshwater; brackish; demersal; large rivers and lakes; estuaries.

Global Distribution: Tropical; Africa: widely distributed in Lake Tanganyika and the Congo basin.

Description: This species has a conical shaped body and scaleless tough skin. Tiny spines are seen except on the round snout and lower beginning of the tail fin. There are two forked nasal openings on either side of the head. Dark green/lighter green and yellow patterns are on back. Belly is yellowish or white. It lightens/darkens color with mood and is also able to change patter to camouflage. If dark patches are seen on under belly, then it is the sign of ill health/stress. When swimming vigorously, the fantastic and striped tail of this fish is either folded or well displayed. It grows to a maximum total length of 67 cm.

Food Value: It is a poisonous species and is not to be eaten (FishBase). All the organs of this fish are considered to be toxic

Aquarium Value: It is a component of brackish aquarium and its aquarium parameters are given below.

Aquarium Size: 240 cm x 90 cm x 90 cm) – 2040 liters to house an adult fish (Juveniles can be grown on in smaller tanks, but this fish grows quickly).

Maintenance: This puffer does not require the addition of salt to its tank. Sandy substrate needs to be provided with smooth rocks and drift-

wood pieces for decoration. Plenty of open space is left for swimming. It is also better to create a bamboo zone by fixing bamboo stalks to the bottom.

Water Conditions:

Temperature: 75–79°F (24–26°C)

pH: 7.0–8.0

Hardness: 10–25°H

Temperament to Its Own Species: Aggressive/territorial.

Temperament Toward Other Fish Species: Aggressive/territorial.

Usual Place in the Tank: Bottom levels.

Diet: It relishes all kinds of shellfish, as well as worms and other live and frozen foods. It should be fed snails and unshelled shellfish (such as crab legs, mussels, etc.) regularly, in order to maintain its sharp teeth.

Behavior and Compatibility: A generally aggressive and intolerant species that should be kept alone. Its beak-like mouth can easily bite chunks from other fish, or in extreme cases rip them to pieces. However, some fishes of this species are less aggressive than others.

Sexual Dimorphism: There are no external sexual differences.

Reproduction: Breeding is not possible in aquaria. An enormous volume of water may be required for breeding purposes.

Toxicity: Unknown.

Fisheries Status: There are no commercial fisheries for this species.

Conservation Status: Least Concern.

***Torquigener pallimaculatus* (Hardy, 1983)**

Common Name(s): Orange-spotted toadfish, multi-spotted toadfish.

Habitat: Marine; demersal; coastal bays and estuaries; sandy and muddy substrates; depth range 7–78 m.

Global Distribution: Tropical; Western Pacific: northwestern Australia; Chesterfield Islands, New Caledonia and Papua New Guinea.

Description: Body of this species is elongated, rounded dorsally and flattened ventrally. It is tapering to a narrow caudal peduncle. Mouth is small and terminal. Lips are thin and are covered with many short papillae. Chin is prominent. Eye is moderate, slightly elongate and dorsally adnate. Dorsum is moderately covered with short spines to just before dorsal fin. Small to moderately large, irregularly rounded pale spots, delineated by small dark dots are also present in dorsum. Small dark dots (occasionally larger), which are densely scattered over a greyish –brown ground color are extending to dorsolateral surface. Cheeks are with small moderately brown spots which are becoming larger ventrally. Dorsal, anal and pectoral fins are pale. Caudal fin darkens distally. This species grows to a maximum standard length of 18 cm.

Food Value: This species is venomous (FishBase) and is not utilized.

Aquarium Value: The suitability of this fish for aquarium is unknown.

Toxicity: Toxicity studies made in the fishes of this species of the Malaysian waters have shown that the TTX concentration of liver and skin was at 260 µg/g, and 29.1 µg/g, respectively (Azman et al., 2014).

Conservation Status: Not evaluated.

***Torquigener parcuspinu*s (Hardy, 1983)**

Common Name(s): Yellow-eyed toadfish.

Habitat: Marine; demersal; coastal areas.

Global Distribution: Tropical; Eastern Indian Ocean: Indonesia and northwestern Australia; Papua New Guinea.

Description: Body of this species is elongated, rounded dorsally and flattened ventrally. It is tapering to a narrow caudal peduncle. Mouth is small and terminal. Lips are thin and are covered with many short papillae. Chin is prominent. Eye is moderate, elongate and dorsally adnate. Pectoral fin is dorsally elongated and rounded. Dorsal fin is elongated

bluntly pointed and is based above vent. Ventrolateral skin fold extends from behind pectoral fin margin to caudal fin. Lateral line is distinct with small associated papillae. It is devoid of strong markings. Dorsally many very small black spots are present from snout to caudal fin base with some larger but poorly defined brown spots superimposed. Cheeks are densely covered with small and irregularly sized, dark spots particularly behind mouth. Belly is generally pale. Some spotting is seen on bottom lip, behind chin and before vent. All fins are pale. It grows to a maximum total length of 10 cm.

Food Value: This species is venomous (FishBase) and is not utilized.

Aquarium Value: The suitability of this fish for aquarium is unknown.

Toxicity: Unknown

Conservation Status: Not evaluated.

***Torquigener pleurogramma* (Regan, 1903)**

Common Name(s): Weeping toad fish, striped toadfish, common blowfish, banded toadfish.

Habitat: Marine; brackish; demersal; estuaries and coastal waters; sandy, unvegetated intertidal area; depth range 1–30 m.

Global Distribution: Subtropical; Eastern Indian Ocean: southern Australia, from Western Australia to New South Wales.

Description: This species can be recognized by the dark stripe along the side of the body and the vertical "tear lines" across the cheek. Like all the toadfishes it has fused beak-like teeth. It lives to about six years, attains a maximum size of 23 cm, and is sexually mature at the end of its second year of life, at about 12 cm total length. It is an opportunistic species feeding on a wide variety of organisms such as polychaetes and amphipods (for fish smaller than 13 cm), and bivalve molluscs (for larger fish). This species has a maximum total length of 21 cm.

Food Value: It is a poisonous species and is not to be eaten (FishBase). All the organs of this fish are considered to be toxic. It is sometimes so abundant as to become a nuisance (Shao et al., 2014j).

Aquarium Value: This species is used as a component in brackish water aquarium and its aquarium parameters are given below.

Size of Fish for Tank: under 21 cm.
Minimal Tank Volume: 300 liters (79 US gal).
Water Conditions:
Temperature: 23°C (73.4°F)–26 °C (78.8°F)
pH: 7.5–8.5
Water Hardness: 5–20 dKH
Floor Water Column: Entire water column.
Behavior: Aggressive.
Care Level: Very difficult.
Feeding: Carnivore.
Toxicity: Unknown.
Fisheries Status: It has no commercial fisheries.
Conservation Status: Not evaluated.

3.2.2 LESS TOXIC (HARMLESS) BRACKISH WATER PUFFERFISH

Kingdom: Animalia *Phylum:* Chordata
Subphylum: Vertebrata *Class:* Actinopterygii
Order: Tetraodontiformes *Family:* Tetraodontidae

***Arothron manilensis* (Marion de Procé, 1822)**

Common Name(s): Striped puffer, narrow-lined toadfish.

Habitat: Marine; brackish; shallow coastal slopes, estuaries, sheltered reef flats, muddy substrates and lagoons; seagrass beds and sand; depth range 2–20 m.

Global Distribution: Tropical; western Pacific from east of Borneo and Bali, Philippines south to northern Australia/New South Wales, Australia to Micronesia, Samoa, Tonga, and Fiji, north to the Pacific coast of Japan and the Ryukyu Islands.

Description: The species is identified by the distinctive arrangement of dark, narrow longitudinal lines on the dorsum and flanks. Body color is pale brown to white, and the tail is creamy, or sometimes yellow, edged with black. It feeds on detritus, crabs, small benthic crustaceans, plant material, shrimp, and gastropods. This species grows to a maximum length of 31 cm.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 μg/g tissue). This species is consumed in Japan and is a component of the international pufferfish trade.

Aquarium Value: This species is a component of the marine aquarium trade. It has the following aquarium requirements:

Minimum Tank Length/Size: 125 gallon.

Water Conditions:

Temperature: 72–78°F,

dKH: 8–12

pH: 8.1–8.4

Specific gravity (SG): 1.020–1.025

Diet: Carnivore; variety of meaty food including squid, krill, clams, and hard-shelled shrimp.

Social Behavior (temperament): Aggressive.

Care Level: Easy.

Aquarium Setup: The ideal setup should be an established aquarium with good filtration and a protein skimmer. Aquascape is liberally with live rock and other materials to create an environment rich with nooks and crannies, caves and overhangs while preserving easy access to large open areas. Fish of similar size and temperament should be housed.

Toxicity: It contains considerable amounts of PSP toxins (major component, STX) besides tetrodotoxin (TTX). The toxicity has been

detected in the liver, intestine, muscle and skin of this species (Egmond et al., 2004). Toxicity studies made in the fishes of this species of the Malaysian waters have shown that the TTX concentration of liver muscle and skin was at 50.2 µg/g, 133 µg/g and 10.8 µg/g, respectively (Azman et al., 2014).

Fisheries Status: This species is taken as bycatch in prawn fisheries in the Torres Straight Prawn Fishery in north eastern Australia, which utilizes otter trawls at depths ranging from 12–88 m.

Conservation Status: Not evaluated; Least Concern.

***Arothron reticularis* (Bloch & Schneider, 1801)**

Common Name(s): Reticulated puffer, reticulated blow fish, reticulated toadfish, striped puffer.

Habitat: Marine; brackish; reef-associated; shallow water reefs near sand or seaweed areas; estuaries and protected muddy bays; juveniles in mangroves and entering the lower reaches of streams; adults at moderate depths, often laying on the mud during the day; depth range 1–25 m.

Global Distribution: Tropical; Indo-West Pacific: north to Ryukyu Islands.

Description: Head and body of this species are covered with small spinules except for snout. Nasal organ is with 2 bifid fleshy flaps. White lines are encircling eye. Body is greenish brown to dark brown dorsally, paler ventrally. Many longitudinal dark brown lines are running on body. Dorsal and anal fins are yellowish. Pectoral fins are pale with yellow rays. Caudal fin is yellowish brown with dark margin. *Arothron reticularis* is primarily carnivorous, feeding on corals, molluscs, and other

sand-dwelling invertebrates. It also feeds on seagrass and mangroves. This species grows to a maximum length of 43 cm.

Food Value: It is a harmless species (FishBase). The muscle of this species is within the safe level (less than 10 MU or 2 μg) and is safe for human consumption (Anraku et al., 2013).

Aquarium Value: It is a component of the marine aquarium trade. The required aquarium parameters are:

Minimum Tank Size: 150 gallons.

Water Conditions:

Temperature: 72–78°F

dKH: 8–12

pH: 8.1–8.4

Specific Gravity (SG): 1.020–1.025

Diet: Carnivore; corals and benthic invertebrates; enriched meaty diet, e.g., brine shrimp, earthworms, tubifex worms, chunky fish and shrimp flesh.

Care Level: Easy.

Temperament: Semi-aggressive

Other Requirements: numerous daily feedings and plenty of swimming space.

Avoidance: Not safe with tubeworms and/or, can become finnippers.

Aquarium Setup: The ideal aquarium setup should be with good filtration and a protein skimmer. Aquascape may be liberally with live rock and other materials to create an environment rich with nooks and crannies, caves and overhangs, while preserving easy access to large open areas.

Toxicity: The TTX toxicity has been detected in the liver, intestine, muscle and skin of this species. It also contains considerable amounts of PSP toxins (major component, STX) (Egmond et al., 2004). The muscle of this species has been reported to contain TTX at 0.19 μg/g. The detailed toxicity of this species is however, unknown (Shao et al., 2014l).

Fisheries Status: There is no commercial fishery for this species.

Conservation Status: Not evaluated.

***Chelonodon laticeps* (Smith, 1948)**

Common Name(s): Bluespotted blaasop.

Habitat: Marine; brackish; demersal; weedy areas of quiet waters; inshore, mangrove areas and seagrass beds; eelgrass (*Zostera capensis*) beds; open estuaries.

Global Distribution: Tropical; Western Indian Ocean: 6°S to Xora River mouth, South Africa. Western Central Pacific: Papua New Guinea.

Description: This species is diagnosed by its dorsal fin rays (10); anal fin rays (7–9) and pectoral fin rays (16–18). Body is relatively short and ovoid in cross section. Dorsal surface of the body is covered with spinules from posterior part of interorbital region to just dorsal to pectoral fin base (distance between posterior most spinule and dorsal-finorigin 16.4–47.0% standard length). Ventral surface of body is covered with spinules from throat to just anterior to anus. Dorsal and anal fins are short and slightly pointed. Pectoral fin is fan- shaped and caudal fin is rounded. Nasal organ is with two skin flaps, the posterior flap is larger than the anterior one. Body is light yellowish brown with many bluish to whitish spots on side and dorsum. Ventral side is whitish. Four transverse dark brown bands are seen on back. First band is seen across interorbital region and last on caudal peduncle. It grows to a maximum total length of 20 cm.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 μg/g tissue). It does not appear to be utilized**.**

Aquarium Value: This species is used as a component in brackish water aquarium and its aquarium parameters are given below.

Size: under 20 cm.

Minimal Tank Volume: 300 liters (79 US gal).
Water Conditions:
Temperature: 23°C (73.4°F)–26°C (78.8°F)
pH tolerance: 7.5–8.5
Water Hardness: 5–15 dKH
Floor Water Column: Entire water column.
Feeding: Carnivore.
Behavior: Aggressive.
Care Level: Very difficult.
Toxicity: Unknown.
Conservation Status: Not evaluated.

***Colomesus asellus* (J. P. Müller & Troschel, 1849)**

Common Name(s): Amazon puffer, assel puffer, South American freshwater puffer, Peruvian puffer.

Habitat: Penetrating into tributaries of the upper Amazon; does not tend to be found in highly acidic black-waters; lower, middle, and upper river basins with habitats including sandbars, beaches, floodplain lakes, banks with overhanging vegetation, and fast-flowing rapids over bedrock, boulders, and stones; from habitats with high oxygen levels, suggesting that it may be sensitive to low oxygen availability.

Global Distribution: Tropical; South America: Amazon River basin from Peru to Marajó Island, including tributaries Araguaia and Guaporé Rivers; Orinoco River basin near the mouth; Essequibo River basin.

Description: The coloration of this fish is green above, white below, and patterned with black transverse bands across the dorsal surface. These black bands on the back are much thicker, and it also has a distinctive

black band that rings the base of the caudal fin. This species grows to a length of 12.8 cm in standard length.

Food Value: It is a harmless species (FishBase). However, it is also considered as poisonous and venomous. Further, this species is poorly known by science, since there are not studies concerning its biology, behavior, ecology and toxicity**.**

Aquarium Value: This species is used as a component in brackish water aquarium and its aquarium parameters are given below.

Usual Fish Size in Tanks: 10–14 cm

Tank Size: Minimum Tank Size: 15 US Gallons (55 liters).

Lighting Needs: Moderate - normal lighting.

Water Conditions:

Water Chemistry: Freshwater, ideally soft and slightly acidic.

pH range: 5.9–5.9

Water hardness (dGH): 3–17°N (53.57–303.57ppm)

Specific Gravity (SG): 1.005 (sometimes brackish).

Temperature: 24–27 °C (75.2–80.6°F)

Usual Place in the Tank: Middle levels.

Diet: Carnivore eating meaty food; live and frozen foods (not fish); snails, freeze-dried krill, frozen shrimp, black and bloodworms; live or frozen, ghost shrimp (gut-loaded); and other molluscs and crustaceans. These puffers must be fed a daily diet of snails to prevent beak overgrowth.

Sexual Dimorphism: Not known (no visible sexual differences).

Breeding: There are no reports of breeding in tank.

Estimated Lifespan: 10+ years.

Aquarium Setup and Maintenance: This species does not require a large aquarium, so a 15 gallon aquarium will be enough. However, for keeping more than one or some other species with them, a well planted 20–30 gallon aquarium is ideal. It is important to have some rotating power heads to create current in the aquarium. A larger canister filter that will turn the tank water over 6 to 10 times per hour is recommended. This type of filtration will also help with water movement. The substrate for the tank should be made up of sand; puffers enjoy rooting around in the sand. Planting of tall, twisted rooted plants throughout the tank and especially each corner may cut down the reflection. These plants will

also provide needed cover and swimming area. Some floating drift wood may also be provided in the tank to make them feel secure. The top of the tank should have a secure complete cover as these fishes are great jumpers.

Water Chemistry and Quality: As with all pufferfish, water quality should be good for this species.This species is considered hardy, and is certainly less sensitive to nitrate. However, generous filtration and regular water changes are essential. Taking into consideration their need for strong water current, canister filters providing water turnover of 6–10 times the volume of the tank per hour are in order. About 25–50% of the water has to be changed per week, aiming for less than 20 mg/l nitrate if possible.

Social Behavior: Unlike almost all other freshwater pufferfish, these fishes are not territorial and exhibit no aggressive behavior towards their own kind or other species. They seem to be nervous when kept singly, and become much less "neurotic" when kept in groups. During the daytime, fish will follow one another around briefly, often squabbling over food; but at night (or if alarmed) they will settle on the substrate as a group. It is always advisable to to keep these puffers in groups of three or more specimens.

Health Care: These puffers are very prone to white spot (Ich) and show the symptoms such as "flashing" against rocks and the white cysts on the skin. Treatment needs to be very prompt if serious problems are to be avoided. As a measure of treatment, salt may be added to the aquarium at a dose of 3 g/l and raising the temperature to around 28°C should kill the parasites. This species has peculiarly fast-growing teeth and there is a need to "trim" the teeth one or more times per year. Essentially this involves sedating the fish by placing it into a container of water where clove oil (eugenol) has been added at a dose of 2–4 drops per liter. After about a minute, the puffer should be drowsy for easy handling. Using wet hands, the fish is to be grasped carefully, and cuticle clippers are used to nip off the points from the upper and lower parts of the "beak". After this exercise, the fish is put back into the net, and the net is hanged in the aquarium so that fish is bathed in the water current. After a short while, it will be ready to be released (Childs et al., http://animal- world.com/encyclo/fresh/Puffers/AmazonPuffer.php).

Tank Mates: The safest tank mates of this species are those that hide all day (like Synodontis catfish) and those that are very fast swimmers (such as glassfish and bleeding heart tetras). Species-only tank of 125–180 liter size is more suitable for about 6 fishes.

Toxicity: The HPLC profile of the extracts of this species showed no traces of TTX, but only the presence of PSPs (STX, GTX 2 and GTX 3) (Oliveira et al., 2006).

Conservation Status: Not evaluated.

***Colomesus psittacus* (Bloch & J. G. Schneider, 1801)**

Common Name(s): Banded puffer, parrot puffer, South American estuarine puffer.

Habitat: Marine; freshwater; brackish; demersal; shallow inshore waters usually on soft bottoms; depth range up to 40 m.

Global Distribution: Tropical; Western Atlantic: Gulf of Paria to the Amazon River in Brazil.

Description: Body of this species except for snout, pectoral base and caudal peduncle is covered with prickles. Teeth are fused into plates and there are two plates on each jaw. Nostril is with two openings. Body is dark green dorsally with six transverse black bars, and white ventrally. Fins are dusky green or dark brown. It is carnivorous, feeding mainly on molluscs. This species is solitary or in groups of 2 or 3 individuals but never in schools. When threatened, it becomes inflated like a balloon, in order to ward off its predators. This species grows to a maximum standard length of 28.9 cm.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 µg/g tissue).

Aquarium Value: It is a component of commercial, brackish water aquariums and its aquarium parameters are given below.

Difficulty: Moderate.

Minimum Tank Size: 378.5 liters (100 US G.)

Salinity: Freshwater, brackish, marine.

Suitable Fish Size in Tank: 25.4–30.5 cm.

Water Conditions:

Specific Gravity (SG): 1.010–1.020

pH: 7.0–8.3

Temperature: 24–26 °C (75.2–78.8°F)

Water Hardness: 8–10 °d (149–447 ppm)

Stocking Ratio: 1:1 M:F (male: female)

Lifespan: 5–15 years.

Aquarium Size: An aquarium measuring 180 x 60 x 60 cm is recommended as a bare minimum, but even this may be small for long-term care.

Aquarium Maintenance: The aquarium should be maintained in a well-decorated setup with some driftwood roots or branches in order to mimic its natural mangrove habitats. Moderate levels of dissolved oxygen and water movement are also recommended. For this purpose, additional power heads, pumps, etc., should be employed if necessary. A linear flow pump may be useful while weekly water changes of 30–50% should be considered mandatory. Maintenance in pure freshwater may also present problems, so the addition of marine salt to a standard gravity of ≥1.010 is recommended.

Diet: It is chiefly carnivorous and feeds exclusively on molluscs and crustaceans such as barnacles and crabs.

Behavior and Compatibility: Because of its large size and need for salt water, this species is rarely kept in home aquaria. It is not a schooling species and may be aggressive towards others of its species. So it is usually kept alone.

Sexual Dimorphism: Unknown.

Reproduction: Unrecorded.

Toxicity: This species is known to have edible flesh but its liver is toxic. It is not known whether it contains saxitoxin or tetrodotoxin (as is the case with many marine puffers) (Wikipedia).

Conservation Status: Not evaluated.

***Contusus brevicaudus* (Hardy, 1981)**

Common Name(s): Prickly toadfish.

Habitat: Marine; brackish; mudflats, seagrass beds, and rocky reefs systems; bays, estuaries and along the coast, in depths of 0–20 m.

Global Distribution: Subtropical; Eastern Indian Ocean: southern Australia, from Western Australia to New South Wales, including Tasmania.

Description: Body of this species is robust, rounded, elongate and is tapering to a short, narrow caudal peduncle. Mouth is small, and terminal on a short snout. Lips are thick and covered with many short papillae. Chin is absent. Eye is moderate and round. Pectoral fins are rounded. Dorsal fin is wide and bluntly pointed. Caudal fin is truncate. Ground color of dorsum is pale grey to yellowish. A number of moderate sized, poorly defined greyish to medium brown spots are seen on back. Pectoral fin base is generally darker. Remaining lateral surface and belly are without spots. Fins are pale yellowish. It is a carnivorous fish eating live and frozen foods. Reproduction of this species is unknown. It grows to a maximum length of 25 cm (Hardy, 1981).

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 μg/g tissue).

Aquarium Value: This species is suitable for marine and brackish water aquariums and its aquarium parameters are given below.

Suitable Fish Size for Tank: under 25 cm.

Minimal Tank Volume: 300 liters (79 US gal).

Water Conditions:

Temperature: 23°C (73.4°F)–26 °C (78.8°F)

pH: 7.5–8.5

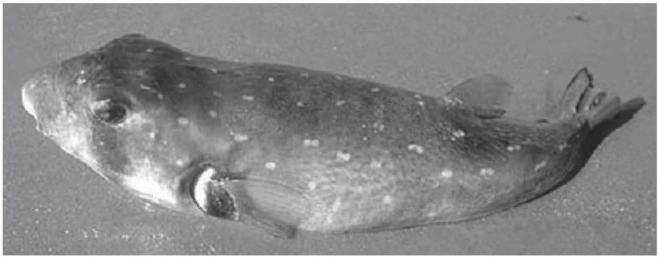
Water Hardness: 5–15 dKH

Floor Water Column: Entire water column
Behavior: Aggressive
Care Level: Very difficult
Food: Carnivore – both live and frozen.
Reproduction: Unknown.

Toxicity: Ingestion of tetrodotoxin (presynaptic neurotoxin) present in the liver of this species may be potentially lethal. Poisoning of this species has lead to the rapid development of flaccid paralysis, respiratory failure, hypotension and shock in humans (http://www.toxinology.com/fusebox.cfm?fuseaction=main.marine_vertebrates.display&id=MV00281).

Conservation Status: Not evaluated.

***Ephippion guttifer* (Bennett, 1831)**



Common Name(s): Prickly puffer, common puffer, globefish.

Habitat: Marine; brackish; demersal; common in shallow coastal waters, and also in estuaries; bays and lagoons, as well as in offshore trawling stations; associated with a variety of habitats including hard substrates and muddy bottoms; depth range 10–100 m.

Global Distribution: Subtropical; Eastern Atlantic: Gibraltar and extreme western Mediterranean southward along the entire west coast of Africa to Angola, near Benguela.

Description: This species is diagnosed by its dorsal fin rays (9–11) and anal fin rays (8–10). Upper lateral line is not reaching end of tail, curving down above anal and meeting lower lateral line. Bony plates are seen on back. Sides are with spines, also on throat and anterior part of abdomen in adults. One nostril is present on each side of snout. Caudal fin is truncate or slightly concave. Color of body is brown above, with white round spots. Belly is paler or white. It feeds on crabs, echinoids and molluscs. It

reaches a maximum standard length and total length of 50 cm and 80 cm, respectively. Its maximum published weight is 4.3 kg.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 μg/g tissue). It does not appear to be consumed.

Aquarium Value: It is a commercial, brackish water aquarium fish and game fish. Its aquarium parameters are given below.

Tank Size: 2199.78 gal (~ 10,000L). This species need a very large aquarium when fully grown.

Suitable Fish Size: 55–80 cm.

Water Conditions:

Temperature: 71.6–80.6°F (22–27°C)

Specific Gravity (SG): 1,020–1,025

pH: 8.0–8.3

Food: Crabs, clams, snails, starfish and fish (little fishes).

Suitable for Aquarium: Not suitable for home aquarium aquariums due to it's size and demands.

Behavior: Peaceful fish.

Degree of Difficulty: Only for advanced aquarists.

Toxicity: This species has a toxin in its skin, which it releases when highly stressed or dying. This poison can kill all the aquatic life in the aquarium.

Conservation Status: Not evaluated.

***Lagocephalus spadiceus* (Richardson, 1845)**

Common Name(s): Half-smooth golden pufferfish.

Habitat: Marine; brackish; demersal; oceanodromous; essentially in marine waters, but enters the mouths of rivers; over sandy bottoms in shallow waters less than 50 m

Global Distribution: Subtropical; Indo-West Pacific: Red Sea, South Africa, Australia. Introduced (Lessepsian) in eastern Mediterranean, Israel, Lebanon, Iskenderun, Mersin, Aegean Sea.

Description: This species is diagnosed by its dorsal fin rays (12), anal fin rays (12) and pectoral fin rays (17). Body is elongated and inflatable. Dorsal and anal fins are short based, both located posteriorly. There are no pelvic fins. Mouth is small and terminal. There are two large teeth in each jaws, with median suture. Two lateral lines are found curving around eyes. There are no scales on the body, but small spinules are seen on nape, interorbital (not extending beyond pectoral fin) and on belly. Body is dark green on the dorsum, silvery yellow on the sides and whitish below. It feeds on crustaceans, molluscs and fishes. This species has a maximum total length of 43.1 cm.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 µg/g tissue). However, this species has long been used as food in many localities of the indo-Pacific, such as Japan, Thailand, Malaysia, etc. It is an ingredient in fish balls. It is harvested for human consumption in East and Southeast Asia.

Aquarium Value: This species is used as a component in brackish water aquarium and its aquarium parameters are given below.

Suitable Size of Fish: under 30 cm.

Minimal Tank Volume: 400 liters (106 US gal).

Water Conditions:

Temperature: 23°C (73.4°F)–26 °C (78.8°F)

pH: 7,8–9

Water Hardness: 5–20 dKH

Floor Water Column: Entire water column.

Behavior: Aggressive.

Care Level: Very difficult.

Feeding: Carnivore.

Toxicity: Internal organs of this species such as liver, gall bladder and sexual organs are very toxic and are potentially lethal to humans (FishBase). Toxicity studies made in the fishes of this species of the Malaysian

waters have shown that the TTX concentration of liver, muscle and skin was at 8.09 µg/g, 8.71 µg/g and 1.71 µg/g, respectively (Azman et al., 2014).

Conservation Status: Not evaluated.

***Marilyna darwinii* (Castelnau, 1873)**

Common Name(s): Darwin toadfish.

Habitat: Marine; brackish; demersal; mud bottom areas frequently in mangrove estuaries or the lower reaches of freshwater streams; depths ranging from zero to 10 m.

Global Distribution: Tropical; Western Central Pacific: Papua New Guinea.

Description: Body of this species is robust, broadly rounded, dorsally and flattened ventrally. It is also elongated and is tapering to a deep caudal peduncle. Mouth is small and terminal on a short snout. Lips are thick and are covered with many short papillae. Chin is lacking. Eye is round and moderate in size. Its rim is completely adnate with the upper border just below the dorsal profile. Pectoral fin margin is rounded. Dorsum is greenish-yellow with grey mottling. Three broad dark bands cross dorsum between eyes at mid-dorsum and at dorsal fin base. Belly and chin are white. All fins are bright yellow. A new mesoparasitic, ergasilid copepod *Majalincola buthi* (Copepoda: Cyclopoida) has been isolated from the gills of this species (Tang and Kalman, 2008). This species grows to a maximum length of 9.5 cm.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 µg/g tissue).

Aquarium Value: This species is used as a component in brackish water aquarium and its aquarium parameters are given below.

Suitable Size of Fish: under 17 cm.
Minimal Tank Volume: 300 liters (79 US gal)
Water Conditions:
Temperature: 23°C (73.4°F)–26 °C (78.8°F)
pH: 7.5–8.5
Water Hardness: 5–15 dKH
Salinity: Brackish – Marine (same salinity where the fish is caught is preferable).
Diet: Carnivore -frozen bloodworms, crustacean meat; sea fans, fleshy plants and corals; live snails.
Floor Water Column: Entire water column
Behavior: Peaceful with other species of puffers, fish and large invertebrates.
Care Level: Moderately difficult.
Feeding: Carnivore.
Sexual Dimorphism: Unknown.
Estimated Lifespan: Unknown 6–10 years
Care: Not much is known about its care.
Toxicity: Unknown.
Conservation Status: Not evaluated.

***Marilyna meraukensis* (de Beaufort, 1955)**

Common Name(s): Merauke toadfish.
Habitat: Brackish; demersal; brackish mangrove estuaries; tidally influenced sections of freshwater creeks and rivers.
Global Distribution: Tropical; Western Pacific: central-southern New Guinea and northern Australia.

Description: Body of this species is robust, broadly rounded dorsally and flattened ventrally. It is also elongated, tapering to a deep caudal peduncle. Mouth is small and terminal on a short snout. Lips are thick, covered with numerous short papillae. Chin is lacking. Nasal organ is a short flattened papilla, which is posteriorly just level with eye. This organ is with 2 widely separated openings, the posterior one larger. Inner surface of papilla is with a large fold located posteriorly on medial portion and about 4 smaller folds located posteriorly on the ventral portion. Eye is round and moderate in size and its rim is completely adnate, with the upper border just below dorsal profile, and the lower border just above level of mouth corner. Pectoral fin margins are rounded. Base color is pale or greyish-brown, usually with dense dorsal covering of small, irregular brown spots. These are especially distinctive in younger specimens but tend to lessen in intensity in larger forms. A dark patch is seen at base of pectoral fin, otherwise fins and belly are pale. It grows to a maximum standard length of 19 cm. A new species of copepod parasite, *Taeniacanthus kiemae* has been described from the branchial cavity wall of this species (Tang, 2011).

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 μg/g tissue).

Aquarium Value: This species is used as a component in brackish water aquarium and its aquarium parameters are given below.

Suitable Fish Size: under 17 cm.

Minimal Tank Volume: 300 liters (79 US gal).

Water Conditions:

Temperature: 23°C (73.4°F)–26 °C (78.8°F)

pH: 7.5–8.5

Water Hardness: 5–15 dKH

Tank Type: Brackish water tank.

Floor Water Column: Entire water column.

Behavior: Aggressive.

Care Level: Moderately difficult.

Feeding: Carnivore.

Toxicity: Unknown.

Conservation Status: Not evaluated.

Marilyna pleurosticta (Günther, 1872)

Common Name(s): Banded toadfish.

Habitat: Marine; freshwater; brackish; demersal; anadromous; associated with a variety of habitats, including vegetated areas and mangroves; very shallow waters at depths of one to two meters.

Global Distribution: Tropical; Western Pacific.

Description: Body is robust, broadly rounded dorsally and flattened ventrally. It is also elongated, tapering to a deep caudal peduncle. Mouth is small and terminal on a moderately short snout. Lips are thick, covered with numerous short papillae. Chin is lacking. Nasal organ is a short papilla just forward of eye, with 2 widely separated openings. Among the latter, posterior one is larger. inner surface of papilla is with a large fold sited posteriorly on medial portion and about 4 smaller folds located posteriorly on the ventral portion. Eye is round and moderate in size. Its rim is completely adnate, with the upper border just below dorsal profile, and the lower border just above level of mouth corner. Ground color of dorsum and dorso-lateral surface are pale olive-green to dark greenish-grey. Dark bands, either solid or composed of irregularly distributed round spots, cross dorsum at eyes, mid-dorsum, dorsal fin base, and distal end of caudal peduncle. These bands either extend almost to ventrolateral region, or remain distinct from moderate to large, dark, lateral blotches. Ventrolateral surface is pale or with silverish sheen. Belly and chin are white. Pectoral and dorsal fins are tinged reddish to reddish-yellow. Anal fin is bright orange to yellow. Caudal fin is reddish-yellow, becoming bright orange distally. Maximum size of this species is 13.6 cm and length at first maturity is 8.9 cm. By feeding on fiddler crabs, *M. pleurosticta* may have a significant impact on the functioning of estuarine ecosystems. The maximum age of this species was estimated at 25 years.

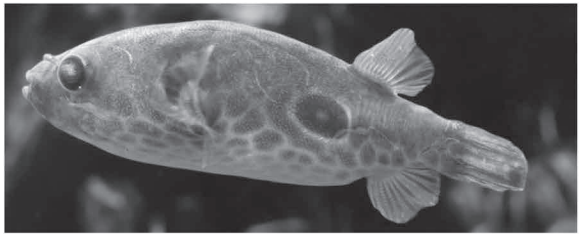
Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 μg/g tissue). This species is not utilized.

Aquarium Value: This species is used as a component in brackish water/ freshwater aquarium. It normally swims on the upper strata of the aquarium tank (usually near the surface) and it rarely goes to the bottom of the tank. It eats shreds of shrimp twice a day. Other aquarium parameters of this species are unknown.

Toxicity: Unknown.

Conservation Status: Not evaluated.

Pao leiurus* (Bleeker, 1850) (= *Tetraodon leiurus)



Common Name(s): Target puffer, twin spot puffer, eyespot puffer.

Habitat: Freshwater; brackish; demersal; streams and rivers in upland and lowland areas; flowing and standing water habitats; swamps and reservoirs; medium to large-sized rivers.

Global Distribution: Tropical; Asia: Thailand to Indonesia; Mekong basin.

Description: Body of this species is oblong and its head region is depressed. Dorsal profile is arched or flattened. Interorbital is flat or convex, often with a median groove. Lateral line system is often distinct. Spines are small, densely set, sometimes in part hidden under papillae, covering back, sides and belly between nostrils and anus. Origin of anal fin is beneath posterior half of dorsal fin base. Mouth is terminal, and is directed forwards or upwards. Lower border of eye is above level of mouth corner and upper border is not interfering with dorsal profile. Ground color of upper parts is tan and of lower parts is yellowish white. Sides are with many polygonal or rounded dark spots leaving mostly only a lighter network of ground color. Color of back is variable, often with a light inter-

orbital band, bordered posteriorly by a dark trapezoid patch reaching to midst of back or beyond. Sometimes a second dorsal dark patch is seen just before dorsal fin. Sometimes a back pattern of many oval or whitish spots may also be seen. Upper part of snout is irregularly dark. Chin and belly are uniformly yellowish white. Fins are plain and caudal fin is darkest. It feeds on molluscs, crustaceans, and other invertebrates. It grows to a maximum size of 16 cm.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 µg/g tissue).

Aquarium Value: It is occasionally seen in the brackish aquarium trade and its aquarium parameters are given below.

Minimum Tank Size: 30 gallons.

Suitable Size of Fish: Less than 13 cm.

Water Conditions:

Salinity: Fresh to brackish

Temperature: 75–82F (24–28°C)

Hardness (dH): 8–12

pH: 7.0–7.5

Diet: Carnivore – live, frozen.

Lifespan: 6–8 years.

Care Level: Moderate.

Temperament: Aggressive.

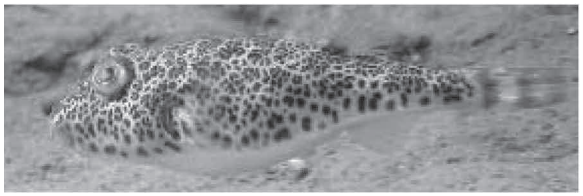
Aquarist Experience Level: Intermediate.

Toxicity: Unknown

Fisheries Status: It is not a commercial fish (FishBase). This species has low fisheries interest, due to its poisonous body (Vidthayanon, 2012).

Conservation Status: Least Concern.

***Sphoeroides greeleyi* (Gilbert, 1900)**



Common Name(s): Green puffer.

Habitat: Marine; brackish; reef-associated; over soft bottoms generally with vegetation such as *Thalassia testudinum*; prefers turbid water.

Global Distribution: Tropical; Western Atlantic: Honduras to Santa Catarina, Brazil.

Description: It is a blunt-headed fish with heavy jaws forming a beak of 2 teeth in both upper and lower jaws. Dorsal and anal fins are set far back near caudal fin. Dorsal fin is with 8 soft rays (no spines); anal fin is with 7 soft rays (no spines) and pectoral fin is with 14 or 15 rays. Pelvic fins are absent. Prickles are present from snout to dorsal fin dorsally, and chin to anus ventrally. Lappets are usually present. Dorsally and laterally, basal pigmentation is light cream color, overlaid with dark, richly pigmented chocolate blotches of various sizes and shapes. Ventral surface is unpigmented. It feeds on slow moving shelled invertebrates. It grows to a maximum total length of 18 cm.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 µg/g tissue). It is locally consumed but its visceral organs may be toxic.

Aquarium Value: The suitability of this fish for aquarium is unknown.

Toxicity: It may be associated with Ciguatera poisoning (FishBase).

Fisheries Status: For this species, no known fishery exists.

Conservation Status: Not evaluated.

***Sphoeroides lobatus* (Steindachner, 1870)**

Common Name(s): Longnose puffer, lobeskin puffer.

Habitat: Marine; brackish; demersal; bays and shallow coastal areas; middle regions of estuaries and in mangroves; bar-formed lagoons; sandy substrata; rocky substrata; depth range 0–107 m.

Global Distribution: Subtropical; Eastern Pacific: California, USA to Chile, including the Galapagos Islands

Description: This species has a moderately elongated body that is inflatable. It is olive-brown with mottling and numerous small light blue spots. Ventral side is white and unusually flat. It has a horizontal row of short brown bars at the transition between lower side and the underside of the body. Skin flaps are seen on its back with a large black blotch behind each. Head has a long narrow snout and is concave between its large elevated eyes. Anal and dorsal fins are small and similarly shaped with short bases. They are found well back on its body with the anal fin being slightly behind the dorsal fin. Caudal fin is deeply convex. Body is covered with small denticles but is without scales. It reaches a maximum total length of 30 cm. It is exceedingly well camouflaged and has the ability to blow up like balloons, as a defense mechanism to avoid predator attacks. It is a rare and poorly studied species and is very limited information is available about its behavioral patterns.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 µg/g tissue)

Aquarium Value: This species is used as a component in brackish water aquarium and its aquarium parameters are given below.

Suitable Size of Fish: under 20 cm.

Minimal Tank Volume: 300 liters (79 US gal).

Water Conditions:

Temperature: 23°C (73.4°F)–26 °C (78.8°F)

pH: 7.9–8.9

Water Hardness: 5–20 dKH

Floor Water Column: Entire water column.

Behavior: Aggressive.

Care Level: Very difficult.

Feeding: Carnivore.

Toxicity: Like many puffers, this species may also be highly poisonous, even fatal, if eaten, due to the presence of the tetrodotoxin, which is found in its skin, viscera, and gonads. Nunez-Vazquez et al. (2000) reported that the value of TTX toxicity of mucous of this species was 0.42 µg/g.

Conservation Status: Least Concern.

***Sphoeroides maculatus* (Bloch & Schneider, 1801)**

Normal fish

Inflated fish

Common Name(s): Northern puffer.

Habitat: Marine; brackish; bays, estuaries and protected coastal waters; demersal; depth range 10–183 m.

Global Distribution: Temperate; Western Atlantic: Newfoundland in Canada to northeastern Florida in USA.

Description: Upper side of this species is grey or brown with poorly defined black spots and saddles. Belly is yellow to white. Tiny jet-black pepper spots of about 1 mm dia. are found scattered over most of pigmented surface, particularly evident on cheeks. Lower sides are with a row of black, elongate, bar-like markings. No lappets are seen on head or body. It feeds primarily on shellfish and occasionally on finfish. It has a maximum total length of 36 cm.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 µg/g tissue). It is locally called "blowfish" and is considered a delicacy in the Chesapeake Bay. After removing the skin and toxic liver and other entrails, the muscular portion of the fish, which resembles drumsticks, is prepared into a dish called "Sea Squab" (Shao et al., 2014e).

Aquarium Value: It is a component of commercial aquarium. There is very little knowledge of this species about its use for brackish aquarium (https://reefapp.net/en/lex/details/sphoeroides-maculatus)

Toxicity: The flesh of this species is considered non-toxic. Northern puffers collected from New Jersey, Maryland, and North Carolina possessed variable toxicity in visceral tissues, but toxicity has not been reported in its flesh (Shao et al., 2014e).

Fisheries Status: This fish has only minor commercial fishery.

Conservation Status: Not evaluated.

***Sphoeroides nephelus* (Goode and Bean, 1882)**

Common Name(s): Southern puffer.

Habitat: Marine; brackish; reef-associated; primarily benthic inhabitant of bays, estuaries, and protected waters to a depth of 11 m; frequently encountered in and around seagrass beds; salt marshes and in protected reef environments; rubble zone barrier reef lagoons; hypersaline lagoons; mangroves or emergent wetland vegetation, such as *Spartina* spp.

Global Distribution: Subtropical; Western Atlantic: northeastern Florida and northern Gulf of Mexico in the USA and the Bahamas to Campeche in Mexico and Lesser Antilles.

Description: This species is diagnosed by its 8 dorsal soft rays, 7 anal soft rays and 14 pectoral fin rays. As with other puffers, its small mouth is comprised of 4 teeth fused together to form a strong beak. Individuals lack scales. Upper side is brown with large dark grey to black spots

and light (pale blue or green in fresh specimens) irregular-shaped reticulations. Lower side is with an irregular row of dusky to black rounded spots. Axil spot is the most intense in the series. Sexually mature, ripe males are sometimes covered with brilliant red or orange spots of about 1 mm dia. (white in preserved specimen). There are no lappets on head or body. This oviparous species feeds on primarily on molluscs and crustaceans, also on some finfish. This species grows to a maximum total length of 30 cm.

Reproduction: Its sexes are separate and fertilization is external. It reaches maturity at 165 mm. Reports suggest that this species has more continuous spawnings at least from spring through fall and possibly year-round within southern portions of the range.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 µg/g tissue).

Aquarium Value: This species is used as a component in brackish water aquarium and its aquarium parameters are given below.

Temperature: It has a relatively narrow thermal tolerance for the species.

Salinity: It is broadly euryhaline and is tolerating salinities ranging from 5.5 ppt to 45.3 ppt.

Dissolved Oxygen*:* It is relatively tolerant of hypoxia with an oxygen minimum concentration of 2.0 mg/L.

Diet: The diet of this species consists primarily of crabs and molluscs which they crush and eat with their powerful fused teeth.

Activity Time: These fishes are primarily active by day, settling into sand bottoms to rest at night.

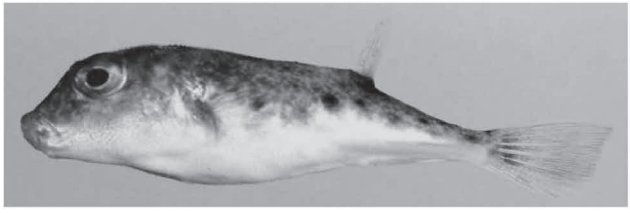
Toxicity: This species is known to accumulate saxitoxin, and has been responsible for poisoning events (Shao et al., 2014c). Since 2002, PSP toxins have been detected in southern puffer fish *Sphoeroides nephelus* from the Titusville region of Florida. Saxitoxin was the dominant congener in unconsumed fishes of this species. Decarbamoyl saxitoxin has also been detected (Etheridge et al., 2006). It is unintentionally caught by recreational fishers, and occasionally consumed despite several reports of saxitoxin poisoning. This species showed the highest concentrations of STX, with average levels in the skin of 1787 µg STX equiv./100 g tissue. Elevated concentrations were also found in the muscle (1102 µg STX equiv./100 g), gut contents (539 µg STX equiv./100

g), gonads (654 µg STX equiv./100 g), skin (599 µg STX equiv./100 g) and liver (214 µg STX equiv./100 g) (Abbott et al., 2009). Landsberg et al. (2006) stated that this species was a hazardous reservoir of STXs in Florida's marine waters and implicate the *dinoflagellate Pyrodinium bahamense* as the toxin source.

Fisheries Status: This species has subsistence fisheries.

Conservation Status: Not evaluated.

***Sphoeroides parvus* (Shipp & Yerger, 1969)**



Normal fish

Inflated fish

Common Name(s): Least puffer

Habitat: Marine; brackish; demersal; coastal waters, bays and estuaries; over open sandy and mud bottoms at depths ranging from less than a meter to 50 meters; associated with salt marshes, sargassum mats and oyster reefs.

Global Distribution: Subtropical; Western Atlantic: northern and western Gulf of Mexico, from northwestern Florida in USA to Campeche in Mexico.

Description: Body of this species is elongated and globular. Lower skin is loose. Jaws form a beak with 2 teeth in upper jaw and 2 in lower

jaw. There are no pelvic fins. Dorsal and anal fins are set far back near tail fin. Small spiny projections (prickles) are seen on belly. Prickles are also seen on head and back. Lappets are absent. Color of body is brown to gold (or yellow) on back and upper sides with several large black spots and many smaller lighter dots. Lower sides and belly are white. It reaches a maximum total length of 15 cm

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 μg/g tissue).

Aquarium Value: The suitability of this fish for aquarium is unknown.

Toxicity: Unknown.

Conservation Status: Not evaluated.

***Sphoeroides rosenblatti* (Bussing 1996)**

Common Name(s): Oval puffer.

Habitat: Marine; brackish; demersal; inshore waters to 4 m depth in brackish-water estuaries; mangroves and river mouths; depth range 1–20 m.

Global Distribution: Tropical; Eastern Central Pacific: Costa Rica and Panama.

Description: Body of this species is oblong, thick and inflatable. Snout is relatively short. Eyes are on high on sides of head. Jaws are composed of 4 fused heavy powerful teeth with a central suture on each jaw. There are no pelvic fins and no spines in fins. Skin is tough and scaleless. Body and head are spiny except in front of nostrils and on tail base. Skin flaps are absent. It is dark grey dorsally; sides are tan and belly is abruptly white. A pattern of pale lines is seen on upper body. There are 2 narrow curved crossbars. A broad band of small black dots is seen along mid-side. Fins except tail are pale. Inner half of tail is dusky

and outer half is black. It has a maximum standard length of 21.9 cm and total length of 30 cm.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 µg/g tissue).

Aquarium Value: The suitability of this fish for aquarium is unknown.

Toxicity: Unknown.

Conservation Status: Least Concern.

***Takifugu coronoidus* (Ni & Li, 1992)**

Common Name(s): Changjiang estuary puffer.

Habitat: Brackish; demersal; at depths ranging from zero to 10 meters.

Global Distribution: Temperate; Northwest Pacific: China.

Description: This species is diagnosed by its 14–15 dorsal fin rays, 13 anal fin rays and 16–17 pectoral fin rays. Dermal prickles are not well-developed. Area of dorsal and ventral dermal prickles is separated from each other and is not connecting in front of the pectoral fin. Body is subcylindrical and is tapering towards the posterior end. In life, it is yellowish brown dorsally, with a yellow longitudinal stripe below the lateral side of body. Formalin preserved specimens are grayish- brown dorsally, with no yellow stripe. Posterior-upper part of pectoral fin is with a dark brown ocellus of moderate size encircled by a pale-colored wide coronal rim. Each side of dorsal fin is with a large brown semi-

circular ocellus and half of the ocellus near the base of the dorsal fin appears dark brown. In juvenile specimens, a dark band crosses the dorsal region between the pectoral ocella. This species feeds on molluscs, crustaceans, and fishes. It has a maximum standard length of 21.4 cm.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 µg/g tissue). There is no use and trade information available for this species.

Aquarium Value: The suitability of this fish for aquarium is unknown.

Toxicity: Unknown.

Conservation Status: Not evaluated.

***Tetractenos hamiltoni* (Richardson, 1846)**

Common Name(s): Common toadfish.

Habitat: Marine; demersal; shallow estuaries; seagrass beds; mangrove forests; shallow, soft-bottom tidepools; near artificial structures such as jetties; often buried in sand with only eyes exposed; a schooling species; depth range 0–20 m.

Global Distribution: Subtropical; Southwest Pacific: Australia.

Description: Body of this species is covered with small prickles. It has small gill slits which are located just in front of the pectoral fin bases. A distinct skin fold is running along the lower sides. Its teeth are fused and form a beak-like structure with a median groove. It is sandy to whitish in color, with small brown spots over most of the back and upper sides, and brown bars and blotches are seen ventrally. This species feeds mostly on adult crabs, but also on gastropods, amphipods, aquatic plants, and insect larvae. Maximum size of this species

is 14.6 cm. Length at first maturity for this species is 8.9 cm. It is able to vary the amount of pigment in its cornea, which becomes yellow in color under bright light. It grows to a maximum total length of 14 cm. Maximum age of this species was estimated at 28 years. This is a loosely shoaling species. By feeding on ubiquitous fiddler crabs, this species may have a significant impact on the functioning of estuarine ecosystems.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 μg/g tissue). This species, however, is not utilized (Shao et al., 2014h).

Aquarium Value: This species is used as a rare component in brackish water aquarium and its aquarium parameters are given below.

Suitable Size of Fish: under 15 cm.

Minimal Tank Volume: 200 liters (53 US gal).

Water Conditions:

Temperature: 23°C (73.4°F)–26 °C (78.8°F)

pH: 7.5–8.5

Water Hardness: 5–20 dKH

Behavior: Aggressive.

Care Level: Moderately difficult.

Feeding: Carnivore -crustaceans, molluscs, nudibranchs and echinoderms.

Sexual Dimorphism: Unknown. possibly related to size of belly and bodily patterns.

Breeding: Unknown

Floor Water Column: entire water column

Activity: Sociable, enjoys conspecific company; often bury themselves in the sand in groups.

Estimated Lifespan: unknown, probably under 10 years.

Aquarium Care: A large tank with a lot of swimming space and a sandy bottom is recommended. It prefers marine conditions, but youngsters can be kept in brackish conditions. It is better to transfer to marine conditions when they grow to about 10 cm.

Toxicity: Unknown.

Conservation Status: Not evaluated.

***Tetraodon cutcutia* (Hamilton, 1822)**

Common Name(s): Ocellated pufferfish.

Habitat: Freshwater; brackish; demersal; ponds, beels, canals and rivers (medium to large-sized); potamodromous.

Global Distribution: Tropical; Asia: India, Bangladesh, Sri Lanka, Myanmar and Malay archipelago, Mekong.

Description: Body of this species is compressed laterally. Dorsal profile is rising nearly rectilinear to midst of back, from there sloping gradually to caudal fin. Interorbital is flat. Body spines are apparently absent. Mouth is terminal and is directing forwards or downwards. There is no prominent chin. Lower border of eye is above level of mouth corner and upper border is not interfering with dorsal profile. Nasal organ is a very short tube with one terminal opening. No skin folds are present on back or belly. In alcohol, ground color of upper parts is grey or greenish and of lower parts is whitish. Back is with dark cloudy or reticulated markings, sometimes descending to sides. A light interocular band is seen. Sides are mostly with a dark meshwork and with a dark ocellus just in front of dorsal and anal fins. Caudal fin is bordered with a darker band. Other fins are plain. It grows to a total length of 15 cm.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 μg/g tissue).

Aquarium Value: This species is used as a component in brackish water aquarium and its aquarium parameters are given below.

Tank Size: 100–150 liters.

Temperament: Aggressive.
Company: Best kept alone.
Water Conditions:
pH: 7.0
Temperature: 24–28°C/75–82°F
dH: 5–15
Feeding: It is very predatory and is best kept on a diet consisting of krill, shrimp, crayfish and crab. It may also accept frozen food.
Breeding: It has been bred in aquariums. The male guards the eggs.
Aquarium Maintenance: At the bottom of the aquarium tank, a mixture of large and medium sand dark tones may be kept. This species is best kept alone or with other ocellated pufferfish. They are fin nippers. If more than one is to be kept, then a lot of hiding places should be provided. The fish should not be able to see each other. Good circulation and regular water changes (up to 50% a week) are required since they are messy eaters. This species, like other puffer species is more sensitive to ammonia and nitrites.
Toxicity: Unknown.
Fisheries Status: This species is of no interest to fisheries. However, it is captured as an ornamental fish in India.
Conservation Status: Least Concern.

***Tetraodon erythrotaenia* (Bleeker, 1853)**

Common Name(s): Samurai puffer, red-striped toadfish.
Habitat: Brackish water; also in freshwaters of tidal creeks and rivers; demersal; mangrove areas.

Global Distribution: Tropical; Asia and Oceania: Indonesia and Papua New Guinea.

Description: Body of this species is oblong. Its anterior part is slightly compressed dorsoventrally and posterior part is slightly compressed laterally. Dorsal profile is arched and is highest at midst of back or behind. Interorbital is convex, without a groove. Lateral line system is indistinct. Spines are short, and slender. In skinny specimens, these spines are distinctly two-rooted and are scantly distributed on back sides and belly between midst of eyes and origin of dorsal fin. Origin of anal fin is situated anterior of dorsal fin or beneath anterior third of dorsal fin base. Mouth is terminal and is directed forwards. Lower border of eye is at level of mouth corner or below and upper border is not interfering with dorsal profile. Ground color of upper parts is tan or dark grey. Belly is whitish, grey or almost black. Both colors are usually separated by a whitish band from snout or head to caudal peduncle. This band on head is often broken up in dots or vertical lines. White band is often bordered inferiorly by a second, dark ban. Fins are plain and caudal fin is often darkest. It reaches a maximum total length of 8.5 cm.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 μg/g tissue).

Aquarium Value: This species is used as a component in brackish water aquarium and its aquarium parameters are given below.

Minimum Tank Size: 94.6 liters (25 US G.)
Suitable Fish Size: 7.6–10.2 cm
Utilization of Fish: Freshwater and brackish aquarium.
Inhabited Floor: Entire water column.
Water Conditions:
Specific Gravity (SG): 1.005–1.010
pH: 6.0–7.8
Temperature: 23.3–26.7°C (74–80°F)
Water Hardness: 12–18 dKH
Diet: Carnivore – live and frozen.
Behavior: Semi-aggressive.
Stocking Ratio: 1:1 M:F (male: female)
Availability: Rare.

Lifespan: 8–10 years.
Difficulty: Moderate.
Sex: Indistinguishable.
Reproduction: Yet unknown and undescribed.
Others: The aquarium tank for this species should have good filtration and frequent water changes. The water should be slightly briny and sweet or highly alkaline. This fish can be kept in freshwater when young, but should be adapted to brackish water as it grows, for its long-term health.
Toxicity: Unknown.
Conservation Status: Not evaluated.

***Tetraodon lineatus* (Linnaeus, 1758)**

Common Name(s): Coral butterfly, freshwater pufferfish, globe fish, stripped puffer, Fahaka pufferfish, Nile puffer, Lineatus puffer.
Habitat: Freshwater; brackish; demersal; large rivers, open water, weed beds and vegetated fringes;
Global Distribution: Tropical; from Senegal to Ethiopia, and along the entire length of the Nile.
Description: Skin of this species is scaleless, but head and body are covered with small spines except on snout and caudal region. Teeth form beak-like structure consisting in each jaw of two pieces fused on midline and covered by layer of enamel. Nostrils are consisting of two fleshy lobes placed in front of folded collar surrounding the opening. Two pairs of non-perforated nasal tentacles are present. Dorsal and anal fins are short and placed far back on body. Pectoral fins are well developed. There are no pelvic fins. Caudal fin is rounded, and its length is of 3 times in standard length. Longitudinal stripes are seen

along sides of body in adults. Black-rimmed red ocelli (eyespots) are present in juveniles. It feeds mainly on benthic organisms which may include freshwater mussels and snails. It rises to surface to inflate its body resembling a balloon. This inflation is useful to the fish as it is less easily eaten by predators. It reaches a maximum total length of 43 cm and weight of 1 kg.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 µg/g tissue). It is unmarketable for food. Some authors reported that its flesh may be poisonous due to the presence of TTX (Akinyi et al., 2010).

Aquarium Value: This species is used as a component in brackish water aquarium and its aquarium parameters are given below.

Aquarium Size: 120 cm x 60 cm x 60 cm – 450 liters is adequate for a single fish. A much larger tank would be required for a group of fishes.

Usual Fish Size in Tanks: 40–44 cm.

Substrate: A sandy substrate is required with smooth rocks and driftwood pieces for decoration.

Water Conditions:

Temperature: 75–79°F (24–26°C)

pH: 6.5–7.5

Water Hardness: 6–10 dKH

Diet: It relishes all kinds of shellfish as well as worms and other live and frozen foods.

Temperament to Its Own Species: Aggressive/territorial.

Temperament Toward Other Fish Species: Aggressive/territorial.

Usual Place in the Tank: Middle levels.

Behavior and Compatibility: It is an intolerant species and should be kept alone. Therefore, an enormous tank is required for keeping it in groups. The fish may still bite one another and fight. Its beak-like mouth can easily bite chunks from other fish, or in extreme cases rip them to pieces.

Sexual Dimorphism: There are no external sexual differences, but when they are full of eggs, females will have rounded appearance.

Reproduction: Due to its aggressive temperament, it is not an easy species to breed. However, reports of breeding successes in large

aquaria exist. A separate breeding aquarium should be used. But the fish may also spawn when kept in a small group in a very large tank. These fishes become sexually mature at about 1 year of age. The female will produce an ovipositor (http://www.seriouslyfish.com/glossary/o/ovipositor) when she is ready to spawn, and will do with any male. The pairing is very weak and lasts only for the duration of spawning. The pair will swim together for a short time, before the male inverts himself and grips onto the underside of the female in such a way that the sexual organs of both fish are in contact. Subsequently there is vigorous spawning, followed by the simultaneous release of eggs and sperm. The fish will often repeat this process several times, with each spawn lasting no more than 30 seconds. Several thousand eggs may be deposited in this manner. The eggs sink and at this point, either the eggs or the parents should be removed to another tank. Fertilized eggs hatch in 72–96 hours, and the fry could be seen lying on the tank bottom, or stuck to the sides. The water level should be lowered to only a few cm post-hatching, as the young seem to need access to the surface. They become free swimming after around a week and initially they require tiny foods such as infusoria. After a few days, they are large enough to accept brine shrimp nauplii. When they grow, they should be separated into groups of similarly-sized individuals, as they become aggressive from quite an early stage.

Aquarium Care: Plenty of open space needs to be left in the tank for free swimming. As they are high waste producers, excellent filtration should be used along with regular water changes. It is also best to keep these fishes in a species tank as they will attack any other tank mates. Further, they need a lot of swimming space and they should not be kept in a small tank.

Experience Level: This fish is for advanced aquarists only.

Lifespan: The expected lifer span of this species is 10 years.

Toxicity: Unknown.

Fisheries Status: There is no commercial fisheries.

Conservation Status: Least Concern.

***Tetraodon nigroviridis* (Marion de Procé, 1822)**

Common Name(s): Green pufferfish, spotted green puffer, spotted river puffer, round spotted puffer.

Habitat: Freshwater; brackish; demersal; streams, rivers and floodplains.

Global Distribution: Tropical; Asia: Sri Lanka to Indonesia and north to China.

Description: This species is diagnosed by its 12–14 dorsal rays and 10–12 anal rays. Body of this species is oblong and posterior part is compressed laterally. Dorsal profile is arched, highest at midst of back. Interorbital is convex, without a groove. Lateral line system is mostly indistinct. Body spines are small and are often hidden under skin for most part. They are not papillose, covering back, sides and belly from eyes to anus. Origin of anal fin is situated slightly anterior of dorsal fin or beneath anterior half of dorsal fin base. Mouth is terminal and is directed forwards. Lower border of eye is slightly above level of mouth corner and upper border is not interfering with dorsal profile. Nostril is a tentacle and is divided into two flattened and broadened lobes. Apposed surfaces of lobes are often with spongy tissue. Ground color of upper parts is tan. Lower parts are yellowish white. Back and sides are covered with many dark spots and rounded blotches. Spots and blotches are very variable in size. Caudal fin is mostly with 1–8 dark transverse bands. Dorsal fin is sometimes with some small dark spots near base. Other fins are plain. Belly is uniformly whitish. It feeds on molluscs, crustaceans, and other invertebrates, as well as some plant matter. It may eat scales and fins also occasionally. This species grows to a maximum total length of 17 cm.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 μg/g tissue).

Aquarium Value: It is a component of commercial, brackish aquarium and its bait. Its aquarium parameters are given below.

Aquarium Size: 120 cm x 30 cm x 30 cm – 110 liters.

Usual Size in Fish Tanks: 10–17 cm.

Aquarium Maintenance: It is advisable to keep this fish in a heavily-planted aquarium setup with twisted roots and branches to provide additional cover. Some open spaces have to be left in between for swimming, as this is an active species. The use of a sandy substrate and floating plants to diffuse the light is also essential. This species is very sensitive to deteriorating water conditions Hence, regular partial water changes should be done. Although it is a true freshwater species, it tends to be more long-lived with the addition of marine salt to a specific gravity of 1.005 in aquariums.

Water Conditions:

Temperature: 75–82°F (24–28°C)

pH: 7.5–8.5

Hardness: 10–20 dGH

Diet: It takes all kinds of shellfish, as well as worms and other live and frozen foods. It should be fed snails and unshelled shellfish (such as crab legs, prawns, etc.) regularly in order to maintain its sharp teeth.

Temperament to Its Own Species: aggressive/territorial.

Temperament Toward Other Fish Species: peaceful.

Usual Place in the Tank: Bottom levels.

Behavior and Compatibility: It is always kept in a community tank, but caution should be exercised in choosing tank mates, as it tends to nip the fins of slow-moving or long-finned fish. It is best kept with robust, active species such as scats, archerfish and Arius catfish. Further, It is not good to keep more than one of these per tank unless a lot of space is made available, as they are usually very aggressive toward conspecifics.

Sexual dimorphism: Unknown.

Reproduction: It has been spawned in aquariums, however, with difficulties. The fish will spawn only in brackish water, and should also be provided with some flat rock surfaces to act as potential spawning sites. The eggs are laid directly onto the substrate or a flat rock, and are guarded by the male. They hatch in about a week, and the fry move to a pre-excavated pit in the substrate where they continue to be guarded by the male. The fry are very difficult to raise and Cyclops nauplii are the ideal food for these fry.

Lifespan: It is approximately 15 years.

Toxicity: Toxicity studies made in the fishes of this species of the Malaysian waters have shown that the TTX concentration of liver, muscle and skin was at 49.8 µg/g, 33.5 µg/g and 1.64 µg/g, respectively (Azman et al., 2014).

Fisheries Status: There are no commercial fisheries for this species.

Conservation Status: Not evaluated.

***Torquigener hypselogeneion* (Bleeker, 1852)**

Common Name(s): Dwarf blowfish, dwarf blaasop, cheek-barred toadfish, Northern toadfish, orange-spotted toadfish.

Habitat: Marine; brackish; demersal; shallow coastal sand flats and in estuaries; seagrass beds or sandy bottoms; depth range 18–22 m.

Global Distribution: Tropical; Indo-Pacific: Knysna, South Africa eastward to Samoa, north to Japan.

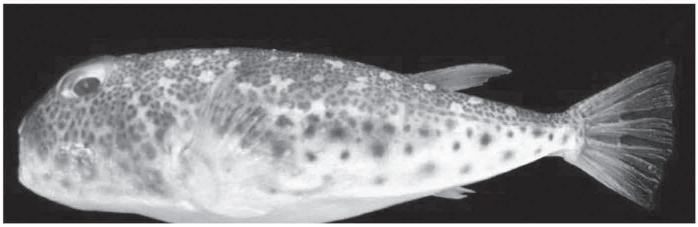
Description: Body of this species is elongated, rounded dorsally and flattened ventrally. It is tapering to a narrow caudal peduncle. Mouth is small and terminal. Lips are thin and are covered with numerous short papillae. Chin is prominent. Eye is small, elongated, and dorsally adnate. Upper border interrupts dorsal profile and lower border is well above level of mouth corner. Pectoral fins are rounded and its first ray is very short. Ventrolateral skinfold extends from behind chin to caudal peduncle, except directly beneath pectoral fin. Lateral line is distinct, with a few small, associated papillae. A dark brown reticulum is seen on back. Spots are pale greenish. Belly is white and a zone of light yellow is separating it from darker dorsal coloration. It feeds mainly on molluscs, fishes, crustaceans. Often it sleeps during the day by burying itself under the sand with just eyes exposed. It grows to a maximum total length of 10 cm (Hardy, 1983).

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 μg/g tissue). This species however, is not utilized.

Aquarium Value: This species is used as a component in brackish water aquarium and its aquarium parameters are given below.

Size of Fish for Tank: Under 10 cm.
Minimal Tank Volume: 150 liter (40 US gal).
Water Conditions:
Temperature: 23°C (73.4°F)–26°C (78.8°F)
pH: 7.8–9
Water Hardness: 5–20 dKH
Floor Water Column: Entire water column.
Behavior: Aggressive.
Care Level: Very difficult.
Feeding: Carnivore.
Toxicity: Unknown.
Conservation Status: Not evaluated.

***Torquigener marleyi* (Fowler, 1929)**



Common Name(s): Slender puffer.

Habitat: Marine; reef-associated; estuaries over sandy and rocky bottoms.

Global Distribution: Temperate; Western Indian Ocean: South Africa (endemic to Kwazulu-Natal, off the Thukela River).

Description: This species when compared to its similar species, *Amblyrhynchotes honckenii*, has its mouth below horizontal line through upper end of pectoral fin base. It has fewer spinules and its belly is with numerous longitudinal pleats. 7 anal fin rays and 13–14 pectoral fin rays

characterize this species. It feeds on isopods, crabs, bivalves and fish. There is little information for this species as it has changed its taxonomy.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 μg/g tissue). This species is not utilized for food, as it is considered to be highly toxic. However, it is occasionally used as poison to animals such as cats.

Aquarium Value: The suitability of this fish for aquarium is unknown.

Toxicity: Unknown.

Conservation Status: Not evaluated.

***Torquigener paxtoni* (Hardy, 1983)**

Common Name(s): Paxton's toadfish.

Habitat: Marine and estuarine habitats; demersal; over sandy bottoms.

Global Distribution: Subtropical; Eastern Indian Ocean: Shark Bay, Western Australia

Description: Body of this species is elongated, rounded dorsally and flattened ventrally. It is tapering to a narrow caudal peduncle. Mouth is small and terminal. Lips are thin and are covered with many short papillae. Chin is prominent. Eye is moderate, elongate and dorsally adnate. Pectoral fin is elongated and rounded. Caudal fin is truncated. Dorsum is slightly covered with short spines to just before dorsal fin and, spines are more dense on belly. Ventrolateral skinfold extends from behind chin to caudal fin except directly beneath pectoral fin. Lateral line is sometimes indistinct with small associated papillae. Second lateral line is very indistinct. Ground color of dorsal and lateral surfaces is pale greyish-brown with irregularly distributed, rounded or elongate pale spots. Darker flecks of varying size are found scattered throughout dorsal and lateral surfaces from snout to caudal peduncle, particularly dense on dorsolateral and mid-dorsal regions. Chin is slightly greyish. Belly and fins are pale.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 μg/g tissue). This species however, is not utilized.

Aquarium Value: The suitability of this fish for aquarium is unknown.

Toxicity: Unknown.

Conservation Status: Not evaluated.

***Torquigener perlevis* (Ogilby, 1908)**

Common Name(s): Spineless toadfish.

Habitat: Marine; brackish; demersal; shallow, sandy estuaries in small aggregations; depth range up to 53 m.

Global Distribution: Tropical; Western Pacific: eastern Australia.

Description: This species has an elongate body with a rounded back and flattened belly. It has a small mouth at its apex with thin lips that have numerous papillae and a prominent chin. It has mottled grey and brown upper parts marked with dark brown. It is distinguished from other members of the genus by its lack of spines. This species grows to a maximum total length of 20 cm.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 μg/g tissue). This species however, is not utilized.

Aquarium Value: This species is used as a component in brackish water aquarium and its aquarium parameters are given below.

Size of Fish for Tank: under 20 cm.

Minimal Tank Volume: 300 liters (79 US gal).

Water Conditions:

Temperature: 23°C (73.4°F)–26°C (78.8°F)

pH: 7.5–8.5

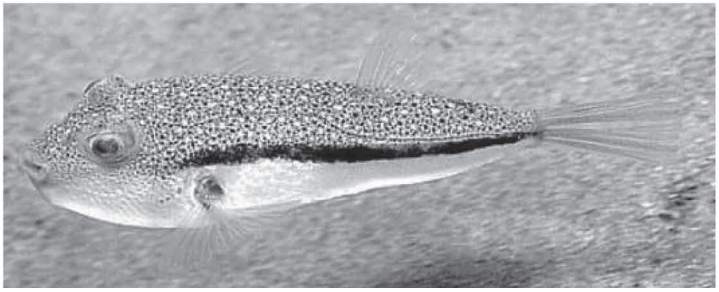
Water Hardness: 5–15 dKH

Floor Water Column: Entire water column.

Behavior: Aggressive.

Care Level: Very difficult.
Feeding: Carnivore.
Toxicity: Unknown.
Conservation Status: Not evaluated.

***Torquigener squamicauda* (Ogilby, 1910)**



Common Name(s): Brush-tail toadfish, scaly tail toadfish.

Habitat: Marine; brackish; demersal; clear estuaries in shallow depths over sand; sheltered bays; sometimes in small aggregations; depth range 0–25 m.

Global Distribution: Subtropical; Southwest Pacific: eastern Australia.

Description: The species looks similar to the Weeping Toadfish but lacks the 'tear lines' on the cheek. Body of this species is elongated, rounded dorsally and flattened ventrally. It is tapering to a narrow caudal peduncle. Mouth is small and terminal. Lips are thin and are covered with numerous short papillae. Chin is prominent. Eye is moderate and elongate. Pectoral fins are dorsally elongate and rounded. Dorsal and anal fins are elongated and are bluntly pointed. Ground color of dorsum is light grey to olive-green with many, small, irregularly scattered greenish to brown flecks, giving a very speckled appearance. There is dark stripe along sides from above pectoral fin. It is yellowish to silvery grey along sides between lateral stripe and ventrolateral skinfold. Belly is white. Pectoral, dorsal and anal fins are pale. Caudal fin is with a yellowish-brown tinge along middle rays. It grows to about 15 cm in length.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 μg/g tissue). It is not utilized.

Aquarium Value: This species is used as a component in brackish water aquarium and its aquarium parameters are given below.

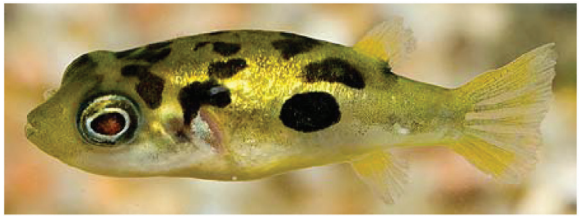
Size of Fish for Tank: under 15 cm.
Minimal Tank Volume: 200 liters (53 US gal)
Water Conditions:
Temperature: 23°C (73.4°F)–25°C (77°F)
pH: 7.5–8.5
Water Hardness: 5–20 dKH
Feeding: Carnivore.
Floor Water Column: Entire water column.
Behavior: Aggressive.
Care Level: Very difficult.
Toxicity: Unknown.
Conservation Status: Not evaluated.

3.3 FRESHWATER PUFFERFISH

3.3.1 TOXIC (POISONOUS TO EAT) FRESHWATER PUFFERFISH

Kingdom: Animalia
Phylum: Chordata
Subphylum: Vertebrata
Class: Actinopterygii
Order: Tetraodontiformes
Family: Tetraodontidae

***Carinotetraodon travancoricus* (Hora & Nair, 1941)**
(= Tetraodon travancoricus)



Common Name(s): Malabar pufferfish, dwarf Indian puffer.
Habitat: Slow moving freshwater rivers.
Global Distribution: Endemic to the state of Kerala, India.

Description: Body of this species is oblong and compressed laterally. Dorsal profile is arched, highest at midst of back. Interorbital space is flat, Body spines are inconspicuous. Skin is finely reticulated. Origin of anal fin is situated beneath anterior third of dorsal fin base. Mouth is terminal and directed forwards. Lower border of eye is slightly below level of mouth corner and upper border is not interfering with dorsal profile. Nasal organ is a hollow cylinder and is nearly as high as wide. Ground color of upper parts is greyish and of lower parts are much lighter. There are usually two black, oval patches on upper lateral surface of body in front of dorsal fin. These patches are located in a much lighter area. Posterior of patches is a dark, broad band running to caudal fin, partly continuing on central rays. Usually, there is a dark spot in the middle of course of band. Other dark spots are seen at base of caudal fin and at base of posterior most two dorsal fin rays. A dark patch is seen above pectoral fin and a spot behind it. Back is with a narrow, light interocular band; two irregular dark patches posterior to V-shaped marking behind patches; an irregular band in front of dorsal fin and triangular patches in front of or behind dorsal fin. Fins are plain. It feeds on zooplankton and various benthic crustaceans and molluscs. It attains a total length of 2.5 cm.

Reproduction: Generally dwarf pufferfish are plant spawners, laying eggs in plants in aquariums. Eggs have been seen to hatch after five days at 27 °C (81°F), with fry initially feeding on infusoria, and brine shrimp when they are a week old, and on regular-sized food finally. They have also been known to scatter their eggs on the substrate hidden within vegetation. The eggs are fertilized externally. They do not guard their eggs or fry. After the eggs are hatched adults and fry are to be separated.

Food Value: This fish is highly toxic and is not fit for human consumption.

Aquarium Value: This species is used as a component in freshwater aquarium and its aquarium parameters are given below.

Fish Size in Aquarium Tanks: 2–3 cm.

Water Conditions:

pH range: 7–8

Water hardness: 71.43–214.29 ppm

Temperature: 22–28 °C (71.6–82.4°F)

Temperament to Its Own Species: aggressive/territorial.

Temperament Toward Other Fish Species: peaceful.

Usual place of Fish in the Tank: Middle levels.

Aquarium Size: A tank as small as 12″ x 8″ x 8″ or 30 cm x 20 cm x 20 cm – 12.6 liters is required for a single fish. However, more space is required for a group. A tank volume of 2–3 gallons per puffer is normally recommended.

Tank Setup: Tank needs places to establish territories. Multiple caves should be added throughout the tank to hide when the fish feel threatened.

Food: Live black worms, brine shrimp, snails, and ghost shrimp; frozen blood worms.

Sexual Dimorphism (sexing): Adult males have a brown vertical line running along the underside of their bellies. During courtship and aggression behavior, this line will become thick and dark. Some males have "Wrinkles" behind their eyes. Females have no brown vertical line or wrinkles. Their body shape is rounder than males', especially during spawning season.

Behavior and Compatibility: Dwarf fish should be kept in a species only tank. They are a very aggressive little fish and will nip the fins of other fish. They are capable of killing tank mates much larger than themselves. Otocinclus catfish , popularly known as "ottos" has been found compatible with this species.

Breeding in Aquarium: Success in breeding has been obtained in a bigger group of fish containing several specimens of each sex, or with a higher ratio of males to females. For a pair or trio of puffers, the spawning tank need not be particularly large. It can be filtered gently with an air-powered filter. It should be planted very densely, with a large proportion of fine-leaved plants such as *Cabomba, Ambulia*, Java moss (*Vesicularia dubyana*) or Willow moss (*Fontinalis antipyretica*).

Once introduced, the group is conditioned with a high quality diet including meaty frozen foods such as bloodworm and small snails. Courtship begins with the male pursuing the female vigorously, often resorting to biting and nipping if she appears disinterested. A successful chase normally ends with the female being driven into a patch of low-lying vegetation where they come together for a few seconds, releasing eggs and milt simultaneously. The near-transparent eggs are tiny (~1mm in dia.), non-adhesive and will simply develop where they

fall. This sequence may be repeated several times. Egg numbers tend to be very low, with most spawning events resulting in a yield of ten or less. The eggs may be removed with a large pipette.

The rearing tank should be set-up using water from that of the parents and maintained at the same temperature. A simple air-powered filter is best. The healthy eggs would hatch in around 5 days and the fry may need another 2 or 3 days to consume their yolk sac, at which point they will start to become more active. Initial foods should be very small and motile invertebrates such as microworm. After a week or so, the fry would be large enough to accept *Artemia* nauplii and can usually be moved onto larger foods such as frozen bloodworms after a month.

Toxicity: Unknown.

Fisheries Status: It is of no interest to fisheries.

Conservation Status: Vulnerable (leading to endangerment).

3.3.2 LESS TOXIC (HARMLESS) FRESHWATER PUFFERFISH

Kingdom: Animalia	*Phylum:* Chordata
Subphylum: Vertebrata	*Class:* Actinopterygii
Order: Tetraodontiformes	*Family:* Tetraodontidae

***Auriglobus amabilis* (Roberts, 1982) (= *Chonerhinos amabilis*)**

Common Name(s): Lovely golden puffer.

Habitat: Freshwater; pelagic.

Global Distribution: Tropical; Asia: Indonesia.

Description: The unique features of this species include a roundish dark spot in the middle of caudal peduncle; a large, distinctively shaped dark mark on dorsal surface of head extending uninterrupted from just behind upper lip to well behind the eyes, set off by pale coloration on the upper lip, sides of snout, nasal flaps, and skin dorsal to orbits; pale white or milky coloration on ventral and lateral surfaces of body extending very far dorsally; dark coloration on dorsal surface of body markedly enhanced around the base of dorsal fin; and a small dark or dusky oval spot with indistinct margins near tip of chin. Further, it has the largest nasal organ; relatively large dorsal and anal fins with angulated margins. Scales on side of body are relatively small, few in number, and with spines directed posteriorly. It feeds almost exclusively on large aquatic insect larvae and has a maximum length of 7 cm.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 µg/g tissue).

Aquarium Value: It is a component of freshwater aquarium. The parameters suitable for this species in aquarium are:

Tank Type: Freshwater tank.
Minimal Tank Volume: 100 liters (26 US gal).
Water Conditions:
Temperature: 22–26°C (71.6–78.8°F)
pH Tolerance: 6.5–7.2
Water Hardness: 5–12 dKH
Floor Water Column: entire water column.
Lifespan: 10 years.
Social Behavior: aggressive.
Care Level: moderately difficult.
Feeding: carnivore.

Toxicity: This species has been identified as high risk but deferred for further assessment due to interest from hobby sector (which may require more detailed biological and/or social assessment) (Moore et al., 2010).

Fisheries Status: It is fished as an ornamental fish for use mainly in aquariums.

Conservation Status: Not evaluated.

***Auriglobus modestus* (Bleeker, 1851) (= *Chonerhinos modestus*)**

Common Name(s): Golden puffer, avocado puffer, bronze puffer.

Habitat: Freshwater; demersal; medium to large-sized rivers.

Global Distribution: Tropical; Asia: Thailand, Malaysia, Indonesia and Mekong.

Description: This species has an unusual shape. It has the deepest caudal peduncle. Scales are relatively large and closely set. Upper and lower lips are about equally projecting or lower lip is slightly protruding. Exposed portion of eye is round. Snout is gently sloping. Nasal organ is moderately large. It has a sleeker, more streamlined, club like body with beautiful iridescent golden, green, to bronze hued colors. Its iridescent body colors modulate between green, gold and bronze. The iridescent gold green body color gets progressively lighter towards the belly, and their fins and tail are translucent. It feeds mainly on terrestrial insects, shrimps, seeds, and to a lesser extent on whole fish, fin rays or scales. These fish can grow up to 11 cm and their lifespan is about 10 years.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 μg/g tissue). However, according to some reports, this species is venomous and it is not fit for consumption (http://animal-world.com/encyclo/fresh/Puffers/Golden-Puffer.php).

Aquarium Value: Occasionally, this species is seen in the aquarium trade. The parameters of aquarium for this species are:

Minimum Tank Size: 20 US gallons (75 liters). This species does not require a large tank, but to keep more than one or some other species with them, a well-planted 50+ gallon tank is recommended.

Nano Tank: A Nano tank is fine as long as it meets the size requirements and has proper filtration.

Water Type: Although it is a freshwater fish, it will be healthier in slightly brackish conditions.

Water Movement: Moderate.

Water Changes: Weekly – Water change should be 30–50% weekly.

Substrate Type: Sand.

Lighting Needs: Moderate – normal lighting.

Water Conditions:

Temperature: 23–26°C (74–80°F)

pH: 6.0–7.8

Size of Fish for Tank: 10.6 cm.

Estimated Lifespan: At least ten years.

Sexual Dimorphism: Unknown.

Food and Feeding:

Diet Type: Omnivore.

Flake Food: Occasionally

Tablet Pellet: Occasionally.

Live Foods (fishes, shrimps, worms): Some of diet.

Vegetable Food: Some of Diet – seeds.

Meaty Food: Most of diet - Live and frozen foods, snails, freeze dried krill, frozen shrimp, bloodworms- live or frozen, gut loaded live ghost shrimp.

Feeding Frequency: Daily.

Aquarium Care: As other pufferfish species this species is also extremely sensitive to nitrites and ammonia and should only be introduced into a fully cycled aquarium. Due to their messy eating habits, over filtration is recommended.

Breeding: No report in captivity.

Aquarist Experience Level: Intermediate.

Aquarium Setup: As it has very messy eating habits, the tank needs large canister filters that turn the tank over 6–10 times per hr. Rotating power heads are needed to simulate the currents. As these are very intelligent fish, they need a well decorated tank. There should be driftwood and caves for this puffer to hide. The tank should have floating vegetation to break up the light and offer shelter. Vegetation and hiding places are also essential if housed with other fish who might have to flee from these aggressive fish.

Aquarium Care: It is more susceptible to diseases, nitrite, nitrate and ammonia levels. Hence, a generous weekly water change of 30% to 50% is the standard recommendation for this species. It is common to have to trim their teeth 3–4 times per year. To do this, 3 drops of clove oil is added per liter of water. This will temporarily sedate the puffer so that it can be held in hand more easily. It is also better to clip bottom and top teeth of this fish using cuticle clippers. Once it is done the fish may be put in a container or net that will have the current flowing over them. Once awake it may be released back into tank.

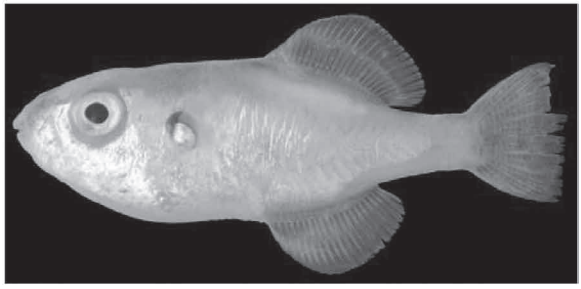
Social Behavior: Community fish will not fair well with this puffer because of its aggressive nipping behavior. However, very fast fish like larger Danios or other danio-like fish would be good choices. This species can be housed with its same species. Other puffers that could be kept with this species are the Malabar puffer or dwarf pufferfish *Carinotetraodon travancoricus* and the Amazon puffer or South American pufferfish *Carinotetraodon asellus*. Slow swimming long-finned fish, like angelfish or gouramis should not be housed with this species.

Diseases: As it does not have gill covers or scales, it is more prone to disease. Wild caught fishes may carry internal parasites. *Heterobothrium* infection is common in its gills. A formaldehyde bath can help cure this problem.

Toxicity: Unknown.

Conservation Status: Least Concern.

***Auriglobus nefastus* (Roberts, 1982)** (= *Chonerhinos nefastus*)



Common Name(s): Greenbottle pufferfish, bottle green gold pufferfish, emerald puffer.

Habitat: Demersal; flowing waters of rivers and streams; flooded forests and plains during the river's high water levels.

Global Distribution: from the Mekong basin (Cambodia, Lao and Thailand) through Malaysia to Indonesia.

Description: Upper lip of this species is usually projecting beyond lower lip. Nasal organ is relatively small. Exposed portion of eye ball is usually horizontally oval. Caudal peduncle is slender. It is "bottle" green in color with white belly. Body is without distinct color markings except for a slightly darkened spot on the dorsal surface of its head, behind its eyes. The sexes of this species are indistinguishable and cannot be determined visually. It primarily feeds on fish fins, rays, and scales. This species grows to a maximum length of 13 cm with a lifespan of about 10 years.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 μg/g tissue).

Aquarium Value: It is a component of freshwater aquarium and the suitable parameters are given below.

Minimum Tank Size: 35 gallons.

Water Conditions:

Temperature: 74–80°F

dKH: 5–12

pH: 6.0–7.8

Hardiness: Moderately hardy.

Substrate: Fine gravel; stone constructions and roots.

Diet: Carnivore live and frozen foods, snails, frozen shrimp, gut loaded ghost shrimp, and occasionally freeze dried krill (A steady diet of snails or other freshwater crustaceans should be fed to them to prevent their beaks from over growing).

Care Level: Difficult.

Temperament: Aggressive. As it is extremely active it should never be included in a community aquarium. Young specimens often frantically dart around the tank and can create havoc with their tank mates.

Aquarist Experience Level: Intermediate.

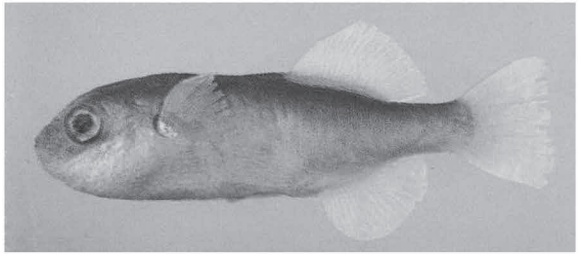
Aquarium Care: This species is to be housed in a large tank with plenty of hiding places. Because they are extremely sensitive to ammonia and nitrites, they need to be kept in a heavily filtered aquarium. This

species should not be introduced to a "new" aquarium that has not been adequately cycled.

Toxicity: Unknown.

Conservation Status: Least Concern.

***Auriglobus remotus* (Roberts, 1982)** (= *Chonerhinos remotus*)



Common Name(s): Northbornean golden puffer.

Habitat: Freshwater; demersal.

Global Distribution: Tropical; Asia: Indonesia.

Description: This species has a narrower and deep caudal peduncle, fewer dorsal and anal fin rays and a more oblique mouth. Spikes are large and are densely arranged to the back and towards the rear. Eye is vertically oval or round. Lower lip is projecting beyond upper lip. Snout is strongly sloping. Scales anterior and ventral to pectoral fin are moderately large and close-set, with spines directed posterodorsally. There are no distinctive color marks except for a well-defined dark blotch on dorsal surface of head posterior to eyes. It grows to only 6.5 cm total length.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 µg/g tissue).

Aquarium Value: This species is used in freshwater aquarium and the suitable aquarium parameters are given below.

Tank Size: 500L

Water Type: Freshwater.

Water Conditions:

Temperature: 25–27°C

pH: 6–7

dGH: 2–100

Food/Feed: Small crustaceans, insect larvae.

Toxicity: Unknown.
Conservation Status: Not evaluated.

***Auriglobus silus* (Roberts, 1982)** (= *Chonerhinos silus*)

Common Name(s): Golden puffer, gold green puffer, elongated golden puffer.

Habitat: Freshwater; demersal; large freshwater rivers and streams.

Global Distribution: Tropical; Asia: Thailand, Malaysia and Borneo and Sumatra, Indonesia.

Description: Snout of this species is more strongly sloping. Lips are also projecting or lower lip is variably protruding. Scales of anterior and ventral to pectoral fin are with spines projecting dorsoposteriorly rather than dorsally. Caudal peduncle is relatively slender. This fish feeds predominantly on crunchy insects, seeds and shrimps. However, it has also been known to eat the fins and scales of other (live) fish. Adults have a shining golden yellow color. It grows to a maximum length of 10 cm.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 μg/g tissue).

Aquarium Value: This species is used in freshwater aquarium and the suitable aquarium parameters are given below.

Tank Type: Freshwater tank.
Minimum Tank Size: 20 US gallons (76 liters).
Water Conditions:
Temperature: 24.4–27.8°C (76–82°F)
pH: 6.0–7.8
Water Hardness: 5–15 dKH

Diet: Carnivore; Live/frozen foods (not fish), snails, frozen shrimp, bloodworms- live or frozen, ghost shrimp (gut-loaded), and other molluscs and crustaceans. These puffers should be fed daily with a diet of snails to prevent their beak's overgrowth.

Estimated Lifespan: About 7 years.

Sexual Dimorphism: Unknown.

Personality/Temperament: Aggressive only with fast-moving fish.

Activity: Very curious and active.

Aquarium Care: As of other pufferfish, this species is also extremely sensitive to nitrites and ammonia and should only be introduced into a fully cycled aquarium. Due to their messy eating habits, extra filtration is recommended.

Breeding: Not known.

Care Level: moderately difficult.

Social Behavior: This is one of the most aggressive species of freshwater puffers and is not suitable for a community tank. Like other species of puffers, they tend to become less active with maturity and spend less time buzzing around the tank chasing other fish. It is to be kept in a species tank, ideally on its own. This species tends to be very quarrelsome with their own species.

Toxicity: Unknown.

Conservation Status: Not evaluated.

***Carinotetraodon borneensis* (Regan, 1903)**

Common Name(s): Bornean red eye puffer.

Habitat: Freshwater; benthopelagic.

Global Distribution: Tropical; Asia: currently known only from southern Sarawak.

Description: This species is diagnosed with its dorsal fin rays (12–13); anal fin rays (11–13); pectoral fin rays (1); and caudal fin rays (12). Males of this species possess a red dorsal fin. Proximal part of two-thirds of caudal fin are grey and distal part is black with white margin. A black blotch is seen on dorsal fin base in male. Pectoral fin base is black. Dorsal fin base length is 12.5–14.0 % standard length and anal fin base length is 10.2–10.9% standard length. This species grows to a maximum standard length of 4.4 cm only.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 μg/g tissue).

Aquarium Value: This species is used as a component in freshwater aquarium and its aquarium parameters are given below.

Aquarium Size: Base dimensions of 75 x 30 cm or equivalent is suitable for a pair or trio.

Minimum Tank Size: 75.7 liters (20 US gallons).

Aquarium Maintenance: This species is best kept in a densely-planted aquarium with floating vegetation and driftwood roots or branches to diffuse the light. The water should be well-oxygenated with a degree of movement. This fish should not be added to a biologically immature set-up as it may be susceptible to swings in water quality, and weekly water changes of 20–30% aquarium volume should be considered mandatory.

Difficulty: Moderate.

Water Conditions:

Temperature: 23.3–26.7°C (74–80°F)

pH: 6.0–7.8

Hardness: 36–215 ppm

Specific Gravity (SG): Freshwater

Stocking Ratio: 1:1 M:F (male: female)

Diet: It normally preys on aquatic molluscs and crustaceans, and should be offered a meaty diet comprising live and frozen bloodworm, *Artemia*, mysids, chopped shrimp, etc. They should also be fed live snails on a regular basis in order to prevent their well-developed crushing teeth from becoming too long.

Behavior and Compatibility: It is less aggressive species. However, it is better to maintain it alone or with a group of peaceful, schooling cyprinids of suitable size.

Sexual Dimorphism: In males, body color is greyish and mottled, and this is not distinctly separated from the whitish belly and underside of the head, rather merging into it gradually. There is a thin, yellowish stripe extending posteriorly from the eye to the caudal peduncle, with a similarly-colored, chevron-shaped marking on the dorsal surface and a narrow interorbital bar. All males have a broad, red mid-ventral stripe and the dorsum is also red. The pectoral-fin is hyaline with a black base, anal-fin is hyaline and tinged with red; dorsal-fin is red with a dark marking at the base and caudal-fin is bluish to yellowish or greyish with black and white distal bands. Females have a pale lateral stripe similar to that of males but it is broader, sometimes interrupted and may contain a few irregular brownish markings. The chevron markings are also present but they are larger and broader than in males. The remainder of the body in this sex is punctuated with irregular pale blotches. The belly is whitish but without brownish markings, and there is a darker blotch just anterior to the anal-fin origin. The fins are mostly hyaline but the dorsal fin contains faint stripes while the caudal fin is yellowish with reticulated markings and several dark bars. The eye is red in both males and females, but it may be greenish-blue in the former.

Breeding: Unrecorded.

Lifespan: 8–10 years.

Toxicity: Unknown.

Conservation Status: Not evaluated.

***Carinotetraodon imitator* (Britz & Kottelat, 1999)**

Common Name(s): Dwarf Malabar puffer

Habitat: Freshwater; benthopelagic.

Global Distribution: Tropical; Asia: Kerala, India.

Description: This species is diagnosed by its more pectoral fin rays (17–18); fewer dorsal fin rays (9–10) and anal fin rays (8–9). It is a small, sexually dimorphic pufferfish. Both sexes of this species possess a pattern of black blotches. Body of male is dirty yellow to orange with several indistinct dark marks but becomes bright yellow to orange without any marks during the sexually active period. Females possess numerous tiny black spots interspersed among larger blotches. Body spination is consisting of few, slender pointed spines. Courting males are with erectable middorsal and midventral keels of skin. It grows to a maximum standard length of 25.6 mm (Britz and Kottelat, 1999).

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 µg/g tissue).

Aquarium Value: This species is used as a component in freshwater aquarium and its aquarium parameters are given below.

Aquarium Maintenance: It is easily maintained in groups with enough space and hiding places in aquariums. Males defend territories and look after the young, so they are most aggressive. Rocks and bogwood are used to create caves and plants are scattered to break up each fish's line of sight.

Stocking Density: About 10 l/2.5 gal per individual fish.

Lighting: Lights are kept low to help them settle in quickly.

Diet: A variety of live and frozen foods. Live foods include small pond snails, *Daphnia*, earthworms, mosquito larvae midge larvae, bloodworms, glassworms, black mosquito larvae and krill; and chopped seafood such as squid and mussel. They are to be fed in small amounts on demand, two or three times per day.

Water Parameters: Water quality should be excellent for this species. Ammonia and nitrite levels should be zero and the nitrate level should also be as low (under 50 mg/l). To ensure good water quality conditions, filtration should be done between four and six times the volume of the tank in turnover per hour. Inlet is protected with a fine

grille. Depending on stocking density, water changes of 25–50% per week are recommended.

Temperature: 25–28˚C (77–82˚F)

pH: 7.5

dGH: 10 (somewhat softer conditions may be required for spawning).

Aquarium Requirements:

Tank size: 45 liter (10 gal) or larger.

Bright lighting is not required.

Plants such as Java moss and Java fern, and hardy species like *Cryptocoryne wendtii* are recommended. Fast-growing floating plants such as *Limnobium laevigatum* are also useful to provide shade and cover besides helping to remove nitrate.

Inclusion of solid surfaces like rocks and sunken wood in tanks.

Breeding Behavior: Sexually mature males can be distinguished by their brighter colors and mature females are rounded as they fill up with eggs. Males get territories among feathery plants with Java moss and willow moss (*Fontinalis* spp.). A male attracts a female by raising his keel and engaging in dance. Spawning is very boisterous with the eggs being scattered into the moss. Male then quickly chases the female away and assumes total responsibility for brood care. The eggs hatch after five days, but the fry do not swim for at least another week. Once that happens the male loses interest and it should be removed. The free-swimming fry will have to be fed now with tiny live foods such as microworms and *Cyclops* nauplii. Growth is rapid and the fry will be 1 cm or so after two months. Spawning occurs readily if and when the dwarf puffers are provided the right conditions, such as lots of live food, slightly soft and acidic water conditions (pH 6.5–7.5; 10 dGH) and suitable spawning sites.

Choosing tank mates: This species cannot be combined with any of the standard community fish, showing a particular liking for the fins of some slow-moving species such as angels, gouramis, livebearers and Corydoras. The dwarf suckermouth catfish of the genus *Otocinclus* could serve as good companions. They are schooling fish which should be kept in groups of at least six specimens. It is advisable to keep dwarf puffers in groups of their own kind.

Toxicity: Unknown.
Conservation Status: Data deficient.

***Carinotetraodon irrubesco* (H. H. Tan, 1999)**

Common Name(s): Red-tail dwarf puffer.

Habitat: Freshwater; benthopelagic; amongst submerged bank vegetation in large rivers.

Global Distribution: Tropical; Asia: currently known only from the lower parts of the Banjuasin basin in Sumatra Selatan; and the Sambas river in Kalimantan Barat.

Description: This species is diagnosed by its dorsal fin rays (10–12); anal fin rays (9–10); and pectoral fin rays (15–16). Its dorsal fin base length is 11.7% standard length and anal fin base length is 9.5% standard length. Males are larger and colored brown with creamy stripes on the flanks and dorsal surface. Females on the other hand are smaller and mottled brown in color with irregular markings on the ventral surface. Both sexes have red eyes and red tail fins. It feeds chiefly on aquatic molluscs and crustaceans. This species grows to a maximum standard length of 4.5 cm.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 μg/g tissue).

Aquarium Value: Red-tail dwarf puffers are sometimes kept as an aquarium fish, but otherwise they have no commercial importance. Their aquarium parameters are given below.

Minimum Tank Size: 56.8 liters (15 US G.).

Water Conditions:

Specific Gravity (SG): Freshwater
pH: 6.0–7.8
Temperature: 23–26°C (73.4–78.8°F)
Hardness: 36 – 215 ppm
Stocking Ratio: 1:2 M:F (male: female)
Lifespan: 5–8 years.
Difficulty: Moderate.

Aquarium Maintenance: It is best kept in a densely-planted aquarium with floating vegetation and driftwood roots or branches to diffuse the light since it is normally quite shy in brightly-lit surroundings. Water should be well-oxygenated with a fair degree of movement. This fish should not be added to a biologically immature set-up as it is susceptible to swings in water chemistry. Weekly water changes of 20–30 % aquarium volume are considered mandatory.

Diet: It preys on aquatic molluscs and crustaceans, and they should be offered a meaty diet comprising live and frozen bloodworm, *Artemia*, mysids, chopped prawn/shrimp, etc. It may also be fed live snails regularly in order to prevent their well-developed crushing teeth, which grow continuously, from becoming too long. Fish fry and small freshwater shrimp are also likely to be consumed by this species.

Behavior and Compatibility: As this species is less aggressive, it is best maintained alone or with a group of peaceful, schooling cyprinids of suitable size. A group, however, is maintained if sufficient cover is available.

Sexual Dimorphism: In males, the body color is greyish and faintly mottled, and this is distinctly separated from the white belly and underside of the head. There is a broad, pale stripe extending posteriorly from the eye to the caudal peduncle, and a similarly-colored, chevron-shaped marking on the dorsal surface and a narrow interorbital bar with the latter markings not in contact with each other. All males possess a broad, red mid-ventral stripe and the dorsal surface is also sometimes red. The pectoral and anal fins are normally hyaline and tinged with red, while the dorsal and caudal fins are red. In females, the body is slightly paler with a broad, pale lateral stripe similar to that of males, but this is often interrupted and may contain irregular brownish markings. Further, there are two or three undulating pale stripes on the body

and these form an irregular reticulated pattern. The belly is whitish with a number of brownish stripes broken into a series of smaller markings and there is a darker blotch just anterior to the anal-fin origin. The fins are mostly hyaline but the dorsal fin has faint stripes while the caudal fin is yellowish with reticulated markings and several dark bars. The eye is red in both males and females, but at times greenish-blue in the former.

Breeding: This species has been successfully bred in aquariums. During courtship, the male displays to the female by darkening its colors and extending its ventral ridge, and after about 2 of hours, the pair deposits several hundred eggs in plants. The adults are subsequently removed if the male is found preying on the eggs. The first fry hatch in 65 hours and are still in possession of a yolk sac but they are free-swimming immediately with the sac fully-absorbed by the third day. By this time, infusoria is introduced as a first food. After 10 days 30–40, the fry are fed on rotifers.

Toxicity: Unknown.

Conservation Status: Not evaluated.

Carinotetraodon lorteti* (Tirant, 1885) *(= Tetraodon lorteti)

Common Name(s): Redeye puffer, red-bellied puffer.

Habitat: Freshwater; benthopelagic; medium to large-sized rivers; slowly flowing or standing freshwater habitats.

Global Distribution: Tropical; Asia: Indochina, Malaysia and Indonesia.

Description: Body of this species is oblong and is compressed laterally. It is strongly compressed at caudal peduncle. Dorsal profile is arched and is highest at origin of dorsal fin. Body spines are small, covering back, sides and belly from nasal organs to end of anal fin base. Mouth is terminal, directed upwards. A heavy chin is present. Lower border of eye is slightly above level of mouth corner and upper border is not interfering with dorsal profile. The iris of the eye is red. Nasal organ is a short cylinder, nearly as high as broad, with one terminal opening. Males are with a ventral and dorsal median skinfold between tip of snout and dorsal fin. Anal fin is accompanied ventrally by shorter, parallel skinfolds on throat. It is sexually dimorphic and males and females are often described as different species. This species is able to change its colors depending on the environment. The color becomes darker in darker surroundings and lighter in lighter surroundings. Females have a brown-gray coloration with wide beige and small dark brown markings. Belly is white with small dark spots. Iris of the eye is blood red. Males have a dark brown back with two yellow markings, both running from the top of the eye. Flanks are lighter brown with a faint, yellow stripe running from the mouth to the top of the caudal peduncle. Belly is white-yellow and bright red. Anal and dorsal fins are small and orange-red in color. Base of the caudal fin may be faint red and the fin may be edged in white. It feeds on zooplankton, molluscs, crustaceans and other invertebrates. This species grows to a maximum standard length of 6.0 cm.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 µg/g tissue).

Aquarium Value: This species is used as a component in freshwater aquarium and its aquarium parameters are given below.

Community Tank: Not recommended.

Stocking Ratio: 1:1 M:F (male: female)

Lifespan: 8–10 years.

Difficulty: Moderate.

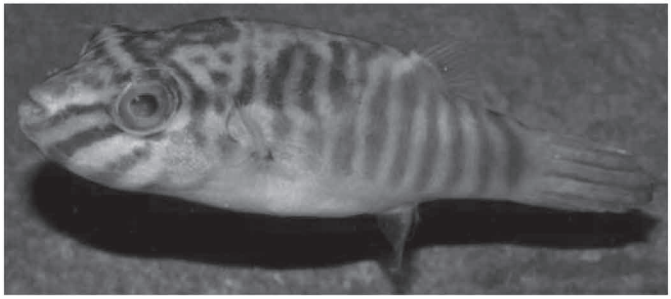
Water Change: Frequent partial water changes are recommended.

Minimum Tank Size: 75.7 liters (20 US G.). Enough hiding place is provided among rocks, wood, and heavily planted areas. Open swimming areas are left and a fine gravel or sand substrate is used. Plants of the tank should be with tough leaves.

Usual Fish Size in Fish Tanks: 5–6 cm.

Water Chemistry: Ideally soft and slightly acidic.
Water Parameters:
pH range: 6.6–7.1
Specific Gravity (SG): Freshwater
Water Hardness: 53.57–232.14ppm
Temperature: 24–28 °C (75.2–82.4°F)
Temperament to Its Own Species: Aggressive/territorial.
Temperament Toward Other Fish Species: Aggressive/territorial. This territorial species will establish an area to protect against other fish. This species is best kept as a single pair in a species tank.
Usual Place in the Tank: Bottom levels.
Diet: It is a carnivore eating meaty foods such as; snails, *Tubifex,* crustaceans, insect larvae, earthworms. It may also eat prepared tablets.
Breeding: The tank is furnished with Java moss. 300–1500 eggs are laid in the moss after an active courtship. The male guards the fry, which hatch in 30 hrs. Parents should be removed from the tank immediately after laying eggs; otherwise, they may eat the eggs. The fry are very difficult to raise because they do not take most foods offered.
Sexing: The male is more colorful and abstract in coloration than the female, which has a grey belly and is spotted.
Toxicity: Unknown.
Conservation Status: Least Concern (LC).

***Carinotetraodon salivator* Lim & Kottelat, 1995**



Common Name(s): Striped red-eye puffer.

Habitat: Freshwater; benthopelagic; large stream with soft and silty bottoms in some parts, sandy in others, with leaf litter and submerged logs; relatively fast flowing waters; depth range 1–2 m.

Global Distribution: Tropical Sarawak, Malaysia.

Description: This species has a shallower body (depth 36–41% standard length), 10 anal fin rays, 16–17 pectoral fin rays and 17–18 vertebrae. Body is elongated; oval in lateral view and pointed at snout tip. Head and eyes are large. Eyes are situated nearer the dorsal profile of the head. Mouth is terminal and directed upward. Lower lip is protruding beyond upper lip. Chin is rather heavy. Nostril is tubular with one terminal opening and a slight lobe. Body and head are greyish in color. Both sexes have a complex reticulated midlateral stripe and 2 dark greyish bands stretching from the anterior lower edge of one eye. Upper band is deeply indented by a large white patch under the lower lip. Ventrum is cream colored and striped in females; and red with 3–5 cross bars anteriorly in mature males. It is an omnivore preying on zooplankton, nematodes, copepod, prawns, gastropods and polychaetes. It is a small pufferfish with a maximum standard length of 4.0 cm.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 μg/g tissue).

Aquarium Value: This species is used as a component in freshwater aquarium and its aquarium parameters are given below.

Difficulty: Moderate.

Minimum Tank Size: 75.7 liters (20 US G.)

Usual fish size in aquarium tanks: 4–5 cm.

Stocking Ratio: 1:1 M:F (male: female)

Water Conditions:

Specific Gravity (SG): Freshwater

pH range: 6.6–7.6

Water hardness: 89.29–357.14 ppm

Temperature: 22–26 °C (71.6–78.8°F)

Temperament to Its Own Species: Peaceful.

Temperament Toward Other Fish Species: Aggressive/territorial.

Usual Place in the Tank: Middle levels.

Food and Feeding: It relishes frozen blood worm and krill. Addition of small pond snails in diet will keep its teeth under check. As it has nocturnal feeding habit, it should be fed in the morning.

Sexing: The males are larger displaying more coloration than the females. The females have a mottled brown body with a light belly.

Breeding: The male will display to the female for several days, when she is ready to spawn the eggs which are laid on the substrate. After this, the female will be driven away from the spawning site and the male will take care of the brood. The eggs normally hatch in about 3 days and the fry are free swimming after 2 days. They can be fed on infusoria initially and then newly hatched *Artemia*.

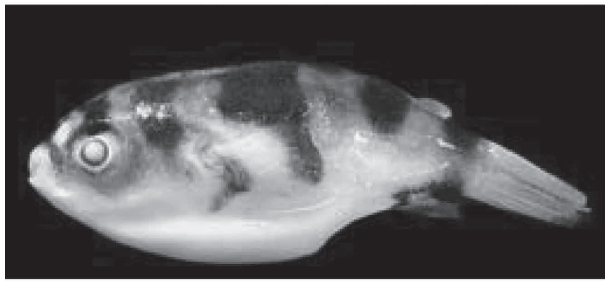
Lifespan: 8–10 years.

Others: These puffers should be kept in a species tank as they are not tolerant of other tank mates. They are also high waste producers and they require excellent filtration and about 10 gallons of water per fish.

Toxicity: In this species, the toxin is highly concentrated in its liver and the concentration was found to range from 2.74 MU/g to 3.94 MU/g. The fish has low toxicity and is considered non-toxic (Ling, 2009).

Conservation Status: Not evaluated.

***Colomesus tocantinensis* (Amaral, Brito, Silva & Carvalho, 2013)**



Common Name(s): Not designated.

Habitat: Riverine systems.

Global Distribution: Known only from the type locality at present. Type locality is 'Tocantins River, near Porto Nacional, State of Tocantins, Brazil'.

Description: In this species, prickles extend along the dorsal, lateral, and ventral surfaces of the body, which is from the level of the eye to the origin of the dorsal fin. The color pattern and the extent of the dorsal and ventral lateral lines are similar to those found in *Colomesus asellus*. There are five transverse dark bars across the dorsal region of the body. A dark blotch is seen on the underside of the caudal peduncle. Interspaces between the dark bars are light yellow, with gradually decreasing pigmentation and becoming white in the ventral region. Nasal sac is higher than that of *C. asellus*. Two large lateral and anteromedial nostrils are present. They are similar to those found in *C. psittacus*. Anterior surface of the nasal sac is smooth while the posterior surface of it is folded as in *C. psittacus,* exhibiting a "T-shaped" ridge with a relatively small dorsal flap. This flap seems much smaller than the one found on *C. asellus*, although more flexible when compared to *C. psittacus*. No dermal flaps could be seen in the specimens from the Tocantins River, although they are always present in examined specimens from other regions. Its reproduction is unknown. The largest specimen in the type series measured 34.9 mm, but it should grow larger.

It is a new species and further research is needed to understand about its toxicity and use as food and aquarium specimen.

Pao abei **(Roberts, 1998)** (= *Tetraodon abei, Monotrete abei*)

Common Name(s): Abei puffer.

Habitat: Freshwater; demersal; rivers and tributaries; occasionally in marshlands.

Global Distribution: Tropical; Asia: Meklong, Chao Phraya and Mekong basins.

Description: Entire dorsolateral surface of body of this species is with numerous pale spots uniformly distributed over a dark background. These spots are orange and the background is brown or blackish brown. In preserved specimens, the spots may be faintly orange. All adults have numerous spots. In preserved specimens the spots are pale. They are molluscivores (mollusc eaters), using the beak-like teeth to break open the shell of the prey. They are also opportunistic piscivores (fish eaters). This species has a maximum standard length of 10.3 cm.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 µg/g tissue).

Aquarium Value: The species is occasionally seen in freshwater aquarium trade. Its aquarium parameters are given below.

Minimum Tank Size: 94.6 liters (25 US G.).

Suitable Fish Size: 10–11 cm.

Stocking Ratio*:* 1:1 M:F (male: female)

Water Conditions:

pH: 6.4–7.1

Water Hardness: 53.57–267.86 ppm

Temperature: 23–27 °C (73.4–80.6°F)

SG: Freshwater

Food: As of the other the puffers, the teeth of this species also needs to be constantly ground down. Hence these fishes are to be supplied with shelled food such as snails and crustaceans. They will also feed on live or frozen foods in the form of blood worms, krill and prawns.

Temperament to Its Own Family and Other Species: Aggressive

Preferred Swimming Area (Usual place in the tank): Bottom levels.

Activity: Very active hunter, especially during and after sunset.

Breeding Type: Spawning.

Sexing: There are no visible differences between the sexes.

Breeding: Breeding of this species is very difficult. The male will take on the parenting role and the female will be driven away.

Difficulty**:** Moderate.

Expected Lifespan: 8–10 years.

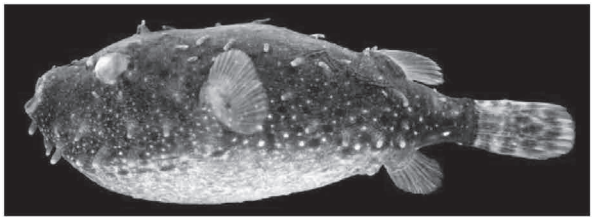
Aquarium Care: As these fishes are very sensitive to poor water quality, excellent filtration must be provided. Further, owing to their very messy eating habit, regular gravel vacuuming and water changes should

also be performed. A few plants may be included in the tank to make the fish feel at ease.

Toxicity: Unknown.

Conservation Status: Least Concern.

***Pao baileyi* (Sontirat, 1989)** (=*Tetraodon baileyi*)



Common Name(s): Hairy puffer.

Habitat: Freshwater; demersal; rocky habitats including rapids of the Mekong mainstream and its larger tributaries.

Global Distribution: Tropical; Asia: Mekong basin.

Description: Head and body of this species are sparsely or densely covered with epidermal outgrowths or cirri. The latter may be missing in specimens smaller than 3 cm standard length. Body is entirely without scales. Abdomen of live fish is golden or orange with no other markings. This fish feeds on a combination of snails, freshwater shrimp and crabs, and any slow-moving fish. It grows to a maximum standard length of 12 cm.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 μg/g tissue)

Aquarium Value: This species is used as a component in freshwater aquarium and its aquarium parameters are given below.

Usual Size in Fish Tanks: 11–12 cm.

Water Conditions:

pH: 6.7–7.4

Water Hardness: 71.43–357.14 ppm

Temperature: 23–28 °C (73.4–82.4°F)

Temperament to Its Own Species: Aggressive/territorial; it deserves a species tank

Temperament Toward Other Fish Species: Aggressive/territorial.

Usual Place in the Tank: Middle levels.

Food and Feeding: This species enjoys a diet of shellfish, earth worms, white worms, blood worms and brine shrimp. They are also to be fed with shelled fish and snails to keep their teeth sharp and in trim.

Sexing: It is believed that the males have more of the hairy growths than the females but this has yet to be proven.

Breeding: It is yet to be achieved in the aquarium.

Lifespan: Unknown in the aquarium.

Aquarium Care: As it is a bottom-dwelling species, it needs a soft, silver sand substrate to allow it to burrow. Some rocks may also be added in the tank for hiding places. Although found among rapids, it is not a strong swimmer and tends to spend most of its time between crevices and rocks. Plants will be safe with this species. Some powerful filtration may be added to recreate a river-like flow pattern. This species will change color depending on its mood. This species of puffer is quite rare in the aquarium trade and the price of the fish will reflect this.

Toxicity: Unknown.

Conservation Status: Least Concern.

Pao bergii (Popta, 1905)

Image not available.

Common Name(s): Unknown.

Habitat: Freshwater; demersal.

Global Distribution: Tropical; Asia: Kapuas drainage, Borneo in Indonesia.

Description: Unknown.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 μg/g tissue).

Aquarium Value: Unknown.

Toxicity: Unknown.

Conservation status: Not evaluated.

***Pao brevirostris* (Benl, 1957)** (= *Tetraodon leiurus brevirostris, Tetraodon cochinchinensis*)

Common Name(s): Short-nosed pufferfish.

Habitat: Freshwater; demersal; midland to lowland rivers and tributaries. still and slow-moving bodies of water including rivers, lakes and ponds, rarely in brackish water; marshes and swamps with clear and stagnant water in places with many aquatic plants.

Global Distribution: Tropical; Southeast Asia; Indonesia, Malaysia, the Philippines, Singapore, Brunei, Vietnam, Laos, Myanmar, Cambodia, Thailand.

Description: Body color in its upper part is greyish yellow and brownish-grey. This color passes down the flanks to finish on a cream-white. Much of the body is with rounded spots of different colors (olive-brown, ash blue, yellow, etc.). Fins are transparent and have no radiation. Soft and pelvic are absent. Dorsal and anal fins which are at the same level, are placed very back of the body. Head which is almost one third of the body is with a short and truncated snout. Ribs are absent and the number of vertebrae is small. Skin has no scales and is thorny. Body has a strong protective slime. Eyes are very mobile and the "beak", is formed by the welding of dental plates. Diet of this species includes mainly juvenile fishes Nile Tilapia, *Oreochromis niloticus*, and cyprinids, *Barbonymus gonionotus, Cirrhinus siamensis* and *Hypophthalmichthys molitrix*. This fish shows sexual dimorphism in adulthood. Male is much more slender and has a less dull color than the female coloration. Male and female fish of this species have the maximum standard length of 9.5 cm and 7.7 cm, respectively.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 μg/g tissue).

Aquarium Value: It is a component of the freshwater aquarium trade and its aquarium parameters are given below.

Usual Fish Size in Tanks: 6–7 cm.

Water Conditions:

pH range: 6.6–7.5

Water Hardness: 89.29–357.14ppm

Temperature: 23–28 °C (73.4–82.4°F)

Temperament to Its Own Species: Aggressive/territorial.

Temperament Toward Other Fish Species: Aggressive/territorial.

Usual Place in the Tank: Bottom levels.

Food and Feeding: This species needs plenty of live or frozen meaty foods. Cockles, mussels, and prawns are ideal. A steady supply of snails with shells will help to keep their beaks trimmed down.

Sexing: There are no visible differences between the sexes.

Breeding: It has been bred in the aquarium rarely. When fry are produced there is no parental care and they should be removed.

Lifespan: The expected lifespan for this species is 10 years.

Aquarium Care: As it is extremely aggressive to its tank mates, it should be kept in a species tank. For keeping more than one specimen, plenty of plants and décor are added to break up the views so that they can establish their own territories. They are high waste producers and it is best to over filter the water rather.

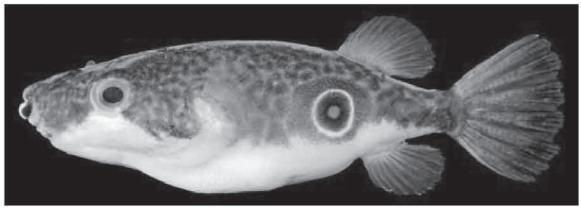
Caution: This species contains a "fugu" toxin that causes severe nerve disorders. This results in aquarium, causing the death of fish in the vicinity of a frightened or sick Tetraodontidae. Similarly, it is better to avoid acclimatizing one of these fish with other subjects as well as cohabitation in a small aquarium. It is extremely sensitive to nitrites and ammonia and it produces mucus hyper secretion covering the skin with a whitish slime layer. It is therefore an urgent need for a massive water change. This species is suitable for an experienced beginner.

Important: The capture of this fish with dip net for a transfer should be done without taking the fish out of water, even a short time. It is rare for sale.

Toxicity: Unknown.

Conservation Status: Least Concern.

***Pao cambodgiensis* (Chabanaud, 1923)** *(=Tetraodon cambodgiensis)*



Common Name(s): Cambodian puffer.

Habitat: Freshwater; demersal; habitats with swift current including rapids.

Global Distribution: Tropical; Asia: Mekong basin.

Description: In this species, there is a conspicuous single ocellus on its flank. It is dark green or bluish-green back and side. It has an immaculate white belly. Upper margin of caudal fin is orange. This species grows to a maximum standard length of 15.3 cm.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 μg/g tissue).

Aquarium Value: This species is used as a component in freshwater aquarium and its aquarium parameters are given below.

Tank Size: 120–180 liters.

Suitable Fish Size: 15 cm

Temperature: 24–28 degrees Celsius

Water Type: hard and soft water aquaria (brackish water is not needed).

Food and Feeding: Mussels, squid and unshelled prawns; live foods include are pond snails, earthworms and river shrimps; bloodworms and other sorts of insects for smaller specimens; these fish are to be fed only every second day.

Behavior: As it is aggressive, one fish per tank is recommended.

Activity: Hidden most of the time; only becoming active at dawn and dusk.

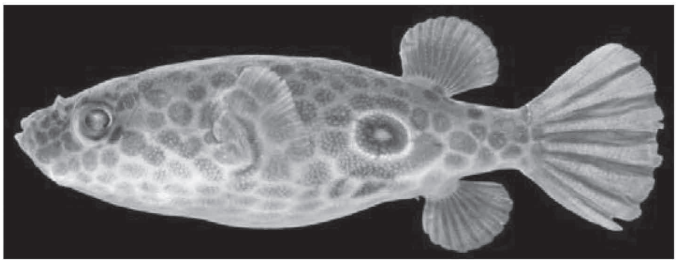
Basic Care: A filter that provides at least 4 times the volume of the tank in turnover per hr is used. Generous water change and certainly not less than 50% per week is advisable.

Toxicity: Unknown.

Conservation Status: Least Concern.

***Pao cochinchinensis* (Steindachner, 1866)**

(= Tetraodon cochinchinensis)



Common Name(s): Fang's puffer, red spot puffer.

Habitat: Freshwater; demersal.

Global Distribution: Tropical; Asia: Mekong and Chao Phraya basins; possibly also the Malay Peninsula and Sumatra, Indonesia.

Description: This species has a greenish back with black spots, not well demarcated from belly. Belly is greyish to dark brown, with or without dark markings. Adult has an ocellus which is red, but it is most commonly made of a large black blotch surrounded by a paler area and a series of more or less contiguous large black blotches. Juvenile is with a small red spot in center of concentric pale and black circles. It grows to a maximum standard length of 11.3 cm.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 µg/g tissue).

Aquarium Value: This species is used as a component in freshwater aquarium and its aquarium parameters are given below.

Usual Fish Size in Tanks: 6–7 cm.

Aquarium Size: 18″ x 12″ x 12″ (45 cm x 30 cm x 30 cm) – 40 liters.

Water Conditions:

pH range: 6.6–7.5

Water Hardness: 89.29–357.14ppm

Temperature: 23–28°C (73.4–82.4°F)

Temperament to Its Own Species: Aggressive/territorial.

Temperament Toward Other Fish Species: Aggressive/territorial.

Usual Place in the Tank: Bottom levels.

Food and Feeding: Fang's puffer needs plenty of live or frozen meaty foods. Cockles, mussels, and prawns are ideal. They are to be

supplied with a steady input of snails as these food items will help to keep their beaks trimmed down.

Sexing: There are no visible differences between the sexes.

Breeding: It has been bred in the aquariums. When fry are produced there is no parental care and therefore, they should be removed immediately.

Lifespan: The expected lifespan for this species is 10 years.

Aquarium maintenance: Fang's puffer is extremely aggressive to other tank mates. Hence it is best kept in a species tank. For keeping more than one specimen, plenty of plants and décor are to be added to break up the views so that they can establish their own territories. As they are high waste producers, it is best to over filter the water.

Toxicity: Unknown.

Conservation Status: Least Concern.

***Pao fangi* (Pellegrin & Chevey, 1940)**

(= Tetraodon cochinchinensis, Tetraodon fangi)

Common Name(s): Fang's puffer, brown puffer.

Habitat: Freshwater; demersal.

Global Distribution: Tropical; Asia: Vietnam.

Description: Body of this species is elongated and its greatest part is compressed dorsoventrally. Dorsal profile is arched, highest at midst of back. Interorbital is convex, without a groove. Lateral line system is distinct. Body spines are small. Papillae are giving smooth impression and they are arranged in net- like pattern on belly. Origin of anal fin is situated beneath anterior half of dorsal fin base. Mouth is terminal and directed forwards.

Lower border of eye is slightly above level of mouth corner and upper border is higher than lowest point of interorbital. Ground color of upper parts is tan. Belly is yellowish white. Whole of sides and lateral parts of back are covered with many polygonal dark spots, leaving only a lighter network of ground color. Snout is dorsally with dark spots or uniformly dark. Chin is dark. A big ocellus is seen on sides, horizontally on level with pectoral fin and vertically on level with origin of dorsal fin. Ocellus is with light ring, surrounded by circularly arranged, and partly fused polygonal spots. Belly is laterally with dark spots which are more oblong than lateral spots. Centrally it is yellowish white. Fins are plain and caudal fin is darkest.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 µg/g tissue).

Aquarium Value: The suitability of this fish for aquarium is unknown.

Toxicity: The highest toxicity levels for this species were found in skin (813 MU per g) following by eggs (336 MU per g), muscle (331 MU per g), liver (209 MU per g) and intestine (159 MU per g) (Saitanu et al., 1991). Saxitoxin which caused food poisoning in Thailand was identified in this fish (Sato et al., 1997). Food poisoning due to this species occurred in six out of eight people who consumed its spicy soup. All people developed clinical signs of tetrodotoxin intoxication. The incubation period varied from 30 min to 3 hrs and there were no deaths. All internal organs of this species were found to be toxic with skin having the highest toxicity followed by gonad, muscle, liver and intestine (Laobhripatr et al., 1990).

Conservation Status: Not evaluated.

Pao hilgendorfii* (Popta, 1905) *(= Tetraodon hilgendorfii)

Image not available.

Common name(s): Hilgendorf´s puffer.

Habitat: Freshwater; demersal.

Global Distribution: Tropical; Asia: Mahakam basin in Borneo, Indonesia.

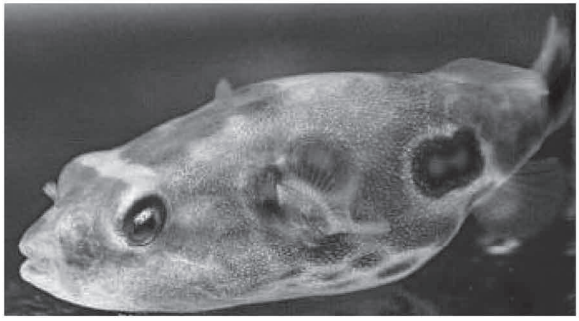
Description: It is a nice pufferfish. Body of the fish has dark brown color above and a light belly with brown spots. It is a carnivorous fish feeding on a variety of invertebrates. It grows to a maximum size of 10 cm.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 µg/g tissue).

Aquarium Value: This species is used as a component in freshwater aquarium and its aquarium parameters are given below.

Fish Size for Tank: Under 10 cm.
Minimal Tank Volume: 150 liter (40 US gal)
Tank Type*:* Freshwater tank.
Floor Water Column: Entire water column.
Feeding: Carnivore – live and frozen.
Reproduction: Yet unknown and undescribed.
Behavior: Aggressive.
Care Level: Very difficult.
Toxicity: Unknown.
Conservation Status: Not evaluated.

***Pao ocellaris* (Klausewitz, 1957)** *(= Tetraodon ocellaris)*



Common Name(s): No common names.
Habitat: Freshwater; demersal.
Global Distribution: Tropical; Asia: Malay Peninsula.
Description: It eats all kinds of shellfish and worms. No other information is available for this species.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 μg/g tissue).

Aquarium Value: This species is used as a component in freshwater aquarium and its aquarium parameters are given below.

Water Conditions:
Temperature: 24–28°C
pH: 6.5–7.8
dGH: 8–15

Food: It eats all kinds of shellfish and worms, and other meaty live and frozen foods. It should be served unshelled snails and crustaceans (e.g., crab legs, mussels, etc.) on a regular basis in order to wiping its sharp teeth.

Aquarium Care: It is best grown in an aquarium with lots of twisted roots and branches. Floating plants are recommended to disperse the light. There is a need for frequent water changes with freshwater because the species is very sensitive to water quality.

Reproduction: It has been bred in aquariums, but there is little data.

Behavior: It is a very aggressive to the same species and should not be kept in groups.

Toxicity: Unknown.

Conservation Status: Least Concern.

***Pao palembangensis* (Bleeker, 1852)** *(= Tetraodon steindachneri, Tetradon palembangensis)*

Common Name(s): Humpback puffer.

Habitat: Freshwater; demersal; lakes and rivers.

Global Distribution: Tropical; Asia: Laos, Thailand, Malaysia, and Indonesia.

Description: Body of this species is oblong and is compressed ventrodorsally at the anterior side. Dorsal profile is roof-like or arched and its highest point between pectorals is often bump-like. Interorbital is concave or flat, often with a median groove. Lateral line system is very conspicuous. Body spines are small and are hidden under papillae in rounded dermal pits. Dermal pits are very conspicuous and are dense at back, sides, and belly between nasal organs and anal fin base. Origin of anal fin is situated beneath posterior half of dorsal fin base. Mouth is terminal and is directed forward. Lower border of eye is at or below level of mouth corner and its upper border is interfering with dorsal profile. Ground color

of upper parts is tan. Belly is yellowish or greyish white. Back has a light interocular band. A dark triangular patch is seen on posterior part of head. Sides and belly are with a dark meshwork which is most distinct and regular on belly. Meshwork on sides look like light vermiculating lines and streaks. Sides are with 3–18 rounded spots which are darker than meshwork. Caudal fin is proximally or distally sometimes darker. Other fins are plain. It feeds on snails, tubifex worms, crustaceans, insect larvae and earthworms. It reaches a maximum standard length of 19.4 cm.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 µg/g tissue). However, it is locally consumed; it is kept alive until processing, and the skin and internal organs are removed before cooking.

Aquarium Value: This species is used as a component in freshwater aquarium and its aquarium parameters are given below.

Aquarium Size: 120 cm x 30 cm x 30 cm – 110 liters (for a single fish).

Aquarium Maintenance: This species needs cover and pieces of driftwood, large rocks and clay flowerpots are all suitable for this. It can be kept in a planted setup, although plants are not essential. Like all puffers, it is very sensitive to deteriorating water conditions, so regular partial water changes are a must.

Water Conditions:

Temperature: 75–82°F (24–28°C)

pH: 6.8–7.6

Hardness: 8–20 dGH

Diet: It relishes all kinds of shellfish, as well as worms and other live and frozen foods. It should be fed snails and unshelled shellfish (such as crab legs, mussels, etc.) regularly, in order to maintain its sharp teeth. Due to its inactive nature, it does not need daily feeding. Adults require only one or two feeds a week.

Activity: This is an immobile species. It either lies motionless by hiding on the substrate, or hangs amongst plants. Any motion of the fish is in relation with feeding only. It prefers a complex enviroment with plants and caves.

Behavior and Compatibility: These puffers are quite belligerent with one another and plenty of cover is required. It is unsuitable for

the community tank due to its piscivorous nature (http://www.seriouslyfish.com/glossary/p/piscivorous). It may be kept with similarly sized or larger, active species such as bigger characins or cyprinids. It is however, best kept as a single specimen. Several fishes can be maintained in a large tank as long as plenty of hiding places and visual barriers are provided.

Sexual Dimorphism: Unknown.

Breeding: Breeding of this fish has occurred in aquariums very rarely. It is a substrate spawner, with the eggs being laid in a pre-excavated pit within a cave. After spawning, the male takes care of the eggs until they hatch. At this point, the adult fish should be removed. The fry can be fed *Artemia* nauplii and even bloodworms from birth.

Lifespan: The expected lifespan for this species is 10–15 years.

Toxicity: The highest toxicity levels for this species were found in skin (907 MU per g) following by eggs (332 MU per g), muscle (282 MU per g), liver (225 MU per g) and intestine (143 MU per g) (Saitanu et al., 1991).

Fisheries Status: It has a minor commercial fishery.

Conservation Status: Data deficient.

Pao suvattii* (Sontirat, 1989) *(= Tetraodon suvatti)

Common Name(s): Arrowhead puffer, pignose puffer, Mekong puffer, hognose puffer, Suvatti puffer.

Habitat: Freshwater; demersal; large rivers with muddy substrate; rocky bottoms.

Global Distribution: Tropical; Asia: Mekong basin.

Description: It is a medium sized freshwater puffer fish reaching up to 15 cm. The turned-up nose of this puffer fish gives it a pig nosed appearance. Black V-shaped mark on the back of its head looks like an

arrowhead. It has an upturned mouth. Light and dark marks are forming a radial pattern surrounding eye. Head and body are depressed. A more or less complete ocellus is seen on the posterior part of the body. A series of oblique stripes are also seen on the cheeks and on the lower anterior part of the body.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 μg/g tissue).

Aquarium Value: This species is used as a component in freshwater aquarium and its aquarium parameters are given below.

Aquarium Size: It is not a very active species, so a tank measuring 75 x 12 x 12 cm (70 liters) may be enough for a single fish.

Aquarium Maintenance: A deep (5–7.5 cm) bed of sand as substrate is essential. Additional cover may also be provided in the form of smooth rocks, and driftwood pieces. Plants can also be used. Like all puffers, it is very sensitive to deteriorating water conditions, so regular and partial water changes are needed.

Water Conditions:

Temperature: 72–79°F (22–26°C)

pH: 6.5–7.5

Hardness: 5–12 dGH

Diet: It requires a meaty diet. Prawns, earthworms, lance fish, mussel, etc. may therefore be offered. Some specimens may only take live foods initially, but most will accept dead alternatives. Due to its inactive nature, it does not need daily feeding. Adults require only one or two feeds a week.

Behavior and Compatibility: It is not really safe to house this species with other species. It is a voracious predator that will eat any fish it can fit in its mouth. It is fairly intolerant of conspecifics but multiple specimens can be kept in a large tank with lots of hiding places and visual barriers.

Sexual Dimorphism: This species is unsexable by external characteristics.

Breeding: Though breeding of this species has been achieved in the hobby, not much information is available about its reproduction. They rare substrate spawners and excavate a small pit into which the eggs are deposited, following a courtship. Both male and female fishes

inflate themselves and display at one another during courtship. Following fertilization by the male, the female guards the eggs until they hatch. The fry will accept *Artemia* nauplii once they have used up their yolk sacs.

Toxicity: Just Like their saltwater cousins, *P. suvatti* contains tetrodotoxin within their skin, and organs (Wikipedia)

Conservation Status: Least Concern.

***Pao turgidus* (Kottelat, 2000)** *(= Tetraodon turgidus)*

Common Name(s): Chamaeleon puffer.

Habitat: Freshwater; pelagic; rivers and streams, marshlands, swamps and floodplains with dense submerged vegetation.

Global Distribution: Tropical; Asia: Mekong basin and possibly also in Chao Phraya basin.

Description: Back of this species is greenish- brown to black and belly is white. This color transition may be gradual or abrupt. Back and side of head and body are with numerous small black spots, usually several of them with a paler (orange to red in life) central area. There is no ocellus or no large blotch below dorsal-fin origin. It is an omnivore feeding on molluscs, crustaceans and sometimes plants. This species grows to a maximum length of 18.5 cm.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 µg/g tissue). This species is locally consumed in households.

Aquarium Value: This species is occasionally found in the freshwater aquarium trade and its aquarium parameters are given below.

Minimum Aquarium Size: 100 liters.

Water Conditions:

Temperature: 24–28°C

pH: 6.0–7.8

dGH: 6–16

Temperament: Aggressive.

Food: These are omnivores. They eat molluscs, crustaceans and sometimes plants. Live and frozen foods: snails, shrimp, bloodworms, mussels, clams and other shellfish are also offered

Propagation (breeding): Unknown.

Inmates: This species can best be taken into solitary.

Activity: Daytime inactive. Very active hunter during and after sunset.

Lifespan: Unknown.

Aquarium Care: These puffers are also extremely sensitive to nitrite and ammonia, and should be introduced in a completely cycled aquarium. Because of its messy eating behavior, it deserves a big filter with overcapacity preferred

Difficulty Level: Easily maintainable.

Toxicity: The toxicity of this species was found localized mainly in the skin and ovary. Paralytic shellfish toxins (PSTs), comprising saxitoxin (STX) and decarbamoylsaxitoxin (dcSTX), account for approximately 85% of the total toxicity. Artificially reared specimens of the same species were however, non-toxic. When PST (dcSTX, 50 MU/individual) was administered intramuscularly into cultured specimens, toxins were transferred via the blood from the muscle into other body tissues, especially the skin. The majority (92.8%) of the toxin remaining in the body accumulated in the skin within 48 h. When the same dosage of tetrodotoxin (TTX) was similarly administered, all specimens died within 3–4 h, suggesting that this species is not resistant to TTX. Toxin analysis in the dead specimens revealed that more than half of the administered TTX remained in the muscle and a small amount was transferred into the skin. The presence of both toxic and non-toxic wild specimens in the same species indicates that PSTs of *T. turgidus* are derived from an exogenous origin, and are selectively transferred via the blood into the skin, where the toxins accumulate (Ngy et al., 2008).

Conservation Status: Least Concern.

***Takifugu orbimaculatus* (Kuang, Li & Liang, 1984)**

Common Name(s): Not designated.

Habitat: Freshwater; demersal; coastal streams and rivers; fresh and brackish water; migrates from brackish water to freshwater; coastal areas.

Global Distribution: Tropical; Asia: China.

Description: No one has described this species.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 μg/g tissue). According to some reports, parts of this fish are poisonous but, it may be eaten.

Aquarium Value: This species is used as a component in freshwater aquarium and some of its aquarium parameters are given below.

Water Type: Freshwater.

Temperature: 25–27°C

Food/Feed: Snails, small crustaceans and insect larvae.

Toxicity: Unknown.

Conservation Status: Least Concern.

***Tetraodon barbatus* (Roberts, 1998)**

Common Name(s): Thai puffer.

Habitat: Freshwater; demersal; in Mekong mainstream as well as in its large tributaries, especially in areas with rocky, sandy or muddy substrates.

Global Distribution: Tropical; Asia: Mekong basin.

Description: This species has an elliptical body and its dorsal profile of head and body are slightly convex. Snout is long and blunt. Eye that is visible from the ventral side of head is slightly large and is protruding laterally. Covering area of spinules includes dorsal surface between internasal to behind dorsal fin end; lateral surface between nasal organ anterior margin and curve line behind dorsal fin end to anterior anal fin origin; and ventral surface between chin and anterior of vent. There is a middle sized, round ocellus with dark center on flank. Ventral surface of body is evidently white. Dorsal and lateral surfaces are yellow to brown background and are covered with small, round scattered-black spots. Lower lip has three black marks: first on middle part and two on lower lip sides. These marks are visible from juvenile through adult stages. Lower lip is usually grey. Pectoral and anal fins are white and slightly hyaline. Dorsal and caudal fins are grey. It grows to a maximum standard length of 13.6 cm (Saenjundaeng et al., 2013).

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 μg/g tissue).

Aquarium Value: It is a component of freshwater aquarium and its parameters are given below.

Usual size in fish tanks: 11–14 cm

Water Conditions:

pH range: 6.3–6.3

Water hardness: 142.86–267.86 ppm

Temperature: 23–27 °C (73.4–80.6°F)

Diet: It feeds on live ghost shrimp, snails, and frozen or freeze dried krill, clam, shrimp, crab legs and other molluscs. It should be fed a steady diet of hard-shelled foods to prevent its fused teeth from overgrowing.

Temperament to Its Own Species: Peaceful.

Temperament Toward Other Fish Species: Aggressive to smaller.

Usual Place in the Tank: Middle levels.

Aquarium Maintenance: As this species highly aggressive, it is to be housed in a single species tank or with fast swimming fish. It is a notorious fin nipper. It needs to be provided with highly filtered water without too much current.

Toxicity: Unknown.

Conservation Status: Not evaluated.

***Tetraodon biocellatus* (Tirant, 1885) (= *Tetraodon steindachneri*)**

Common Name(s): Figure 8 puffer, eyespot pufferfish, circle-eight puffer.

Habitat: Freshwater; demersal.

Global Distribution: Tropical; Asia: Indochina, Malaysia and Indonesia.

Description: Body of this species is oblong and is slightly compressed laterally. Dorsal profile is arched, and is highest at midst of back. Interorbital is convex, without a groove. Lateral line system is distinct. Body spines are small, sometimes partly or wholly indistinct, covering back, sides, and belly between eyes and origin of dorsal fin. Origin of anal fin is situated beneath anterior half of dorsal fin base. Mouth is terminal and is directed forwards. Lower border of eye is slightly above level of mouth corner and upper border is not interfering with dorsal profile. Nasal organ is a tentacle, more than distal half of which is divided into two flattened and broadened lobes. Apposed surfaces of lobes are smooth. Ground colors of upper parts are tan and belly is yellowish white. Three large yellowish-encircled dark patches are seen on back between eyes and dorsal fin. Anterior patch is on posterior half of head, middle patch is between pectoral fins and posterior patch is in front of dorsal fin. A yellowish band is also seen between nasal organs. Two more yellowish bands are found crossing the snout anterior of nasal organs. Sides are with similar bands and lines or broken up in oblong or rounded spots. Sides are with 2–4 dark ocellated spots: one at base of dorsal fin one at base of caudal fin, one at base of pectoral fin and one anterior of eyes. Fins are plain except for an ocellus on interior side of pectoral fin base. It feeds on snails and other benthic organisms. It grows to maximum total length of 8 cm.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 μg/g tissue)

Aquarium Value: Though it is freshwater species, it is best maintained in a commercial brackish aquarium and its aquarium parameters are given below.

Water Type: Brackish water.

Aquarium Size: 75 cm x 12 cm x 12 cm – 70 liters.

Water Conditions:

Temperature: 72–79°F (22–26°C)

pH: 6.5–7.5

Hardness: 5–12 dGH

Cycling a Brackish Water Tank: Once the water is prepared, cycling of the tank should be started. As in the case of freshwater and saltwater aquariums. That is bacteria need to be allowed to get established in this tank before introducing the new fish. Typically this process may take about a week

Tank Decorations: The best environment for this species is a sand or gravel substrate with lots of plastic plants for them to hide in. A cave like structure may also be provided for this species in the aquarium so that it can hide in.

Social Behavior: It is aggressive even to its own species. Hence it is better to have lots of hiding places if it is planned to have more than one fish in the same tank.

Acclimating new pufferfish: For fully brackish water tank, the pufferfish should be slowly acclimated to the new tank through drip acclimation. It may take about an hour to acclimate the new puffer to the brackish water conditions.

Feeding: These pufferfish need crunchy food, like snails, shrimp, mussels and crabs, to wear down their fast growing teeth.

Aquarium Maintenance: This species is best kept in a heavily-planted setup with twisted roots and branches to provide additional cover, although soft-leaved plants may be eaten by the fish. Some open spaces are left in between for swimming, as this is an active species. The use of a sandy substrate and floating plants to diffuse the light is also recommended. This species is very sensitive to deteriorating water conditions, so regular partial water changes must be done. Although it is often considered a true freshwater species, it tends to be more long-lived with the addition of marine salt to a specific gravity of 1.005 in aquaria.

Behavior and Compatibility: This species can be kept in a community tank, but caution should be exercised when choosing tank mates, as it tends to nip the fins of slow-moving or long-finned fish. In freshwater, it does well with fast-moving species such as characins, rasboras and barbs. In a brackish water community tank, tank mates may include monos, bumble bee gobies and salt-tolerant *Chanda* species. Although it will live in the company of conspecifics in a suitably large tank, studies have shown that specimens kept singly usually live much longer in captivity.

Sexual Dimorphism: Almost impossible to sex this species by external features. Generally, adult females may grow larger than males.

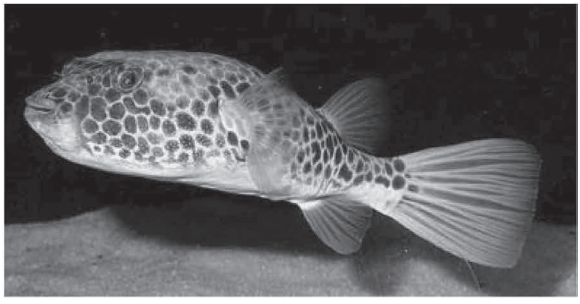
Reproduction: Little information is available on the breeding of this species. Apparently, it is a substrate spawner and the male exhibits some degree of brood care.

Toxicity: Unknown.

Fisheries Status: It has no commercial fisheries.

Conservation Status: Least Concern.

***Tetraodon duboisi* (Poll, 1959)**



Common Name(s): Malebo puffer, Stanley pool puffer, reticulated puffer, Dubois's freshwater puffer, ocellated puffer.

Habitat: Clean water, freshwater, demersal.

Global Distribution: Tropical; Africa: known only from the types from Pool Malebo, in Democratic Republic of the Congo.

Description: This species is really is one of the nicest freshwater puffers, and it is one of the rarest species. It has a maximum total length of 8.7 cm. It lacks further information (http://www.madrean.org/symbfauna/taxa/index.php?taxon=646353&taxauthid=1).

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 μg/g tissue).

Aquarium Value: This species is used as a component in freshwater aquarium and its aquarium parameters are given below.

Minimum Tank Size: 20 US gallons (75 liters).

Water Conditions:

Temperature: 23–26°C (74–80°F)

pH: 6.0–7.8

dH: 5–10

Feeding: It is very predatory. It is best kept on a diet consisting of krills, crayfish and crab (http://www.aquaticcommunity.com/fish/malebopuffer.php). It may also accept frozen food.

Temperament: Aggressive.

Activity: Lurker.

Estimated Lifespan: Not known.

Sexual Dimorphism: None shown.

Breeding: Unknown.

C***ompany:*** It is best kept alone.

Aquarium Care: As it is extremely sensitive to nitrites and ammonia, it should be introduced into a fully cycled aquarium. Due to their messy eating habits, good circulation and regular water changes (up to 50% a week) are also required.

Toxicity: Unknown

Conservation Status: Data deficient

***Tetraodon kretamensis* (Inger, 1953)**

Common Name(s): Not designated.

Habitat: Freshwater; demersal.

Global Distribution: Tropical; Asia: northern Borneo.

Description: Body of this species is oblong, cylindrical, and posteriorly compressed laterally. Head region is sometimes slightly depressed. Dorsal profile is arched, and is highest at midst of back. Interorbital is convex, without a groove. Lateral line system is mostly indistinct. Spines are small and are mostly hidden under the skin. Spines are present between eyes and anus. Origin of anal fin is situated beneath anterior half of dorsal fin base. Mouth is terminal, and is directed forwards. Lower border of eye is at level of mouth corner or lower and upper border is not interfering with dorsal profile. Nasal organ is a tentacle and more than distal half of which is divided in two flattened lobes. Ground color of upper parts is tan. Belly is yellowish white. Both colors are often separated by an irregular dark band running from mouth below eye and pectoral fin to meet band of other side at anus or behind. Back and sides are with round and oblong dark spots of varying sizes. Lateral spots are varying in size and number but always a spot is seen at base of dorsal fin and at base of caudal fin. Belly and chin are uniformly yellowish white. Caudal fin is plain or dusky. It grows to a maximum standard length of 4.5 cm.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 µg/g tissue).

Aquarium Value: This species is used as a component in freshwater aquarium and its aquarium parameters are given below.

Minimal Tank Volume: 100 liters (26 US gal).

Tank Type: Freshwater tank

Floor Water Column: Entire water column.

Behavior: Aggressive.

Care Level: Moderately difficult.

Feeding: Carnivore.

Toxicity: Unknown.

Conservation Status: Not evaluated.

***Tetraodon miurus* (Boulenger, 1902)**

Common Name(s): Congo puffer, potato puffer, brown puffer.

Habitat: Freshwater; demersal; large rivers.

Global Distribution: Tropical; Africa: Congo basin.

Description: In this species, eyes are in high position. Caudal peduncle is thin. Fins are somewhat transparent. Body color of this species varies. One time, it is brown to black and other times, it is bright red. Belly which is flat is usually white or a lighter shade of the base color. Tail fin is normally closed. It is a carnivore feeding mainly on other fish and on crustaceans occasionally. The animas bury themselves into the ground (fine sand), camouflaging themselves to ambush any passing prey. Only the eye and the superior mouth are exposed. It grows to a maximum standard length of 15 cm.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 μg/g tissue).

Aquarium Value: This species is used as a component in freshwater aquarium and its aquarium parameters are given below.

Aquarium Size: 75 x 12 x 12 cm (70 liters) is enough as it is not an active fish.

Usual Fish Size in Tanks: 12–14 cm.

Aquarium Maintenance: A deep (7 cm) bed of sand as substrate is essential. This will allow the fish to exhibit its natural behavior. An additional cover in the form of smooth rocks, and driftwood pieces may also be provided. Plants are used normally in the tank. A powerful pump and internal filter may also be needed.

Water Conditions:

Temperature: 75–82°F (24–28°C)

pH: 6.8–7.5

Hardness: 10–15 dGH

Diet: It requires a meaty diet which may include prawns, earthworms, lance fish, mussel, etc. It is better to feed this fish with live fish or pieces of fish with bones. Some specimens may initially only take live foods but most will take dead animals.

Temperament to Its Own Species: aggressive/territorial.

Temperament Toward Other Fish Species: aggressive/territorial.

Usual Place in the Tank: Middle levels.

Behavior and Compatibility: It is not advisable to keep this species with other fishes. It is a voracious predator which will eat any fish it can

fit in its mouth, and will usually take chunks from larger tank mates. It is also completely intolerant of conspecifics.

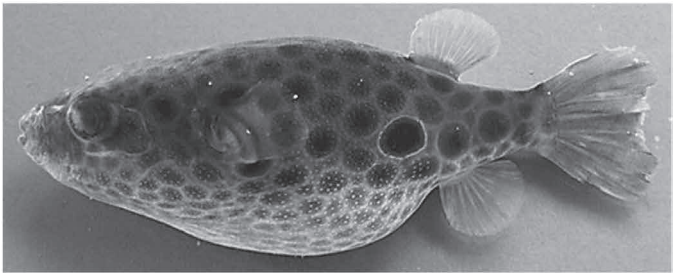
Sexual Dimorphism: Unknown.

Reproduction: It has not been bred in captivity.

Toxicity: Unknown.

Conservation Status: Least Concern.

***Tetraodon palustris* Saenjundaeng,** Vidthaynon & Grudpun



Common Name(s): Not designated.

Habitat: Marshes and swamps with clear and stagnant water in places with many aquatic plants.

Global Distribution: From the middle Mekong basin in Thailand.

Description: Body of this species is stout and its dorsal profile from anterior-most part of snout to end of dorsal-fin base is convex. Dorsolateral surface of body of males has a dark greenish black background with numerous round black spots. Its belly is grey-black with a white reticulated network. In the female, dorsolateral surface of the body has a yellow or light greenish-black background with numerous round black spots. Its belly has a white background with many small dark spots. There are several large dark spots on the lateral surface of the body in males and females. Adult specimens of *T. palustris* have no ocellus on the flank while small juvenile specimens show only one ocellated spot with a red center. This ocellus changes to a large round black spot in the adult. The eye is orange to red. Pectoral, dorsal and anal fins are translucent greenish while the caudal fin is opaque and greenish-black. It is a newly identified fish (Saenjundaeng et al., 2013).

Food Value: Unknown.

Aquarium Value: Unknown.

Toxicity: Unknown.

Conservation Status: Unknown. It is a new species and further research is needed.

***Tetraodon pustulatus* (A. D. Murray, 1857)**

Common Name(s): Redline pufferfish, cross river puffer, cracking puffer.

Habitat: Mainly freshwater species which can tolerate brackish waters; demersal; juveniles and adults are common in the mainstream.

Global Distribution: Tropical; Africa: Cross River within 20 km downstream of Mamfé, Nigeria.

Description: Belly of this species is white to light yellow. Back has a darker shade of yellow. It has a yellow background with red dots. These dots are sometimes so close together that it seems a line. It has a maximum total length of 36 cm.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 μg/g tissue).

Aquarium Value: This species is used as a component in freshwater aquarium and its aquarium parameters are given below.

Water Type: Fresh and slightly brackish water.

Minimal Tank Volume: 500 liters (132 US gal).

Size of Fish for Tank: 30.5–35.6 cm

Stocking Ratio: 1:1 M:F (male: female)

Water Conditions:

Temperature: 25°C (77°F)–27 °C (80.6°F)

pH: 7–7,5

Water Hardness: 5–15 dKH

Specific Gravity (SG): 1–1.010

Behavior: Aggressive.

Activity: Very active swimmer, constantly hunting.

Care Level: Very difficult.

Food and Feeding: carnivore - live and frozen food (no fish): snails, shrimp, bloodworms, mussels, clams and other shellfish; frozen food.

Propagation (Breeding): Unknown.

Company (Inmates): Best kept alone.

Lifespan: 8–15 years.

Aquarium Care: Like other puffers, it is also extremely sensitive to nitrite and ammonia, and it should be introduced in a completely cycled aquarium. Because of its messy eating behavior, a big filter is preferred. Good circulation and regular water changes (up to 50% a week) are also required.

Comments: It is a very rare pufferfish.

Toxicity: Unknown.

Conservation Status: Vulnerable.

***Tetraodon sabahensis* (Dekkers, 1975)**

Common Name(s): Sabah puffer, giant spotted puffer, Saba puffer.

Habitat: Freshwater; demersal.

Global Distribution: Tropical; Asia: Indonesia.

Description: Body of this species is oblong and is posteriorly compressed laterally. Head region is depressed. Dorsal profile is arched, and is highest at midst of back. Interorbital is convex, without a groove. Lateral line system is distinct or indistinct. Spines are small and are sometimes indistinct. Covering area of spines is between eyes and anus. Origin of anal fin is situated beneath anterior half of dorsal fin base. Mouth is terminal and is directed forwards. Lower border of eye is at level of mouth

corner and upper border is not interfering with dorsal profile. Ground color of upper parts is tan and lower parts are yellowish white. Four dark marks are seen on back between eyes and dorsal fin. Anterior most mark is a cross band between eyes. Second mark is most prominent and is V-shaped, pointing backwards. Third mark is at midst of back, and is oblong. Posterior most mark is just in front of dorsal fin and is rounded. Often a dark band or spot is connecting or between nostrils. Sides are with 7–16 rounded dark spots, of which one is at base of dorsal fin and one is at base of caudal fin. Belly is uniformly yellowish-white or dirty. Caudal fin is with 1–7 dark cross bands. Other fins are plain. This species grows to a maximum standard length of 10.8 cm.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 μg/g tissue)

Aquarium Value: This species is used as a component in freshwater aquarium and its aquarium parameters are given below.

Tank Type: brackish water tank

Minimum Tank Size: 208.2 liters (55 US G.)

Size ***of Fish for Tank:*** 12.7–17.8 cm

Water Conditions:

Specific Gravity (SG): 1.005–1.015

pH: 7.8–8.2

Temperature: 23.3–26.7°C (74–80°F)

Water Hardness: 12–18 dGH

Stocking Ratio: 1:1 M:F (male: female)

Availability: Rare

Diet: Carnivore – Mussels, cockles, prawns, whitebait; but smaller foods such as bloodworm and krill are usually ignored.

Personality/Temperament: An extremely interactive puffer once it gets used to its owner

Tank Mates: unknown

Activity: Activity levels of these fishes may vary. They may be quite inactive during the day choosing to rest on the substrate, in rock crevices or under mangrove roots. Activity levels raise during the later hours of the day, that is, evening and night

Sexual Dimorphism: No physical sexual differences currently known.

Lifespan: 8–15 years

Care Level: Moderately difficult.

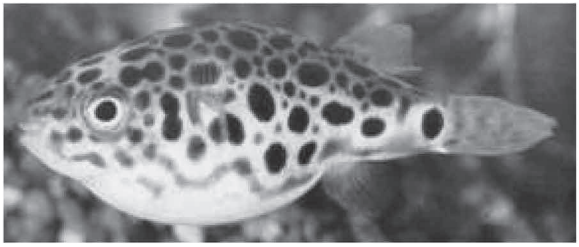
Aquarium Care: This species is relatively easy once settled in and feeding well. Though it is a freshwater species and seems to prefer a much lower salinity, it is safe to keep this fish at a salinity of 1 ppt or half-brackish.

Others: There seems to be several variants of this species with different body markings which are not typically associated with *T. nirgroviridis* or *T. fluviatilis*.

Toxicity: Unknown.

Conservation Status: Not evaluated.

***Tetraodon schoutedeni* (Pellegrin, 1926)**



Common Name(s): Spotted Congo puffer, leopard puffer.

Habitat: Freshwater; demersal; large rivers.

Global Distribution: Tropical; Africa: reported from large rivers in the Congo basin

Description: This species is armed with thorns around the body with exception of mouth and caudal region. Background color is from yellow to brownish- green with black spots in the form of points and is also constituting more thick patches interspersed. Belly is white. It feeds on benthic animals such as snails and worms. This species has the maximum total length of 9 cm.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 μg/g tissue).

Aquarium value: It is a component of commercial, freshwater aquarium and its aquarium parameters are given below.

Water Type: Freshwater.

Minimum Tank Size: 80 liters.

Size of Fish for Tank: Up to 9 cm

Water Conditions:

pH: 6.5–7.5

Temperature: 72–79°F (22–26°C)

Hardness: 10–20 10–20 dGH

Diet: It is a carnivore feeding on live food, maggots, live fish, crustaceans snails and frozen foods. There is a need to feed this fish snails, shrimp with shell or open mussels to prevent the overgrowth of their teeth.

Behavior: It is aggressive only when it is hungry. In old age, it can become intolerant. Aggressiveness is manifested primarily to individuals of their own species. It is however, peaceful to others.

Care: Medium.

Suitability: Good for all.

Sexual Dimorphism: Difficult to detect. The female is larger.

Breeding: Though, breeding of this species is difficult in aquarium, it is possible. Eggs are laid on the substrate and on the plants. Water temperature should be around 27°C. Eggs are guarded by the males. Young hatch within 5 days and start swimming. Young ones take small live food (daphnia, brine shrimp and *Cyclops* – depending on its size).

Disease: This species may develop unnatural dark spots on its skin.

Other Aquarium Requirements: This species requires a sandy bottom and a number of shelters as it needs space for swimming. Further, it is very sensitive to ammonia and nitrites and they need frequent replacement of half water.

Lifespan: 5–8 years.

Toxicity: Unknown.

Fisheries Status: It has no fisheries.

Conservation Status: Data deficient.

***Tetraodon waandersii* (Bleeker, 1853)**

Common Name(s): Not designated.

Habitat: Freshwater; demersal.

Global Distribution: Tropical; Asia: Indonesia.

Description: This species is diagnosed by its 11 anal soft rays and 12 dorsal fin rays. Body is oblong. Dorsal profile of head is rounded. Interorbital is convex, without a groove. Lateral line system is indistinct. Spines are present on back, sides and belly and from eyes to near origin of dorsal fin. Origin of anal fin is beneath anterior half of dorsal fin base. Ground color of upper parts are tan and belly is yellowish. A total of 35 transverse, small dark bands are seen on upper half of body from snout to caudal peduncle and a few of which have their ends branched or mutually united. Fins are plain and caudal fin is darkest. This species grows to a maximum standard length of 3.6 cm.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 μg/g tissue).

Aquarium Value: This species is used as a component in freshwater aquarium and some of its aquarium parameters are given below.

Tank Type: Freshwater tank.

Minimal Tank Volume: 60 liters (16 US gal).

Temperature: 25–27°C

Feeding: Carnivore – snails, small crustaceans and insect larvae.

Floor Water Column: Entire water column.

Behavior: Aggressive.

Care Level: Moderately difficult.

Toxicity: Unknown.

Conservation Status: Not evaluated.

***Xenopterus naritus* (Richardson, 1848)** *(= Chonerhinos naritus)*

Common Name(s): Bronze pufferfish, yellow pufferfish, golden puffer.

Habitat: Freshwater; rivers; demersal; amphidromous.

Global Distribution: Tropical; Asia: Myanmar, Indochina and Indonesia.

Description: This species can be easily identified by its prominent yellowish or golden coloration especially at the lower part of the body. Body is torpedo-shaped. It has three lateral line canals on side of its body. Dorsal fin has 22 or more rays and anal fin is with 18 or more rays. Scales are relatively large and extend dorsally to the pectoral fin. Nasal flaps are greatly reduced and the olfactory lamellae are almost entirely exposed. Each scale has a spine-like distal portion which projects more or less straight out from the skin when erected. When the scales are not erect, they are partially or wholly retracted beneath the skin, and the spines may be oriented dorsally, dorsoposteriorly, or posteriorly. This species grows to a length of 28.5 cm.

Food Value: It is a harmless species (FishBase) as its muscle is less toxic (safe level, less than 10 MU/g tissue (i.e., 2 μg/g tissue).

Aquarium Value: This species is a component of freshwater aquarium and the parameters are given below.

Aquarium Size: 120 cm x 45 cm x 45 cm – 255 liters.

Water Conditions:

Temperature: 75–82°F (24–28°C)

pH: 6.5–7.5

Water hardness: 5–12 dGH

Food and Feeding: Live or frozen foods should be offered to this fish. It will accept shrimps, cockles, mussels and pieces of fish. A regular supply of snails needs to be provided to help these fishes keep their teeth trimmed down.

Temperament to Its Own Species: Aggressive/territorial.

Temperament Toward Other Fish Species: Aggressive/territorial.

Usual Place in the Tank: Middle levels.

Compatibility: It is an intolerant species which requires its own aquarium. It's beak-like mouth can easily bite chunks from other fish, or in extreme cases rip them to pieces.

Sexing: There are no visible differences between the sexes.

Breeding: Due to their high aggressive nature it is not possible to breed this species in the home aquarium.

Lifespan: The expected lifespan of this species is 10+ yrs.

Aquarium Maintenance and Care: A sandy substrate is required for this species in its aquarium. Smooth rocks and driftwood pieces may be provided for decoration. Plenty of open space should be left for swimming. Although it is a freshwater species, it actually requires the addition of marine salt to a specific gravity of at least 1.005 in aquaria. Like all puffers, it is very sensitive to deteriorating water conditions, so regular partial water changes are mandatory. These fishes should be kept as a single specimen in the tank. A larger tank may be required for this species when it matures. As these fishes are high waste producers, excellent filtration is needed along with regular water changes as any drop in the quality of the water can affect their health.

Toxicity: Toxicity studies made in the in liver, skin, muscle, gonad and stomach of this species of Malaysian waters showed that the concentrations of TTX all tissues were significantly high. The highest mean of TTX was detected in the ovary (330 μg/g), followed by the stomach (22.1 μg/g), liver (17.8 μg/g), skin (17.1 μg/g), muscle (11.1 μg/g) and testis (7.88 μg/g). All the tissues in the present study contained TTX that exceeded the regulatory limit of 2 μg/g (10 MU/g) established as a safe level for human consumption by the Japan Food Hygiene Association (2005). The information gained from this study indicates the importance removing TTX to ensure the safe consumption of puffer fish (Mohamad, 2013). Similar studies made in the species of the same region showed that the liver dominated in TTX concentration (45.2 μg/g) followed by muscle (12.2 μg/g) and skin (7.8 μg/g) (Azman et al., 2014). The tetrodotoxin (TTX) and saxitoxin (STX) in dried salted eggs of this species ranged from 95.6–195.5 MU/g and 1.72–3.58 MU/g, respectively. The results indicate that the dried salted eggs samples were found to contain TTX 9–20 times above the regulatory limit for human consumption (10 MU/g). The amount of STX in salted eggs extract was however, slightly below the accepted threshold limit (4 MU/g). The local public needs to be educated on the potential danger of consuming dried salted eggs of this species (Azman, and Norhana, 2013).

Fisheries Status: There are no commercial fisheries for this species.

Conservation Status: Not evaluated.

KEYWORDS

- ***Acropora***
- **aquarium value**
- **aquascape**
- **conservation status**
- **food value**
- **spirulina**
- **toxicity**

CHAPTER 4

PUFFERFISH TOXINS

CONTENTS

4.1 TETRODOTOXIN (TTX)

Distribution of TTX: Tetrodotoxin (TTX), owes its name to the family of the pufferfish (Tetraodontidae) and was first isolated in 1950 from the ovaries of a pufferfish (though it was named upon its discovery in the pufferfish species *Spheroides rubripes* in 1910). For a long time, TTX was believed to occur only in pufferfish (Tetraodontidae). However, this toxin has been found in a wide variety of marine plants and animals like dinoflagellate, *Alexandrium tamarense,* red alga *Jania* sp., flatworms, *Bipalium adventitium* and *Bipalium kewense* and ribbon worm *Cephalothrix simula*, Philippine crabs (*Zosimus aeneus*), xanthid crabs, *Atergatis floridus*, the horseshoe crab, *Carcinoscorpius rotundicauda,* the gastropods *Nassarius clathrata*, *Charonia saulia*e (trumpet shell), Japanese ivory shell *Babylonia japonica*, the blue-ringed octopus *Hapalochlaena maculosa,* the starfish *Astropecten scoparius* and *A. polyacanthus,* the goby *Yongeichthys criniger*, boxfish,*Ostracion* spp., Harlequin frogs (*Atelopus* spp.), Costa Rican frog (*Atelopus chiriquiensis*), Brown Newt or Sword-tailed Newt, *Cynops ensicauda*, California newt, *Taricha iorosa* (Stokes et al., 2014; Asakawa et al., 2013).

Mechanism of TTX Accumulation in Marine Animals: The TTX is accumulated in marine animals in two ways. In the first process, the

Tetrodotoxin (TTX)-Producing Bacteria Isolated From Puffer Fish

TTX-Producing bacterial sp.	Pufferfish	TTX Concentration (µg/mL)
Vibrio alginolyticus	*Fugu vermicularis vermicularis*	0.0012
Pseudomonas sp.	*Fugu poecilonotus*	NA
Shewanella putrefaciens	*Takifugu niphobles*	0.012
Vibrio sp.	*Fugu vermicularis radiatus*	NA
Microbacterium arabinogalactanolyticum	*Chelonodon patoca*	0.042
Serratia marcescens	*Takifugu alboplumbeus*	0.04
Vibrio alginolyticus	*Takifugu niphobles*	0.03
Bacillus sp. & *Actinomyces* sp.	Fugu rubripes	0.32
Nocardiopsis dassonvillei	*Fugu rubripes*	0.1
Vibrio harveyi	*Arothron hispidus*	0.5–15.7
Kytococcus sedentarius	*Arothron hispidus*	NA
Cellulomonas fimi	*Arothron hispidus*	NA
Bacillus lentimorbus	*Arothron hispidus*	NA
Bacillus sp	*Fugu obscurus*	NA
Lysinibacillus fusiformis	*Fugu obscurus*	0.024
Aeromonas sp.	*Takifugu obscurus*	0.002
Raoultella terrigena	*Takifugu niphobles*	0.008
Shewanella putrefaciens	*Lagocephalus lunaris*	0.195–0.366
Providencia rettgeri	*Lagocephalus* sp.	0.015–0.021

NA: Data not available.

Source: Magarlamov et al. (2017).

TTX produced by the marine bacteria such as *Vibrio alginolyticus*, *Shewanella alga*, *S. putrefaciens,* and *Alteromonas tetraodonis* gets dissolved in seawater or adsorbed on and precipitated with dead planktonic cells or accumulated in sediment through decomposition. Through food chain, the primary consumer such as small zooplankton, detritus feeder, flatworm, ribbonworm, arrowworm, xanthid crab, small gastropod and skeleton shrimp will feed on dead planktonic cells on the sediment that consists of

TTX followed by the secondary consumers which consist of puffer fish, tropical goby and large gastropods. As a result, the secondary consumer will possess TTX in their body. The second way is the TTX producing marine bacteria will act as parasite or create symbiotic relationship with small zooplankton, detritus feeder or other bigger marine animals such as pufferfish, tropical gobies and gastropods (Azhar, 2012).

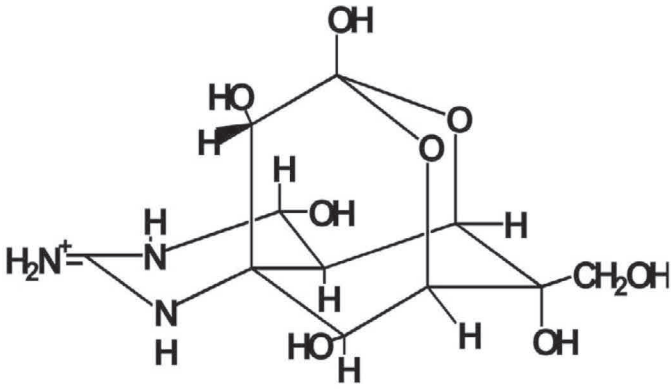
Though the true origin of TTX is thought to be bacteria, other organisms also contribute to this factor. For example certain marine dinoflagellates that proliferate in nutrient loaded "red tide" waters has been reported to produce TTX. These dinoflagellates are first consumed by animals like crustaceans, molluscs, sponges and sea urchins. When the latter are in turn consumed by the pufferfish, the TTX gets bioaccumulated in the skin and other internal organs of the pufferfish (http://www.flkeys-fishing.com/articles/pufferfish.html#.Vc1zGbKqqko).

Other Possibilities of TTX Accumulation in Pufferfish: There are several theories as to why puffers might be toxic. One theory considers that puffers produce the toxin themselves as a kind of defense mechanism against other predators. Another theory suggests that it is the bacteria that live naturally inside the puffers that produce toxins and they only produce these toxins in certain species of puffer fish. Another possibility that is currently being investigated is that other environmental factors could play a role.

Characteristics of TTX

- It is a neurotoxin of low molecular weight and an alkaloid.
- It is a heat-stable (except in alkaline environment) and acid-stable.
- It is a white crystalline solid and odorless.
- It is a water soluble non-protein.
- It is not an enzyme or organic base.
- It does not degenerate when exposed to high temperature, washing or freezing. Therefore, TTX does not decompose when it is cooked.
- TTX binds to voltage-gated sodium channels on nerve membranes, thus blocking nerve conduction and causing motor paralysis and ultimately death from suffocation (http://www.mapoflife.org/topics/topic_396_Tetrodotoxin/).

- It is 275 times more lethal compared to cyanide (Haque et al., 2008). However, according to other reports it is 1200 times more toxic to humans than cyanide.
- It has no known antidote.



Chemical Structure of Tetrodotoxin (TTX).

The Mechanism of TTX Toxicity: TTX is a sodium channel blocker. The toxin binds to the sodium channels of the excitable tissues (muscles and nerves) of the victim and the inhibition of sodium ions through the channels immobilizes these tissues effectively. In humans, the onset and severity of the symptoms of TTX poisoning after ingestion is dose dependent. Initial symptoms include tingling (paresthesias) of the tongue and lips, followed by or concurrent with headache and vomiting, which may progress to muscle weakness and ataxia. In severe cases, death may occur due to respiratory and/or heart failure. The only treatment for TTX intoxication is observation and appropriate supportive care (Bane et al., 2014).

Toxic and Non-Toxic Pufferfish: The TTX toxin is primarily localized in gonads (chiefly ovaries), at the end of the spring and before the spawning period. From this latter point of view, females are considered more toxic than males. Species of pufferfish such as *Canthigaster valentini, Lagocephalus lagocephalus, Chelonodon patoca, Tetraodon fahaka* as well as many species of the genus *Fugu* have been considered to be more toxic than other pufferfish species (http://memim.com/tetraodontidae.html). It is interesting to note that the toxic species of puffers can withstand about 500 to 1,000 times the concentration of tetrodotoxin compared with non-toxic pufferfish (http://www.nytimes.com/2009/12/22/science/22creature.

Toxicity of Organs of Pufferfish Species

	Maximal toxicity*						
Species	**Ovary**	**Testis**	**Liver**	**Skin**	**Intestine**	**Muscle**	**Blood**
Takifugu niphobles	IV	II	IV	III	IV	II	0
T. poecilonotus	IV	III	IV	III	III	II	0
T. pardalis	IV	II	IV	III	III	I	I
T. snyderi	IV	I	IV	III	III	II	0
T. porphyreus	IV	I		IV	III	III	I
T. chinensis	IV	0	IV	0	0	0	0
T. obscures	IV	I	III	III	III	1	0
T. exascurus	IV	I	III	III	0	I	0
T. pseudommus	IV	I	II	II	II	I	0
T. chrysops	III	I	III	III	II	I	I
T. vermicularis	III	I	III	III	II	I	0
T. rubripes	III	I	III	I	II	I	I
T. xanthopterus	III	I	III	I	II	I	0
T. stictonotus	III	I	III	II	I	I	0
Takifugu flavidus	IV	III	IV	III	III	II	0
Tetraodon alboreticulatus	IV	0	II	II	III	II	0
Tetraodon nigroviridis	0	0	I	III	II	II	0
T. steindachneri	0	0	I	III	I	I	0
Pleuranacanthus sceleratu	IV	0	II	II	III	II	0
*Chelonodon patoca***	III	III	III	IV	0	III	0
Arothron firmamentum		I	I	II	I	I	0
Canthigaster rivulata	I	0	II	III	II	I	0
Lagocephalus lunaris	I	I	I	III	I	IV	I
L. inermis	I	I	III	I	I	I	0
L. wheeler	I	I	I	I	I	I	0
L. gloveri	I	I	I	I	I	I	0
Sphoeroides pachygaster	I	I	I	I	I	I	0

Note: I: <10 MU/g tissue; II: 10–100 MU/g tissue (weakly toxic); III: 100–1000 MU/g tissue (moderately toxic); IV: >1000 MU/g tissue (strongly toxic); 0: no data.

Source: Noguchi and Arakawa (2008).

html?_r=0). Interestingly, pufferfish species like *Takifugu rubripes, Lagocephalus wheeleri, L. gloveri* and *Takifugu xanthipterus* became non-toxic when they were fed TTX-free diets in an environment like aquaculture in which the invasion of TTX-bearing organisms is completely prevented (Bane et al., 2014). The TTX is said to be almost absent in flesh and especially blood. Though several species of pufferfish are toxic, there are certain species which are either non-toxic or less toxic and fit for human consumption.

TTX Content of Pufferfish: The TTX content of pufferfish may be varying from 5000 to 15000 MU/g tissue (1–3 mg/g tissue) depending on the nature of species of pufferfish and their internal organs (http://www.nbcnews.com/health/health-news/frightful-fish-tale-doctors-warn-poison-pufferfish-n277591). 1 MU (mouse unit) which is equivalent to 0.2 μg is defined as the amount of toxin required to kill a 20-g male mouse (ddY strain) within 30 min after intraperitoneal administration) (Noguchi and Arakawa, 2008; Arakawa et al., 2010; Azhar, 2012). The minimum lethal dose of pufferfish TTX for humans is only about 10 μg/kg body weight. Just half an ounce of the fish liver eaten by daring connoisseurs, can be lethal (http://www.nytimes.com/2009/12/22/science/22creature.html?_r=0).

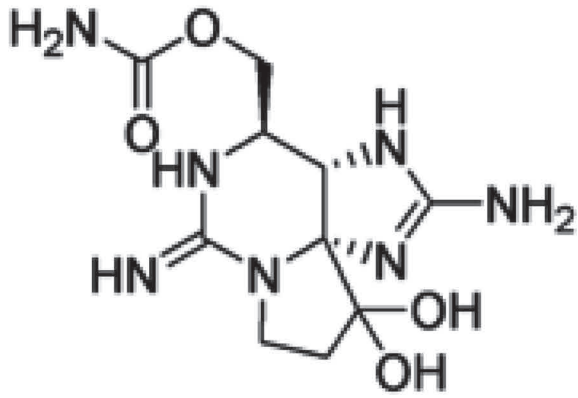
Functions of TTX: The tetrodotoxin is employed in the defence of pufferfish, in combination with their rather bizarre inflation behavior. When threatened, puffers inflate their body by swallowing water, while excreting TTX from their skin. The TTX containing eggs of pufferfish can also be highly toxic, probably to get protected from the predators. Intriguingly, in some marine species such as *Fugu niphobles*, the females seem to employ TTX as a pheromone to attract males during spawning and thus increase the chances of their eggs being fertilised.

Resistance to TTX in TTX Bearing Organisms: Interestingly, the TTX bearing organisms are themselves resistant to the toxic effects of TTX. The reason is because in these animals, the aromatic amino acid chain in the p-loop region of domain I in the sodium channels is replaced by a non-aromatic amino acid and this prevents the sodium channels in these species from being blocked. Resistance to TTX can also be related to the presence of a TTX-binding protein present in in pufferfish, *Takifugu niphobles* and *Fugu pardalis* (Bane et al., 2014).

4.2 SAXITOXIN (STX)

Saxitoxin (STX) is a neurotoxic molecule found in both marine and freshwater organisms. Like TTX, it also acts as a sodium channel blocker which is capable of causing of paralytic shellfish poisoning (PSP) upon consumption of species that produce STX or consume other microorganism contaminated by STX producing microalgae.

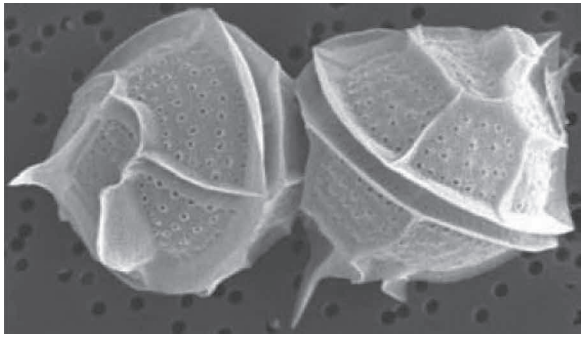
Structure of Saxitoxin: Saxitoxin is the parent molecule in a class of compounds, typically referred to as paralytic shellfish toxins (PSTs). Its basic structure is that of a trialkyl tetrahydropurine, with positions 2 and 8 of the purine ring containing the NH2 groups, which form the two permanent guanidinium moieties (Cusick and Sayler, 2013).



Chemical Structure of Saxitoxin (STX)

Origin and Occurrence of STX: The dinoflagellate *Pyrodinium bahamense* is the source of STX and the occurrence of STX was first identified from three species of Florida pufferfish viz. *Sphoeroides nephelus, S. testudineus* and *S. spengleri* which were presumed to have TTX through the food web of *Pyrodinium bahamense* (Santhanam, 2015). STX has been detected in the skin, muscle, viscera, and gonads of Indian River Lagoon pufferfish. A highest tissue concentration of 22,104 µg, STX eq/100 g tissue, has been reported in the ovaries of a southern puffer fish. Interestingly, even after a year of captivity, the skin of mucus of this pufferfish showed high values of toxic concentrations. The concentrations in pufferfish from

the United States were also similar to those found in Philippine, Thailand, Japan, and South American countries.



Pyrodinium bahamense

Characteristics and Functions of STX: Saxitoxin is heat- and acid-stable and does not alter the odor or taste of food. This toxin cannot be destroyed by cooking or freezing. It is rapidly absorbed through the human gastrointestinal tract and excreted in urine. The molecule is complex and contains a guanidinium moiety. This portion of the molecule is believed to block the opening of the voltage-sensitive Na+ channel, preventing the rapid entrance of sodium into the cell at depolarization. The rapid movement of sodium is necessary for propagation of neural impulses and mediation of cellular function. The outcome of blockage at this site is motor paralysis.

Biological Fate of Paralytic STX: STX and its derivatives (STXs) exert their neurotoxic effects by binding to membrane proteins in neurons and muscle cells. Specifically, STXs bind with high affinity to an extracellular site on voltage-gated sodium channels, effectively blocking the flow of sodium ions into excitable cells. Consequently, action potentials are terminated and signal transmission between neurons is inhibited. A dose of 0.75 µg/kg STX produces marked weakening of nerve elicited twitches in the tibialis anterior. In higher dose, hypotension occurs at the same time as paralysis. A lethal dose of STX is said to be 0.5 mg. Reports of PSP have been worldwide among people living on the coast. It starts off with numbness of the lips, tongue and fingertips within minutes after consumption, followed by the numbness of the legs, arms and neck, accompanied by feeling of lightness, drowsiness, dizziness and headache. Death by respiratory

distress and muscular paralysis are the final stage which can occur within 2 to 24 hours after consumption. No lasting effect has been observed after 24 hours of survival (Saksrithai, 2008). When administered to mice orally and intraperitoneally, the LD50 for these compounds are 263 µg/kg and 10 µg/kg, respectively. Symptoms of intoxication include numbness and tingling, weakness, ataxia, inefficient ventilation, and with doses as small as one-milligram respiratory paralysis and death may occur (http://ic.ucsc.edu/~msilver/ocea142/sections/Ocea_242_STX_paper.pdf).

KEYWORDS

- ***Alexandrium tamarense***
- **marine bacteria**
- ***Pyrodinium bahamense***
- **saxitoxin (STX)**
- **tetrodotoxin (TTX)**
- **TTX toxicity**

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CHAPTER 5

PUFFERFISH POISONING

CONTENTS

Many cases of human intoxication due to the ingestion of several TTX-bearing pufferfish species have been recorded, mainly in Japan, China, and Taiwan where they have been historically consumed, and several victims have died. This risk has also been reported among the consumers of the Mediterranean countries where several invasive, toxic pufferfish species are present. The intoxication cases are mainly due to lack of awareness among consumers or misidentification of species. The severity of the intoxication depends on the amount of TTX ingested and death usually occurs after 6–24 hours in 60% of the cases, but may even occur after 17 minutes in certain situations (Nader et al., 2012).

Toxins Associated with Pufferfish: In Japanese restaurants specially licensed chefs prepare "fugu" from very thin slices of the flesh of certain species of pufferfishes. During this process, the skin is removed and the flesh carefully separated from all internal organs, minimizing the amount of toxin in the portion to be consumed. Despite the care taken in its preparation, it often produces mild symptoms due to minute traces of tetrodotoxin present in the flesh. Serious poisoning and death from eating fugu is common in certain countries like Japan and Taiwan. Pufferfish poisoning is

Food Poisonings due to Animal Natural Toxins

Causative food	Causative toxin
Pufferfish of Tetraodontidae	Tetrodotoxin
Ciguateric fish	Ciguateric toxins
Gastropods of Buccinidae	Tetramine
Boxfish (Ostraciidae)	Palytoxin-like toxin
Prickleback	Dinogunellin
Marine turtle	Unknown

Source: Arakawa et al. (2010).

more or less similar to paralytic shellfish poisoning and the toxins responsible for this type of poisoning may be either Tetrodotoxin (TTX) or saxitoxin (STX) and the poisoning may accordingly be called as tetodotoxin pufferfish poisoning (TPFP) or saxitoxin pufferfish poisoning (SPFP).

Toxic Species/Parts of Pufferfish: The toxic parts are different depending on species of pufferfish, their size and areas of catch. In general, viscera, especially the liver and ovary of majority of the pufferfish are highly toxic (the toxicity often exceeds 1,000 MU/g). In marine pufferfish, toxicity is generally high in liver and ovary, followed by intestine and skin. On the other hand, in brackish and freshwater pufferfish, toxicity has been reported to be high in their skin. In toxic marine pufferfish, the liver toxicity shows very high throughout the year except the breeding season, during which the ovary becomes highly toxic due to the accumulation of TTX transferred from liver. *Lagocephalus lunaris, Takifugu oblongus,* and *T. niphobles* that occasionally cause food poisonings in Taiwan were highly toxic (Arakawa et al., 2010). In *C. patoca* collected from brackish coastal waters and freshwater, the skin showed the highest toxicity. Muscle, testis and skin of species such as *T. rubripes, T. xanthopterus, Logocephalus wheeleri,* etc., are non-toxic (less than 10 MU/g) and are edible. The skin is toxic, but muscle and testis are edible in species like. *T. snyderi, T. porphyreus* and *T. vermicularis*. The testis is toxic, and only muscle is edible in species such as *T. niphobles, T. poecilonotusI* and *T. pardalis*. *Lagocephalus gloveri* and *L. wheeleri,* which are used as ingredients for producing dried dressed fish fillets, are invariably non-toxic in all tissues. However, some reports mention that these fishes may show weak toxicity in certain areas of their catch. Except *L.lunaris* and *Chelenodon patoca*),

the muscle and testes of other species of pufferfish are considered to be non-toxic or weakly toxic and are regarded edible.

5.1 TETRODOTOXIN PUFFERFISH POISONING (TPFP)

Tetrodotoxin (TTX) poisoning results normally from the ingestion of the flesh or viscera of certain species of pufferfish. TTX is about 10,000 times more lethal than cyanide by weight and 50 times more potent than strychnine or curare. The minimum lethal dose of TTX to human is estimated

Worldwide Occurrence of Tetrodotoxin (TTX) Poisoning

Country	Causative species	Year of poisoning
Australia	Toadfish	2004
Australia	Pufferfish	2001–2002
Bangladesh	Pufferfish, *Takifugu oblongus* & *Arothron stellatus*	2008
Bangladesh	Pufferfish	2001–2006
Bangladesh	Pufferfish	2002
Bangladesh	Pufferfish, *Takifugu oblongus*	2002
Bangladesh	Pufferfish, *Takifugu oblongus*	1998
India	Pufferfish	2007
Egypt and Israel	Pufferfish, *L. sceleratus*	2005, 2007, 2008
Taiwan	Pufferfish, *Lagocephalus lunaris*	2001
Taiwan	Pufferfish, *Takifugu niphobles*	2000
US (California)	Pufferfish transported from Japan	1996

Source: Bane et al. (2014); Yong et al. (2013).

to be 2 to 3 mg and the minimum dose that necessary to cause symptoms is about 0.2 mg; but this may vary depending on the age and health of the person, and therefore does not apply in all cases. Further, the concentrations of TTX differ among different pufferfish species and it is very hard to determine one standard dose.

TTX Poisoning in Japan: In several Asian countries where pufferfish are consumed, TTX poisoning is the most commonly reported fish poisoning. In Japan, even though it has been known for years that the liver is very toxic, some individuals dare to consume it. The intoxication cases have been decreasing with time, with pufferfish poisoning constituting 12.5% of all food poisonings in 1890, 16% in 1895, 20% in 1900, 12% in 1905, and 4% in the 1950s. By the year 2000, this number had decreased to 2%. The Japanese Ministry of Health recorded 73% of pufferfish poisonings at home and 15% in restaurants in the year 1952. Even today, more than three-fourths of the poisoning cases occur at home. These results of frequent cases of poisoning has led the Japanese Ministry of Health and Welfare (http://www.mhlw.go.jp/english/) to ban the liver of all pufferfish from being sold in the market or served in restaurants. Regardless of the fact that only trained and licensed cooks prepare the pufferfish in Japan, still cases of poisoning occur mostly due to its preparation by uncertified handlers (Noguchi and Arakawa, 2008; Nader et al., 2012).

TTX Poisoning in Singapore: A case of mild poisoning due to *Lagocephalus scleratus* has been reported by Yong et al. (2013).

TTX Poisoning in Thailand: Joob and Wiwanitkit (2015) reported at least 3 reports on 55 cases of puffer fish poisoning in Thailand. When these cased visited the physician within 30 min, the severity of symptoms

Pufferfish Poisoning in Japan

Years	No. of incidents	No. of patients	No. of deaths	Mortality (%)
1965, 70, 75	204	300	151	47.7
1880, 85, 90	109	186	25	13.5
1995–2000	155	233	17	7.3
2001–2005	180	253	16	6.5
2006–2010	142	212	7	3.1

Source: Noguchi et al. (2011).

at stage 1, 2, 3 and 4 was 16%, 8%, 4% and 72%, respectively. However, there was no death case in the present series.

TTX Poisoning in Taiwan/China: In Taiwan and China, though people do not eat pufferfish as often as the Japanese, many food poisoning cases due to ingestion of wild pufferfish have also occurred. According to the record of TTX poisoning in Taiwan, there are some cases caused by the mistaken ingestion of muscles of a pufferfish species with toxic muscle, by ingesting puffer roe that had been sold as a fake of dried mullet roe or by ingesting a dried dressed fish fillet produced from toxic pufferfish by a food-processing company (Noguchi and Arakawa, 2008).

TTX Poisoning in Taiwan: Food poisoning incident following fish ingestion occurred in Chunghua Prefecture, western Taiwan in January 2000. A total of five victims (4 men, 58–64 years old and 1 woman, 46 years old) were reported. Symptoms of these patients included paralysis, coma, nausea, vomiting, ataxia, aphasia, and difficult respiration. Among these victims, two men suffered from more serious symptoms and were treated with intravenous fluids, mechanical ventilation, and intensive treatment in the hospital. They were then discharged after 1 week of hospital management. According to the victims, the causative puferfish was pufferfish *Takifugu niphobles*. The results indicated that the TTX toxicity of the cooked pufferfish liver was 280 MU/g, and all the *T. niphobles* specimens had high toxicity (>850 MU/g) in their liver (Noguchi and Arakawa, 2008).

TTX Poisoning in United States: Ten human fatalities due to the consumption of marine pufferfish have been reported in the United States. Among them four cases were reported from Hawaii during 1908–1925. The *Arothron* sp. was found responsible for all the poisonings. There was also a case, in which two Dutch sailors died within 17 to 20 minutes after ingesting the liver of a South African marine pufferfish (Noguchi and Arakawa, 2008).

TTX Poisoning in Bangladesh: In Bangladesh, a food poisoning incident due to ingestion of the roe of the marine pufferfish *Takifugu oblongus* was reported in November 1998. This incident affected eight people resulting in five deaths. Their symptoms were dyspnea, numbness of the lips, paralysis, and stomachache followed by vomiting, which appeared 2 hours after ingestion. Two victims became unconscious within 5 hours of exposure. On the way to the hospital, two of the eight patients died and the remaining six were admitted. Three of the six patients died in the hospital

and three recovered (Noguchi and Arakawa, 2008). A 2002 publicized case in Bangladesh reported that 37 patients were suffering from TTX induced symptoms. They had all bought puffer fish from a market in their village and none of them was aware of the risks. It also reported that eight patients died within a few hours and the cause of death was declared as respiratory muscle paralysis which led to respiratory failure. Further, out of nine persons who consumed pufferfish egg curry, six people developed symptoms which included vomiting, diarrhea, paresis, and tingling sensation; and two persons died (Islam et al., 2011).

TTX Poisoning in Malaysia: In Malaysia, where *Lagocephalus spadiceus* and *L. lunaris* are consumed, the consumption of *L. sceleratus* has been declared illegal due to several cases of severe intoxication (Nader et al., 2012).

TTX Poisoning in Egypt: In Egypt, where the puffer fish is banned, fish markets are flooded with the pufferfish fillets. According to a report in the Egyptian news source, Al-Shorfa Monday, six people died from eating the fish in 2012, raising the number of poisoning victims to 24 over the past three years. Deaths have been reported in Alexandria, Ismailia and Suez. To implement the ban strictly and to protect the public safety, authorities advise more rigid oversight is required. In addition, Fishery authorities say more public awareness is required as residents buy these toxic fish due to their low cost (http://www.examiner.com/article/banned-puffer-fish-kills-six-egypt-this-year).

TTX Poisoning in Brazil: The poisonings occurred after the consumption of pufferfish meat at a lunch meeting in which 22 people were present. Eleven people who ate the fish fillets developed neuromuscular symptoms in 20 minutes to two hours after ingestion. The initial symptoms included paresthesia in the perioral region and nausea/ vomiting. The patients were taken to various health centers of the municipality. One child had discrete manifestations and was released after observation. Another 10 patients developed moderate symptoms, such as mild muscular weakness, and were hospitalized for observation. Three patients were severely affected (one adult and two children) and were treated in an intensive care center. The adult had a cardiac arrest and one child developed mydriatic pupils, but with response to light stimulation. Both were diagnosed with respiratory failure and received mechanical ventilatory support and therapeutic

clinical support, which comprises a critical situation in this type of accident. All patients improved their health condition and were discharged, initially those with moderate symptoms and later the seriously ill. The last patient (a child that was in the intensive care unit) was discharged without symptoms after ten days. The patients had no sequelae (chronic condition). This series of poisonings has some peculiarities: despite the severity of the condition caused by poisoning, no deaths occurred, although two patients developed severe symptoms (de Souza Simões et al., 2014).

TTX Poisoning in Australia: A five-year-old boy suffered horrific injuries after he was attacked by a 30 cm puffer fish, in his feet. This happened when he was wading in shallow water off the beach on Thursday Island, near Queensland. The fish took huge chunks of flesh out of his feet, leading to 30 stitches and two operations, along with a two-week stay in hospital on antibiotics, to guard against any infection. His wounds were unbelievable. The ball of his left big toe was missing and a chunk of flesh was missing out of his right heel. The species of puffer fish concerned was found to be *Feroxodon multistriatus*, also known as the Ferocious puffer fish, due to the fact that it has been known to make unprovoked attacks on humans (http://www.practicalfishkeeping.co.uk/content.php?sid=4960).

TTX Poisoning Due to *L. sceleratus* in Mediterranean Region: In the Mediterranean, several cases of poisoning have been recorded due to *Lagocephalus scele*ratus which was marketed regardless of the risk it poses to public health. There have already been 13 recorded cases of death in the Eastern Mediterranean as well as other cases of intoxication. From the time L. sceleratus settled in the Mediterranean, it is being sold and consumed in Egypt, where it is now considered a delicacy irrespective of its ban by Egyptian law. In Turkey, where *L. sceleratus* landings have also been banned, fishermen still sell it illegally and Turkish fishermen readily consume it. Moreover, this species is also consumed in Lebanon by some fishermen and a small number of consumers ignorant of the health threats it poses where several cases of unofficial intoxication have been reported in that country after eating *L. sceleratus*. The only official record was in 2008 when a 68-year-old woman complaining of limb weakness and dyspnea was brought to a hospital in Beirut. This case was due to the half-cooked liver of *L. sceleratus*. Even though in that particular case the woman survived, the local media records seven

cases of death in the past few years in Lebanon due to consumption of puffer fishes. As a result, the Lebanese authorities banned the fishing, selling and consuming of all puffer fishes including *L. sceleratus* in 2011 (Nader et al., 2012).

Symptoms Associated with TPFP: The usual route of human intoxication is via the ingestion of TTX-bearing pufferfish species. Patients with TTX poisoning usually develop symptoms within 30 minutes to 6 hrs of ingestion. Both central and peripheral nervous systems are affected after ingesting the TTX. Depending on the amount of TTX ingested, the time after ingestion of TTX, hydration state of the body and the general health status of the patient, there may be a spectrum of symptoms including:

(i) Gastrointestinal symptoms such as nausea, diarrhea, and vomiting, abdominal discomfort;
(ii) Neurological symptoms such as paresthesia in the face, motor in-coordination, muscle weakness and slurred speech; and
(iii) Other symptoms including hypotension, hypoxia and tachycardia.

According to Fukuda and Tani (1941), the clinical toxicity of TTX poisoning can be graded into four stages according to the neurological and cardiovascular features.

5.1.1 CLINICAL GRADING SYSTEM FOR TTX POISONING BASED ON SIGNS AND SYMPTOMS

Grade Clinical Features:

1. Perioral numbness with or without gastrointestinal symptoms;
2. Numbness involving tongue, face and distal areas; early motor paralysis and incoordination; slurring of speech; normal reflexes;
3. Generalized flaccid paralysis; dyspnea or respiratory failure; aphonia; and
4. Hypoxia and severe respiratory failure; cardiovascular effects including hypotension, bradycardia and arrhythmia.

Stages in Symptoms: The first symptom of intoxication is slight oral numbness of the lips and tongue, typically appearing 20 minutes to 3 hours after ingestion of the toxin but the onset can be earlier with higher dose

of toxin. The next symptom is increasing paraesthesia in the face and extremities, which may be followed by sensations of lightness or floating. Headache, epigastric pain, nausea, diarrhea, vomiting and occasionally, reeling or difficulty in walking may occur as well. The next stage of intoxication is progressive paralysis including inability to move, difficulty in sitting, increasing respiratory distress, speech problem, dyspnea, cyanosis and hypotension. In serious cases, paralysis may increase and convulsions, mental impairment and cardiac arrhythmia may occur. Respiratory failure and cardiovascular collapse can occur usually within 4 to 6 hours (with a known range of about 20 minutes to 8 hours) and may result in death. If the victim survives in the first 24 hours, they are expected to have full recovery as the toxin can be removed from human body through urination.

5.2 SAXITOXIN PUFFERFISH POISONING (SPFP)

Origin of Saxitoxin: Saxitoxin and its congeners are the causative agents of paralytic shellfish poisoning (PSP) and, as determined recently, saxitoxin pufferfish poisoning (SPFP). In the case of PSP, filter-feeding bivalve molluscs and crustaceans ingest the toxic dinoflagellate cells (*Pyrodinium bahamense*), concentrating the toxins within the organs and tissues. Although mussels and clams are the dominant vectors for paralytic shellfish toxins (PSTs), there are increasing reports of non-traditional organisms, such as gastropods, crustaceans and certain fish which also serving as vectors.

Description of Saxitoxin Pufferfish Poisoning (SPFP): SPFP is a similar illness, expect that bioaccumulation occurs in pufferfish (rather than shellfish) through food chain. From January 2002 to May 2004, 28 puffer fish poisoning (PFP) cases in Florida, New Jersey, Virginia and New York were associated with the pufferfish (*Sphoeroides* spp.) harvested from the Indian River Lagoon (IRL), Florida, USA. Saxitoxin and two of its derivatives were found to be the active toxins, with the dinoflagellate *P. bahamense* identified as the source. This lead to the characterization of the food poisoning syndrome as saxitoxin pufferfish poisoning (SPFP) to distinguish it from pufferfish poisoning (PFP), which is traditionally associated with tetrodotoxin. These findings led to a permanent ban on pufferfish harvesting along the east coast of Florida along with the establishment

of a monitoring program to determine the distribution and concentrations of PSTs in various pufferfish species. This monitoring program found that STX concentrations from pufferfish tissue averaged greater than 20-times the action limit for shellfish, with maximum values exceeding 200-times the action limit (Cusick and Sayler, 2013). Small-sized brackish water and freshwater pufferfish have also occasionally caused food poisoning incidents, including fatal cases in Asian countries such as Thai, Bangladesh, and Cambodia, though the causative toxin is PSP bearing saxitoxin in freshwater species (Noguchi and Arakawa, 2008).

Symptoms of Saxitoxin Poisoning: Saxitoxin which is associated with paralytic shellfish poisoning acts through blockade of the voltage-sensitive sodium channels, thus blocking propagation of nerve and skeletal muscle action potentials. Symptoms usually occur within 30 minutes of ingestion. Gastrointestinal (GI) symptoms include nausea, vomiting, diarrhea and abdominal pain. The neurological symptoms include paresthesias and numbness of the mouth and extremities, sensation of floating, headache, ataxia, vertigo, muscle weakness, paralysis and cranial nerve dysfunction such as dysphagia, dysarthria, dysphonia and transient blindness. While gastrointestinal symptoms are less common, neurological symptoms predominate.

Illness Associated with STX: Visible symptoms associated with the SPFP may include slight tingling around the mouth progressing to numbness, which spreads to the face and neck, for moderate cases. The numbness in severe cases spreads to the extremities causing lack of coordination and breathing difficulty. Severe cases may also exhibit difficulty swallowing, incoherency or loss of speech. In very severe cases, within 2–12 hrs there is complete paralysis and death due to respiratory failure. After 12 hrs, regardless of severity, victims start gradually recovering and within a few days there are no residual symptoms.

5.3 TREATMENT AND MANAGEMENT OF PUFFERFISH POISONING

Diagnosis and Laboratory Investigation: Clinical diagnosis is usually planned based on the patient's signs and symptoms supported by a positive food consumption history and detection of TTX in patients' health samples or food remnant such as the tissue of puffer fish.

Detection of TTX in Urine and Blood Samples: TTX can be found in blood up to 24 hrs after ingestion while it may be detected in urine up to 4 days from the time of ingestion. It is therefore important to collect urine and blood samples from affected patients as early as possible for diagnosis. There are several analytical methods for detecting TTX in urine and blood samples including chromatography based methods and enzyme-linked immunosorbent assay (ELISA).

Patient Management: There is no antidote for TTX poisoning at present and the mainstay of treatment is primarily supportive. For victims who are brought to hospital immediately after ingestion of TTX-containing food, normally within 1 hr, gastric lavage or activated charcoal can be considered to remove the unabsorbed toxin but medical parameters such as blood pressure, heart rhythms, respiratory function and electrolyte balance should also be carefully monitored.

5.3.1 TETRODOTOXIN TOXICITY TREATMENT AND MANAGEMENT

5.3.1.1 Prehospital care

- Prehospital care is provided with careful attention to the airway, breathing, and circulation (ABCs).
- Patients may require endotracheal intubation for oxygenation and airway protection during muscle weakness and respiratory failure.
- Cardiac dysfunction may need IV intervention with fluids, pressors, and antiarrhythmics.
- Clues (from the environment and bystanders) from severely poisoned patients who may have difficulty in speaking, and be unable to provide a history.

5.3.1.2 Emergency Department Care

- Immediate focus on the ABCs.
- Secure the airway before respiratory failure or aspiration occurs.
- Establishment of an IV intervention early if acute antiarrhythmics or vasopressors are needed.

- Toxin is removed from the intestinal tract by the usual toxicologic modalities. The use of nasogastric or orogastric lavage is theoretically beneficial but can be complicated by aspiration and damage to the oesophagus. The administration of activated charcoal (with or without a cathartic) is advised recommended for all symptomatic patients.
- Gastric lavage is not indicated if vomiting has occurred.
- Vital signs and oxygenation should be monitored carefully in the Emergency Department because patients can decompensate suddenly. All alterations in vital signs should be treated vigorously.
- Further treatment should be based on supporting cardiovascular function until the toxin is eliminated from the body.
- No specific antidote has been tested in humans. Monoclonal antibodies have been reported to be life saving in mice treated both before and after the ingestion of a lethal dose of TTX. Further studies are however, needed to document the efficacy in humans.
- In another study, where 4-aminopyridine (a potassium channel blocker) was used in guinea pigs intoxicated with tetrodotoxin or saxitoxin, a dramatic improvement in respiratory, cardiac, and CNS status was found to occur after administration of the drug. However, no human studies of this drug for use in tetrodotoxin poisoning are available (Benzer, http://emedicine.medscape.com/article/818763-medication#2).

5.3.2 MEDICATION SUMMARY

In several studies made so far, no drug has been shown to reverse the effects of tetrodotoxin poisoning. Treatment is symptomatic. Specific drug efficacy has been documented anecdotally.

Anticholinesterase drugs (e.g., neostigmine) have been suggested as a treatment option but have not been tested adequately (http://emedicine.medscape.com/article/818763-medication#2).

Treatment: Currently, the only treatment for TTX poisoning is to provide the victim with respiratory support until the TTX is excreted completely. Endotracheal intubation can be provided to facilitate ventilation

of the lungs. Mechanical ventilation may also be provided. Patients with respiratory support may recover within 4 days.

In the case of early stage TTX poisoning victims may be given activated charcoal in order to help the adsorption of TTX to prevent its absorption through the stomach. Gastric lavage (the passage of a tube via the mouth or nose down into the stomach followed by sequential administration and removal of small volumes of liquid) can be performed in TTX poisoning in order to reduce its severity. This procedure should be performed within 60 min after ingestion of TTX. Intravenous fluids are also given in order to maintain fluid-electrolyte balance in the body during TTX poisoning. Antiemetic may also be given as it is effective against vomiting and nausea.

Antibodies against TTX have been used successfully. They are able to neutralise the toxic effect of TTX both in vitro and in vivo. A monoclonal antibody for TTX (anti-TTX) is available commercially from Hawaii Biotech, Inc., Aiea, HI, USA. However, studies on the efficacy of this monoclonal antibody in vivo have not been published, but this may herald the advent of a new type of approach to the treatment of TTX poisoning in the future (Bane et al., 2014).

Treatment: No antidote is available and patients with more severe tetrodotoxin poisoning usually require ventilation for 2 to 5 days. Atropine is indicated for bradycardia.

Use of Atropine: Atropine 0.5 to 1.5 mg IV bolus. It is repeated after 15 minutes if necessary (for child: 0.02 mg/kg up to 0.5 mg IV bolus; it is repeated after 5 minutes if necessary up to a maximum of 1 mg) (https://www.tg.org.au/etg_demo/desktop/tgc/twg/7299.htm).

5.3.3 PREVENTION AND CONTROL MEASURES

1. *Surveillance and food poisoning investigation:* TTX poisoning should be notified as a statutory notifiable disease. Upon notification of food poisoning involving TTX, authorities should initiate prompt epidemiological investigation and control actions, particularly the source of faulty food in order to stop its further distribution and consumption by other persons. On risk communication, health advice should be given to the patients and food collaterals and, conduct public announcement to warn the general public of

the food poisoning case and remind them on the measures for preventing the disease.

2. *Food regulations:* Any person selling food unfit for human consumption should be prosecuted in cases of pufferfish food poisoning. Each country should have a Food and Environmental Hygiene Department (FEHD) as the statutory body to enforce actions against any sale of incriminated food.
3. *Food surveillance:* A Food Surveillance Programme needs to be operated. It should cover the surveillance of all aquatic foodstuffs such as fish, shellfish, shrimp, crab, squid and their products.
4. *Public education:* As majority of the TTX poisoning results mainly from the consumption of pufferfish, public education is very important in preventing the disease. A variety of health education materials should be prepared to educate the food trade and the general public on pufferfish poisoning (http://www.chp.gov.hk/files/pdf/tetrodotoxin_poisoning_in_hong_kong.pd).

5.3.4 LEGISLATIONS RELATING TO PUFFERFISH IN GENERAL AND TOXIC LAGOCEPHALUS SCELERATUS *IN PARTICULAR THROUGHOUT THE WORLD*

Intoxication due to consumption of pufferfish species and their products is well recognized and the reasons are known worldwide. Therefore, several governments have already banned or restricted the consumption of any such products. In addition, awareness campaigns are being regularly conducted in several countries to inform the threat of pufferfish to consumers but illegal consumption is still going on and therefore, intoxication risk still poses a serious threat. Nevertheless, several countries still show lack of regulation and awareness increasing the risk of exposing their consumers to pufferfish.

Legislation in Japan: In Japan, the government collects data regularly about Fugu poisoning from physicians, who report every case. A Food Sanitation Law #37 was passed in this country during 1947 and this law states "No person shall sell, handle, manufacture, import, process, use, prepare, store, or display with intent to sell any food. [that] contain[s] or bear[s] toxic or injurious substances. However this provision does not

apply to the cases which are prescribed by the Minister of Health, Labour, and Welfare as not injurious to human health." In 1958, another law was enacted which prescribed the specially trained cooks to obtain a license to serve Fugu. Today, the Japanese Criminal Code may provide a fine or up to 5 yrs of imprisonment for serving pufferfish without a license and causing a death or injury. Further, pufferfish imported to Japan needs a sanitary or health certificate from the food sanitation inspectors. Fugu may be imported either unprocessed or gutted. Pufferfish should be tagged with an official certificate from the exporting country identifying it by scientific name, fishing area, and an attestation to the fact that it underwent proper sanitary handling. If the fish is frozen, it should have been deep frozen and stored at a temperature below –10°C. Further, each fish should be individually frozen for easy identification. If this is not possible, fish may be frozen in blocks, but each fish's back and belly must be made visible for species identification. If official certificates are incomplete or detached, or if the cargo is mixed with other species restricted from import, such cargo should be returned to the exporters. Imports of the same or other pufferfish species collected in other waters should be negotiated with the Japanese Government to determine certificates of toxicity, fishing location, species, etc. (Nader et al., 2012; Noguchi & Arakawa 2008).

Legislation in Thailand*:* In this country, puffer fish imports, exports, and production were completely banned in 2002 after six cases of death in that year due to pufferfish poisoning. This country implemented this complete ban as "differentiating between properly cleaned pufferfish and toxic pufferfish was too difficult." The Food and Drug Administration also formed teams of people for inspecting the arrival of toxic pufferfish in markets and restaurants. Those who fail to comply are either fined or imprisoned for up to 2 years. However, illegal selling of this fish still going on in this country (Nader et al., 2012).

Legislation in United States*:* In 1989, the Food and Drug Administration (FDA) of the United States, reached an agreement with the Japanese Ministry of Health and Welfare to allow the import of pufferfish from Japan under certain conditions. The agreement however, permitted only the import of the meat, skin, and gonads of tiger puffer fish, *Takifugu rubripes*, which must have been prepared in a specific facility and certified. In addition, this product would be sold only to restaurants belonging

to the Torafugu Buyers Association. In case puffer fish are imported into the US by a country other than Japan or by Japanese which are not complying with the terms of the 1989 agreement, such individuals become subject to the FDA Import Alert #16–20, which allowed for their detention.

***Legislation in Canada**:* In this country, the imports of tetrodontid puffers are prohibited by the law for "Regulatory Requirements for Fish Import License Holders", Section 4.2.1.

***Legislation in Europe**:* According to Corrigendum Regulation (EC) No 854/2004 of the European Parliament of the Council of April 2004, the toxic pufferfish are not to be kept in the markets of Europe. This regulation laid down specific rules for the organization of official controls on products of animal origin including pufferfish intended for human consumption.

***Legislation in Lebanon**:* In Lebanon, the Ministry of Agriculture has issued a decree in 2011 (Ministry of Agriculture, Lebanon, Decree 676/1), which bans fishing, selling and consuming of the puffferfish *Lagocephalus sceleratus*.

***Legislation in Turkey in Other Countries**:* In Turkey, the Ministry of Food, Agriculture and Livestock has issued a ban on the fishery of *Lagocephalus sceleratus* (Bilecenoğlu, 2012). The Egyptian, Cypriot, and Greek governments have also completely banned the fishing and selling of pufferfish (Nader et al., 2012).

KEYWORDS

- **atropine**
- **food regulations**
- **food surveillance**
- **prehospital care**
- **saxitoxin poisoning**
- **Toxic species of pufferfish**
- **TTX poisoning**

CHAPTER 6

PUFFERFISH AQUARIUMS

CONTENTS

Pufferfish are commonly used in freshwater, brackish water and saltwater aquariums all around the world. They are very entertaining fish, full of life, and constantly on the move. Most species of pufferfish also seem to be quite intelligent, quickly learning to recognize their owners and often becoming tame enough to be hand fed. They are also very adaptable and present the aquarist with few serious problems. In fact, the most widely traded species can be considered hardy and easy to keep. The main problem with puffers is their behavior. Some species are very tolerant and accommodating while young, but become much more solitary and aggressive as they mature. The small species are often too aggressive or nippy to be mixed with fish of similar size, but are themselves likely to be threatened by substantially larger tank mates. The bigger puffers are usually predatory and they make risky additions to community tanks. For any aquarist desiring to keep pufferfish, a single-species (and often single-specimen) aquarium is recommended. Pufferfish are notoriously intolerant of high

nitrate levels and low oxygen concentrations. Hence, large water changes are helpful, with as much as 50 percent needing to be changed on a weekly basis. Any aquarist maintaining pufferfish needs to think carefully about their maintenance beforehand.

Size of Aquarium Tanks: Depending on the species of pufferfish and their density for maintenance, the size of the tank is to be chosen. Medium aquariums have at least 113 liters (30 US Gallons); large aquariums have at least 265 liters (70 US Gallons); and very large aquariums hold at least 700 liters (185 US Gallons).

Aquarium Keeping – General Tank Requirements: The tank requirements of pufferfish include clean water, regular water changes, plenty of swimming space, and preferably soft sand for digging. All pufferfish need good, clean water. In the case of brackish water species, the aquarists must also ensure that the water is hard, alkaline and sufficiently saline. The main water quality parameters of aquarium to be considered are pH, general water hardness, carbonate hardness and temperature. Puffers easily handle fluctuations in salinity, though as long as it is a gradual transition. Many of the larger marine puffers have been recorded travelling into heavily brackish tributaries in search of food. On the other hand, many of the smaller breeds of puffer actually travel into fresher waters to breed. For saltwater varieties, full marine salinity is needed for the long-term health of these puffers.

Water Quality Maintenance: It is always best to plan on doing substantial water changes on the aquarium tanks to help with the waste production of the fish. If a puffer is forced to live in a small tank and in poor water quality, then the puffer will end up having stunted growth, as well as severe health concerns like recurring itch or skin problems. Pufferfish are sensitive to dirty water, and should be kept in mature tanks with good filtration, and weekly water changes of at least 25% are essential.

6.1 WATER CHEMISTRY

Hardness (dGH): Water hardness is the amount of certain dissolved salts in the water. The general hardness (GH) measures the levels of calcium or magnesium in the water. Soft waters have value below 8°N dGH

(142.86 ppm, 2.86 mEq) and hard water is above 18°N dGH (321.43 ppm, 6.43 mEq).

pH: It is an indicator which says if the water is acidic, neutral or alkaline. Actually it is the concentration of hydrogen ions in water. The more hydrogen ions are to be found in the water, the more acidic the water is. The acidic water is characterized by pH ranging from 0 to 7 (7 not included), 7 is neutral water, and pH above 7 is alkaline.

Specific Gravity: The amount of salt in water is measured by the parameter called specific gravity (SG) with a device called hydrometer. Specific gravity of the fresh water is 1,000, and saltwater has a SG of about 1,025. Brackish water should have a SG ranging between 1,005 and 1,015.

6.2 EQUIPMENTS FOR AQUARIUM

Light: Plants and fish should be given normal amounts (not longer than 12 hrs a day) of light. Longer days cause stress and algal blooms.

Filtration: An internal filter or an external canister filtration system would be ideal for freshwater aquarium. Undergravel filtration is not perfect for a tank with sandy bottom as small particles may clog up the filter.

Water Heater and Thermometer*:* In order to maintain the required temperature and for monitoring the same, a water heater and thermometer are necessary for freshwater aquarium.

(1)

(2)

(3)

(4)

Aquarium equipments: (1) Lighting; (2) Skimmer; (3) Filter; (4) CO_2 system.

Stocking: None of the puffers are ideal community fish and most are best kept alone, that is, one to a tank.

Diet: In terms of diet, unshelled crustaceans and molluscs are normally preferred, The diet items are selected according to the pufferfish species maintained. Pond snails, clams, krill, shrimps, and crayfish are all useful foods. Soft foods, like mussel meat and bloodworms are enjoyed, but these do not wear down the pufferfish's teeth. Like rodents, puffers have teeth that grow constantly, and without abrasion, become too long for the puffer to feed properly. They can be clipped manually using cuticle cutters, but it is best to simply prevent this happening by offering suitably "crunchy" foods.

Teeth: All puffers are predators. The interesting aspect of these puffer's teeth is that they continually grow throughout the life of fish. To cope up this situation, puffers in the wild eat hard-shelled crabs, snails, and crustaceans all the time. Luckily this fish is so quick to accept food that it can easily be kept with standard frozen or store bought foods. Supplemental feedings of hard-shelled foods can take care of the ever-growing teeth.

Feeding: It is always advisable not to feed the new puffers for 24 hrs as they are getting settled in to their new tank. Usually these fish adjust relatively quickly and will accept food within a few hrs of being introduced to their new home. Generally, puffers will eat just about anything, and will quickly adapt to prepared foods. It is best to start with live snails as the first feedings. However, puffers regularly need hard-shelled meals to wear down their bony teeth. Small live ghost shrimp and varieties of live snails are perfect to wear down the teeth of the puffers. Instead of daily feeding,

it may be done twice or thrice a week. A varied diet is the key to a happy and healthy puffer. Before feeding, the freshly bought live clams or other molluscs should also be kept in container with fresh seawater to excrete their wastes. In the wild, puffers will also graze on algae and soft plants. Though the algae are not a large part of it's diet, they are still needed as sources of essential nutrients. A few species of puffers will graze on algae formed in the tank. With their expandable stomach, puffers can eat a large amount of food. Further, an area of the tank has to be chosen to feed the puffer. Puffers will become trained to take things from that area of the tank. Small pufferfish only need to be fed once a day. Overfeeding pufferfish causes a variety of problems, the chief of which is deteriorating water quality.

Coloration: Appearance of pufferfish can change with their moods and there is no real stable coloration. Most puffers will have a paler coloration to them when they are resting, sometimes referred to as their "sleep coloration". This sleep coloration is often shown when the fish is sick or if it is stressed. If a normally darker colored puffer turns lighter shades that could be a sign it is stressed. Though, with many of the other breeds, like the dog-faced puffer, the body actually turns dark brown to even black when it is extremely stressed.

Behavior of Healthy and Unhealthy Fish: A healthy puffer will have its caudal fin out behind it, and the tail fanned out. A sick or stressed puffer will fold their caudal fin alongside their body. This trait can be seen while the puffer is sleeping, or if they are forced to live with a more aggressive species of fish.

Lifespan: Generally puffers are very long-lived fish. Even in captivity, they easily go over 10 years with proper care. Many of the smaller brackish varieties have been recorded to 18 years of age. Larger marine varieties have been reported to live for more than 20 years.

6.3 FRESHWATER AQUARIUMS

Popular Pufferfish Species of Freshwater Aquariums

- Abei Puffers (*Pao abei*)
- South American Puffers (*Colomesus asellus*)

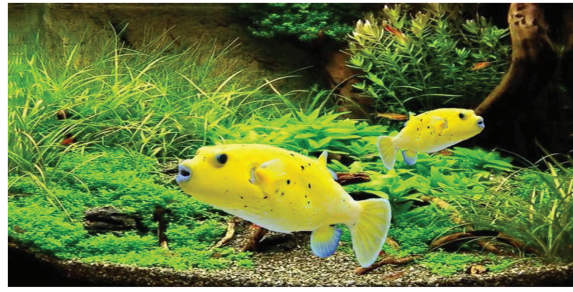
- Dwarf Puffers (*Carinotetraodon travancoricus*)
- Figure Eight Puffers (*Tetraodon biocellatus*)
- Ceylon Puffers (*Tetraodon fluviatilis*)

Source:(http://www.allaquariuminfo.com/2013/12/puffer-information-types.html)

6.3.1 FRESHWATER SPECIES – TANK SETUP

Freshwater puffers are more sensitive to extreme values of water chemistry in comparison to brackish species as conditions are not likely to change unexpectedly or too fast in freshwater aquariums. The "common" requirements for a properly set freshwater aquarium tank are as follows:

Fine gravel or top-notch sand should be used as substrate. Puffer should never be introduced to a tank with no substrate as many of them love to hide or dig in sand. Hiding places are also equally important for puffers as they are known to spend a lot of time being hidden. Additionally, many of the freshwater puffers are nocturnal. Tufa rock, pebbles or sandstones may be provided as hiding areas. Rocks or other objects that are put to a fish tank must be aquarium-safe, that is, they should not affect the water quality of the aquarium. Further, these rocks should not have sharp shape as such shapes may injure a fish. Driftwood can be added to a puffer tank. However, too much of driftwood may reduce pH. Driftwood should be boiled in order to remove parasites or diseases from it. Plants may be grown in a puffer fish tank as they decompose fish' waste. Moreover plants produce oxygen. Rcommended plants include *Echinodorus, Cryptocoryne, Anubias, Ceratophyllum, Microsorium, Pistia,* and *Riccia*.



Freshwater Pufferfish Aquarium

6.4 BRACKISH WATER AQUARIUM

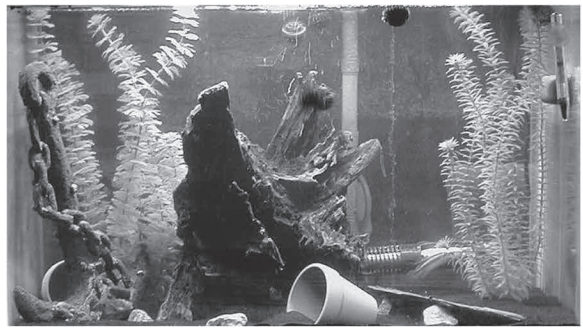
Popular Pufferfish Species of Brackish Aquarium

- Dog faced puffer, *Arothron hispidus*,
- Milk spotted puffer, *Chelonodon patoca*
- Common toadfish, toado, *Tetractenos hamiltoni*
- Eyespot pufferfish, *Tetraodon biocellatus*
- Green spotted puffer, *Tetraodon nigroviridis*
- Red-line/band, Samurai puffer, toadfish, *Tetraodon erythrotaenia*
- Green puffer, *Tetraodon fluviatilis*

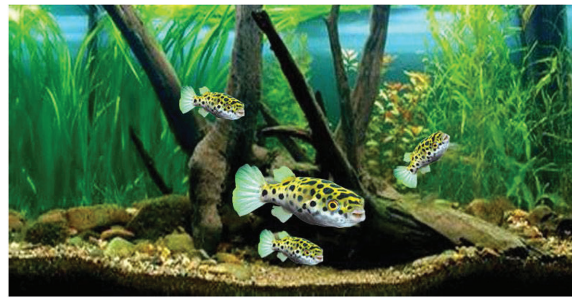
Source: (http://www.thetropicaltank.co.uk/Fishindx/puffers.htm)

Items Needed for a Brackish Aquarium

- 20- to 50-gallon aquarium tank
- Gravel or sand substrate
- Filter
- Heater
- Aquarium lighting
- Rocks and plants (fake or real)
- 10-gallon bucket
- Marine salt or Instant Ocean
- Beneficial bacteria solution
- Water conditioner
- Ammonia, nitrate and nitrite water testing kits
- Digital probe thermometer
- Hydrometer
- pH test kit
- Crushed coral or aragonite (optional)
- Live or frozen food



Brackish pufferfish aquarium



Brackish pufferfish aquarium with spotted puffer

6.4.1 PREPARATION AND MAINTENANCE OF BRACKISH AQUARIUM

6.4.1.1 Brackish Tank Setup

Brackish water puffers tolerate a wide range of salinity and temperature. In general, there are two types of brackish water setups viz. the mangrove swamp and the typical brackish water aquarium. The Mangrove swamp setup/biotope looks more natural as it is built on a sandy bottom (which can be replaced with fine gravel in case suitable sand is not available), tufa rocks and wood that is found anywhere in mangrove swamps. Caves can be made of rockworks. Plants that tolerate salty environments are as follows: *Elodea canadensis, Ceratophyllum, Sagittaria, Echinodorus, Vallisneria spiralis, Hygrophila polysperma, Vesicularia dubyana*, etc. As in freshwater tank, basic equipments like filter, heater, lighting, and thermometer are required for brackish water aquarium also. Hydrometer is also a must for this type of aquarium. Of course hiding places, rocks, bogwood, eventually flower pots, plants and free-swimming places are common for all types of tanks.

6.4.1.2 Preparation and Maintenance of Brackish Tanks

Step 1: A 20-gallon tank is ideal for one adult puffer, but a 50-gallon tank is more appropriate for aquarium with plants and other fish.

Step 2: Gravel or sand is washed and is spread evenly over the base of the tank. Rocks, decor and plants are added to provide plenty of hiding places. A heater is attached to the back wall, inside the tank, diagonally for optimal heat dispersal. A filter is placed centrally on the back wall.

Step 3: Tap water and marine salt is mixed in a 10-gallon bucket or large container. Brackish water should have a specific gravity (SG) ranging between 1.005 and 1.015. The easiest way is to prepare the required brackish water is to mix one part of the marine water (SG, 1.025) and one part of fresh water (SG, 1.000). The salinity levels are checked with a hydrometer. Water conditioner is also added to the brackish water to remove chlorine, chloramine and other chemicals that are found in tap water to make the water safe for the pufferfish. A few drops of beneficial bacteria solution may be added to this prepared water to stabilize and cycle the aquarium to prevent a build-up of ammonia, nitrate and nitrite.

Step 4: The water so prepared is poured into the aquarium and the filter and heater are switched on. The heater is set to about 78°F and the ambient water temperature is monitored with a digital probe thermometer, for a stable reading of between 74 °F and 82°F. The aquarium lights are set to be on for eight to 10 hours a day.

Step 5: The pH level of the water is checked with a test strip. Puffers prefer slightly alkaline conditions but they are fairly adaptable with pH values ranging from 7.5 to 8.5. Crushed coral or aragonite may be added to achieve the required pH if necessary.

Step 6: A water test is carried out at least once a week for the first month to make sure there is no ammonia, nitrate or nitrite present in the aquarium. If any of these toxins are allowed to develop unchecked, they will kill the puffer. About 25% of the water is changed once a week and beneficial bacteria solution is added at the recommended dosage at least once a week as a precaution.

Feeding Brackish Pufferfish: Brackish water puffers may be carnivorous or omnivorous. Diet of carnivorous pufferfish may include aquatic snails (such as ramshorn snails); chopped and whole mussels; earthworms; flies; live or frozen food (blood worms, mosquito larvae, daphnia, freshwater shrimps, glassworms, *Artemia* (brine shrimps), *Cyclops, Tubifex*); shellfish (such as cockles, but they are needed with the shell) and whole prawns. Omnivorous puffer fish should be given the above-mentioned foods along

with aquarium plants such as courgette, lettuce and peas. These fish should be ideally fed twice a day with small amounts of food. Overfeeding should be avoided as uneaten food negatively affects water quality.

6.5 MARINE (SALTWATER) PUFFERFISH AQUARIUMS

6.5.1 POPULAR PUFFERFISH SPECIES OF SALTWATER AQUARIUMS

- White spotted blowfish, stars and stripes puffer (*Arothron hispidus*)
- Guinea fowl puffer, golden puffer (*Arothron meleagris*)
- Arothron dog face puffer (*Arothron nigropunctatus*)
- Scribbled Arothron puffer (*Arthron mappa*)
- Immaculatus puffer (*Arothron immaculatus*)
- Narrow lined puffer (*Arothron manilensis*)
- Sharpnosed puffer, false eye puffer, blue spotted puffer (*Canthigaster solandri*)
- Black saddled puffer, valentine puffer (*Canthigaster valentini*)
- Papuan toby puffer (*Canthigaster papua*)
- Saddle puffer (*Canthigaster coronata*)
- Spotted puffer (*Canthigaster jactator*)
- Bennett's sharpnose puffer (*Canthigaster bennetti*)
- Leopard puffer (*Canthigaster leoparda*)

Source: http://www.saintlouisaquariums.com/pages/saltwaterLife/saltwaterFish/pufferfish/puffers.html.

Saltwater pufferfish aquarium

6.5.2 SETTINGUP SALTWATER AQUARIUM:

- *Saltwater aquarium setup takes considerable time.* It usually takes 4 to 8 weeks before any saltwater pufferfish is added safely to the saltwater aquarium. Before setting up a saltwater aquarium, the following need to be kept ready.
- *Tank:* At least 40 liters, preferable 70 liters
- *Water:* Either natural sea water (preferable) or a specialized artificial slat mix
- *Sand:* Small grained sea sand or crushed marble
- *Rock:* 1 kg of rock per 20 liter of water
- *Filter:* Almost any kind of mechanical filter
- *Circulation:* A small (100 liters per hour) internal pump to keep the water moving
- *Heating:* 100 watts of heating per 50 liter of water
- *Lighting:* One or more fluorescent light
- *Thermometer:* To test the temperature
- *Hydrometer:* To test the water salinity
- *Nitrite test kit:* To test the level of nitrites in the water
- *pH test:* To test the pH of the water

Step 1: *Location, aquarium size and aquarium stand:* The first step in saltwater aquarium setup is choosing a location which should not be close to natural lighting sources. Close to windows, entrance that has a clear door where sun rays come in and patios are not ideal locations. As intense sunlight may produce excessive algae, a cooler room temperature that is well-ventilated would be the best. A large area is always chosen for a successful saltwater aquarium.

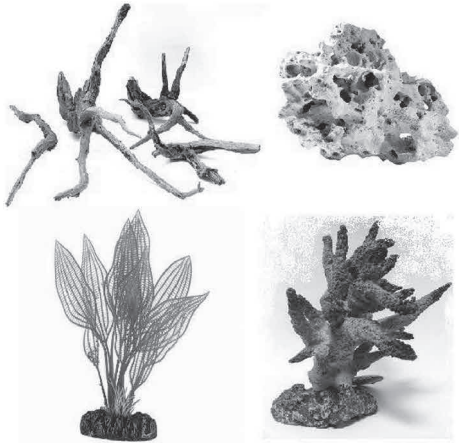
Tank: The first requirement is a proper glass tank which may be the largest one.

Larger aquarium provides a much more stable environment. Surface area of the aquarium should also be taken into account in saltwater aquarium setup. Oxygen enters the water and, more importantly, unwanted gases such as carbon dioxide escape into the air at the water surface. So the larger the surface area, the more efficient the exchange of gases will be. Another important factor in saltwater aquarium setup is its shape. Shapes of saltwater aquarium tank may vary from rectangular or hexagonal to

octagonal, bow-fronted and even trapezoidal. A sturdy stand that is capable of supporting the weight of a filled aquarium may also be needed.

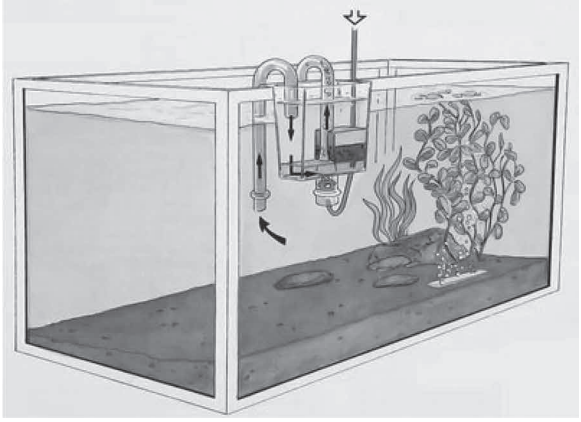
Step 2: *Preparation and settingup the saltwater aquarium:* The freshly bought tank is to be first cleaned with freshwater with a soft cloth or sponge. Chemical cleaners are not suitable for this purpose. Now the sand or gravel is added at the bottom of the aquarium followed by saltwater. A pre-mixed saltwater or filtered, dechlorinated water with sea salt mix may be used for the latter. Initially, the aquarium is to be filled 1/3 full. The ideal specific gravity of this water should be 1.025. All the other equipments such us lighting, heater, and filter should be installed and they may be allowed to run for a day.

Step 3: *Aquascape:* Aquascaping the saltwater aquarium means decorating the aquarium. There is no correct or perfect set up of decorating this type of aquarium. Live, cured rock may be chosen for this purpose. Fish will adjust better to their new rocky environment because it is similar to their natural habitat. Live, rock also becomes a biological filter of the saltwater aquarium. It provides the beneficial organisms for proper water management. Another advantage of live rock is that it acts as a home for corals and other invertebrates and can be used by shy or frightened fish as their hiding place. Most live rock may be fully cured in 1–3 weeks. Curing of the live rock may be done in any type of plastic container (or inside a new aquarium) that is suitable in size to fit the amount of live rock. Curing live rock would avoid the accumulation of ammonia, a toxic compound and pollutant in the saltwater aquarium.



Aquascaping materials

Step 4: *Cycling (Biological aquarium filtration):* The biological aquarium filtration is the most important of all types of filtrations. The lack of effective biological filtration is probably responsible for the death of more aquarium fish than any other cause. The particular dissolved compounds (like ammonia and nitrite) controlled by biological filtration are very toxic to fish even at low concentrations. In the newly setup tanks, the aforesaid compounds may kill fish very quickly. In saltwater aquariums that have been running longer but are overstocked with fish, there can be constant low levels of these unwanted compounds in the water. This creates chronic, long-term physical stress, resulting in diseased and dying fish.



Biological aquarium filtration

Nitrogen cycle: It is the basic process of biological filtration in the aquarium. Ammonia is one of the key elements in the nitrogen cycle. Fish produce ammonia directly both as a by-product of respiration and as a waste product from the digestion of foods. Solid wastes are also converted into ammonia. It is therefore important to remove these solid wastes through mechanical filtration. Uneaten food, plant materials, and other organic items that decay in the tank are also converted to ammonia. This ammonia, a nitrogen-based compound, is extremely toxic. In any aquarium, it can build up quickly and threaten all the fish in the tank. The bacteria already accumulated in the gravel bed of the aquarium help in this regard. *Nitrosomonas* sp. will first act upon the ammonia (in the presence

of dissolved oxygen) and convert the same into nitrite, a toxic compound. This compound in the long run tends to be a larger problem than ammonia. Subsequently another species of bacteria viz. *Nitrobacter* sp. converts it into nitrate, a relatively harmless compound that can be used up by plants and algae.

As with *Nitrosomonas* bacteria, it takes some time before the *Nitrobacter* are able to multiply to sufficient numbers to handle all of the nitrite. While it may take about a week for the population of ammonia-converting *Nitrosomonas* to grow to sufficient numbers, it may be six weeks for the *Nitrobacter* to reach sufficient levels. Thus the process of starting the nitrogen cycle may generally take a total of six to eight weeks the period of which is known as "breaking in the tank." If there are too many fish in the tank during this process, and not enough water changes are made, many of the fish will die. This situation is known as "new tank syndrome" (Santhanam, 1990b; http://animals.howstuffworks.com/pets/choosing-aquarium-equipment4.htm).

Step 5: *Addition of new puffers in saltwater aquarium:* Once the saltwater tank has been newly cycled, it is now ready for adding new puffers which are added at the rate of 1 or 2 into the aquarium at a time. It is better to allow the aquarium's nitrifying bacteria base to adjust to the additional load of puffers. This means nothing is added at this point of the set up, and over a week's time the aquarium water should be tested daily for any appearance of ammonia and possibly nitrite. Zero readings would mean it is safe to add the next 1 or 2 pieces of livestock. Even when the test results are showing zero, it is better to wait for one or two weeks before adding further livestock.

Breeding of Aquarium Pufferfish: Only a few puffer species have been successfully bred in fish tanks. They are spawners and females will only produce eggs that must be fertilised by male outside of her body. Further, breeding requirements of these species are mostly unknown. Raising a pair in one tank is impossible in most cases. Even though some species can be kept in a community tank, sexing is impossible.

Raising the Pufferfish Fry: Pufferfish fry must be fed with very small pieces of meaty food and this is hard to achieve in an ordinary fish tank. The fry can also be fed Infusoria or *Cyclops*. Once they become a little bigger, it is better to feed them newly hatched brine shrimp, *Artemia*. As

newborns grow larger and larger, they can be fed all foods that are given to the adult specimens.

Spawners: Based on the spawning habits, the pufferfish are divided into three groups viz. substrate spawners, rock spawners and plant spawners.

Substrate Spawners*:* These spawners usually dig a small hole into the substrate and lay their eggs into it. Then the parents guard the eggs and later one of both of them look after the fry. Species that belong to this category include green pufferfish (*Tetraodon fluviatilis*) and twin spot puffer (*Tetraodon leiurus brevirostris*). Green puffer is successfully bred in brackish aquariums only, even though it lives in fresh and saltwater environments. The above species can lay up to 500 eggs at a time. However, it is important to remove the female from the tank as only the male will guard the eggs. If the tank is big enough, and if the male does not become too aggressive towards his partner, it is better to keep both parents in the same aquarium. The eggs will hatch in 5 days and it is ideal to separate them from parents once they become free swimming. Newly hatched brine shrimp and *Cyclops* should be given to newborns. However, the survival rate of these young is very low in general. Further, as small puffers will become aggressive towards each other, stronger specimens will go after weaker ones. Therefore, cannibalism should be reduced by using tank dividers.

Rock Spawners: These spawners lay their eggs on rocks and they guard the eggs and fry as there is no shelter on rocks. Species of this group include sea frog (*Tetraodon cutcutia*) and green puffer (*Tetraodon nigroviridis*). Rock spawners will firstly clean a rock which is later used for the purpose of laying eggs. The male will guard the eggs for about 10 days as this period is required for eggs to hatch. Speed of hatching depends on temperature. The higher the temperature, the sooner they hatch. It is important to remove the male from the tank once the eggs hatch because he may feed on them. The fry should be fed on *Cyclops* and newly hatched brine shrimps (*Artemia salina*). As they grow bigger food may be given. The difference between green puffer and sea frog lies in space that should be given to a pair. Sea frogs will require more space, at least 400 liters (105 US gallons) as this species is more territorial. These sea frogs will start dancing when they are ready to spawn. Further the male's tail may also develop red on the edge at the time of spawning.

Plant spawners: These puffers lay eggs on leaves and roots of plants. They also guard eggs and fry. This group includes species such as figure 8 puffer (*Tetraodon biocellatus*), spotted Congo puffer (*Tetraodon schoutedeni*) and red eye puffer (*Carinotetraodon lorteti*). The figure 8 puffer and the spotted Congo puffer lay their eggs onto leaves. The male will chase the female away after they breed. 6 or 7 days later, the eggs hatch which is the ideal time to separate male from newborns. The fry should be fed on small, live foods. It is normal for a spotted Congo puffer male to catch a female when breeding. This is actually the process when eggs are being released and fertilized by male. The red eye puffer lays about 300 eggs. Just like the spotted Congo puffers, the red eye puffers will sldo display this behavior when male catches a female in his mouth. Once the eggs are laid, both parents should be removed from the breeding tank, as the eggs will be eaten by the latter. The eggs will hatch in 2 days and they should also be fed *Cyclops*, *Artemia salina* or microworms.

Water quality in breeding tank: Water quality in a breeding tank must be high, and the tank must be maintained on a regular basis otherwise the survival rate of newborns decreases. Filter, heater, lighting, substrate and plants are also to be kept without fail. It is better to use a sponge filter. Regular water changes and water quality testing are also necessary.

Introduction of a New Fish Into the Tank: As most fish come in a plastic bag, it is important to turn off the lights before emptying the bag into the water. Before opening the bag, the latter is allowed to float at the top of the prepared tank for about 10 minutes in order to adjust temperatures of the fish and tank water (i.e., acclimation). Now the bag gets opened and the fish are allowed into the tank. As most puffers are aggressive, it is better to keep them in a dedicated tank. Otherwise, their tank mates should be given enough hiding places. Puffers should be ideally kept alone or in large tanks with fish.

Tank Mates: Since most puffers are terribly territorial, they are best kept alone.

Cleaning a Pufferfish Tank: A puffer tank requires regular water changes and water testing which are crucial for keeping healthy fish. Most puffer tanks need from two to four partial water changes a month, that is, from 10% to 25% per week. Large tanks usually require less maintenance as pH, specific gravity and process of decomposing excrements are more

stable when compared to small tanks. For water exchange, a siphon is always used. There is no need to siphon the substrate. It is always better to remove water from top levels of the tank. The newly added water should be chlorine-free. The pH, General water hardness (dGH), specific gravity (SG) and temperature of newly added water should be more or less similar to that of the existing water of the tank. The filtration media should not be rinsed in tap water as this would kill all or mostly all beneficial bacteria. It is ideal to perform water changes and filtration media cleaning at the same time because aged water can be used from the tank to rinse the filtration media (for suitable aquarium parameters of the individual species, *see* Chapter 3).

Aquarium Pufferfish Species at Risk: Ornamental, aquarium pufferfish species such as *Carinotetraodon travancoricus, Auriglobus amabilis, Auriglobus nefastus, Chonerhinos silus Colomesus psittacus, Carinotetraodon lorteti, Tetraodon baileyi, Colomesus asellus, Tetraodon mbu, Carinotetraodon borneensis, Takifugu vermicularis, Takifugu radiates, Tetraodon nigroviridis, Chelonodon laticeps, Takifugu rubripes* and *Chelonodon pleurospilus* have been identified as high risk but deferred for further assessment. This aspect may require more detailed biological and/or social assessment (Moore et al., 2010).

KEYWORDS

- **brackish pufferfish**
- **freshwater aquariums**
- **plant spawners**
- **pufferfish aquariums**
- **rock spawners**
- **saltwater aquarium**
- **water chemistry**
- **water quality maintenance**

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CHAPTER 7

DISEASES AND PARASITES OF PUFFERFISH AND THEIR MANAGEMENT

CONTENTS

Diseases and parasites are the major problems in the natural habitats and aquarium of pufferfish. The disease indicators of pufferfish include abnormal behavior, poor coloration, and external abnormalities. A thorough knowledge on the diseases and parasites of pufferfish living in freshwater, brackish water and marine habitats would largely help in their profitable aquarium keeping and trade.

7.1 MOOD/STRESS/DISEASE INDICATIONS

Puffers are one of the easiest fish to recognize stress or contentedness. Some of the disease indications of the pufferfish are:

- ***Loss of Appetite:*** Generally, puffers have voracious appetites. One of the first signs of stress in these fishes will be either drop in or loss of appetite. If the puffer refuses to eat or only picks at its food, something is wrong with its health.
- ***Appearance of "Stress Line":*** This is a light to deep grey line that appears between the dorsal coloring and the belly. It will start on the sides of the mouth and extend along both flanks to the tail. On white-bellied puffers, the tummy will begin to darken to grey. It will be light at first, but as the problem persists, the grey will deepen to nearly black.
- ***Abnormal Behavior****:* Lethargy and hovering near the surface are some of the problems associated with the abnormal behavior of pufferfish. Swimming patterns may also be the indicators of this problem. The common "up and down" swimming pattern of aquarium puffers can sometimes be an indicator of illness or discomfort. Surface breathing, scraping against the objects, or shimmying are also some of the signs of this abnormal behavior. Cock-eyed swimming is also an indicator. Although puffers will manipulate their axis to gain an advantageous angle on food, unbalanced swimming is definitely bad. Improper ballast is a sure fire indicator of infection. Inactivity may be another indicator.
- ***Poor Coloration****:* Puffers often change color according to mood, time of day, and position in the tank. It is better to know the range of coloration of species maintained in the aquariums. Although poor coloration is a stress indicator, it is not to be worried as long as it is only temporary.
- ***External Abnormalities****:* If and when the pufferfish exhibits clamped gills, damaged fins, cuts and scrapes, or signs of parasitic infection, it becomes quite clear something is wrong with the health of puffers. These are often the most obvious indicators of sick puffers. In some cases, these abnormalities are preceded by the clamped gills and damaged fins. Hence, special attention may be paid to behavior and coloration of pufferfish before diagnosing their disease problems.

The above said problem indicators do not necessarily mean disease. They may also be due to changes in water parameters (such as variations

in salinity, temperature, pH, nitrites, and ammonia), tank mates, absence of enough hiding places and areas and decorations (Leigh, 1996–2015).

7.2 PARASITES

The most common diseases of pufferfish are the following:

- ***Marine Ich (Marine White Spot):*** Marine Ich is caused by an infestation of the protozoan species, *Cryptocaryon irritans* (a ciliate covered by cilium, or fine 'hair-like' processes that beat in unison to give movement). Symptoms of this deadly infestation include flashing (scratching against substrate or décor), rapid respiration, increased mucous layer, abnormal swimming, loss of appetite or frayed fins. The most telltale sign of *C. irritansis* is the characteristic white dots that are similar to grains of salt stuck to the body of the fish.

A black diamond pufferfish with Ich infection

- ***Lifecycle of* Cryptocaryon irritans***:* In order to better understand about the treatment of this disease, it is necessary to know about the lifecycle of *C. irritans*. In its life cycle, this parasite has a number of different stages *viz* protomont (crawling adult), tomont (cyst), tomites (daughter parasites), theronts (free-swimming), and finally a trophont (adult stage attached to the host). Basically, a trophont will spend 3–7 days feeding on its host (pufferfish). Afterwards, it will drop off (usually under the cover of darkness when the fish

is resting) and spend up to 18 hours crawling along the substrate (protomont stage) until it attaches to the substrate and begins to encyst (tomont stage). Subsequently, the parasite will divide into hundreds of daughter parasites (tomites) within the cyst and can remain there for up to 28 days. Finally, the cyst will hatch, releasing the free-swimming theronts that need to find a host within 24 hours (This is the most vulnerable stage and most treatments target the theronts). Normally, this parasite will attach to skin and gill tissue where they can transform into adult trophonts (http://absolutelyfish.com/conservation-education/education/marine-ich-cryptocaryon-irritans/).

- ***Treatment of Marine Ich:*** It is always better to remove the affected fish from the tank and treat them separately rather than adding medications into the aquarium. A copper or ionic copper based medication with copper sulphate, copper pentahydrate or other copper compounds as active ingredients is normally used in the treatment of marine Ich. A proper amount of copper solution to the quarantine tank until a concentration of 0.12 to 0.18 ppm is obtained. Quinine based medication (Chloroquine phosphate or Quinine hydrochloride at 5–10 ppm has also been used with great success to treat *Cryptocaryon* outbreaks. Formalin (which is an aqueous solution of about 40% formaldehyde gas) however, is rarely used to treat this disease. It is also important to monitor the tank daily to make sure that the levels do not exceed or decrease beyond the advised medicated levels. It is always better to treat and monitor the affected fish for a minimum period of 21 days before releasing them back into the display tank.
- ***Freshwater Ich (Freshwater White Spot):*** This diseases is caused by *Ichthyophthirius multifiliis*, a protozoan ciliate largely resembling the freshwater Ich-causing *C.irritans* in shape and life cycle. It is the most common disease to infect freshwater fish. The Ich life cycle is temperature dependent. While higher temperatures within its livable range speed up every stage of the life cycle, the lower temperatures will slow it down. At 18°C/64°F, the cycle takes about 12 days to complete. It has been found that Ich does not infect new fish at 29.4°C/85°F, stops reproducing at 30°C/86°F, and dies at

32°C/89.5°F. The disease normally develops in stressed fish which is a case of poor water quality, constant harassment, inadequate feeding, lack of nutriments and other unnatural states.

- ***Treatment of Freshwater Ich:*** Some of the treatment methods of freshwater Ich are given below.
- ***Increasing Temperature****:* An increase in temperature to 30°C/86°F has been reported to prevent the reproduction of Ich. So the first step would be to increase the temperature slowly, 1°C/2°F per hour until the correct temperature is reached. This increased temperature should be maintained for about 10 days, and then slowly returned to normal.
- ***Increased Aeration:*** Increased temperature leads to increased metabolism and oxygen demand in puffers. As oxygen is lower in warmer water, it is very important to increase the surface agitation during the treatment to increase oxygenation. In planted tanks with CO2 injection, the CO2 should be turned off and extra aeration should be provided.
- ***Partial Water Exchange:*** A 25% daily partial water changes will keep the water very clean, which will help fish cope with the stress of the disease. It will also remove some of the trophonts and tomites; and will add oxygen. This author also recommends the use of NovAqua+ to condition the change water. If the water changes seem to stress the fish, the size and/or frequency of the water changes may be reduced.
- ***Use of a Micron Filter****:* The Aqua Clear Quick Filter is an easy way to capture both free-swimming stages and the cysts of Ich in water that passes through the filter. A diatom filter can also be used. Both of these filters trap particles like smallest stage of Ich, the free-swimming, swarming tomite which is approximately 30 microns.
- ***Gravel Removal****:* The temporary removal of the gravel seems to reduce the attachment sites for the tomont and makes it easier to siphon the floor of the aquarium where many tomonts will be located.
- ***Use of Salt:*** In a non-planted aquarium with tolerant fish, the addition of Aquarium salt at the rate of 1 teaspoon per 4 liters of water

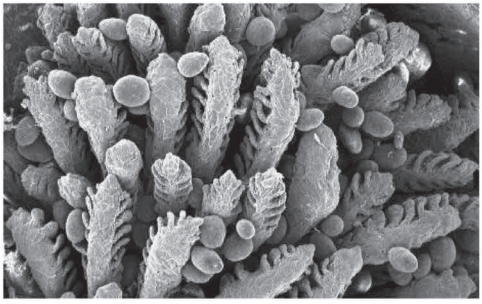
disrupts the fluid regulation of Ich. It is always better to dissolve salt in a small amount of tank water before adding to tank. This dosage may be repeated every 12 hours for a total of three treatments. When Ich is over, salt is removed with daily 25% water changes. A separate salt bath is also very effective for individual puffers. The higher concentration of salt will destroy embedded trophozoites on the body of the fish by preventing them from maintaining fluid balance. To prepare a salt bath for small and medium sized fishes, 2 Tablespoons Aquarium Salt is dissolved in 4 liter of conditioned tap water that is the same temperature as the tank water. It is also stirred well to make sure all salt is dissolved before using.

7.3 MARINE VELVET DISEASE (AMYLOODINIOSIS)

This disease is caused by the microbial, parasitic dinoflagellate, *Amyloodinium ocellatum*. The life cycle of *Amyloodinium* is more or less similar to *Ichthyophthirius multifiliis*, which causes freshwater Ich. This parasite is able to infect the majority of both salt and freshwater fish. The pufferfish species *Sphoeroides parvus* has been reported to be affected by this parasite. Affected fish had the density of cells at 75–200 per gill filament and such fishes died in 16–28 hours (Lawler, 1980).

- ***Symptoms:*** The symptoms of marine velvet disease usually involve the skin and lungs. Mild infections will usually only infect the gills and the fish may show minimal symptoms. As the infestation becomes more severe, the gills will become inflamed, bleed, and the lung tissue will begin to die. The fish will show signs of irritation and distress, with rapid breathing and lethargy. As the inflammation increases, the fish will lose its ability to transport oxygen across the gill membranes resulting suffocation, and if treatment is not initiated, death will often result. During severe infections, small gold-colored spots will cover the skin, which can progress to create a "velvet" appearance which gives the disease its name. Many fish have been reported to die from this disease without ever showing any visible skin changes.

- ***Treatment:*** Immediate treatment of affected fishes is a must because the disease has such a high mortality level if not treated quickly. Treatment for this disease is almost exclusively with copper. Copper comes in several forms including ionic and chelated forms. The chelated forms are preferred. When copper is used, the water should be tested twice a day for copper levels for the first few days, and then daily for the rest of the treatment period. An ionic copper level of between 0.15 and 0.2 ppm is recommended for a minimum of 14 days. It is always best to use copper or any treatments in a quarantine tank for treating only the infected fish.



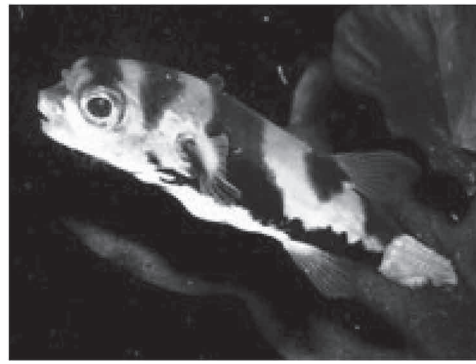
Amyloodinium ocellatum **on the gill filaments of pufferfish**

7.4 COTTON WOOL DISEASE (FUNGAL DISEASE)

This disease usually develops in open wounds which may be a result of fight among the individual fish. Most fungal infections have a characteristic white fluffy appearance and are commonly known as 'cotton wool disease.' As the fungal infections worsen, they may take on a gray or even red appearance. Poor water quality can also lead to an increase in fungal infections even in healthy fish population. Other conditions increase the possibility of fungal infections include poor hygiene; dead fish or large amounts of decomposing organic material in the tank; and fish that are injured, old, or have other diseases. Figure 8 pufferfish has been reported to be affected with white fungus growth. This stuff grows from their sides and even covers over the eyes of this species (http://www.tropicalfish-keeping.com/tropical-fish-diseases/f8-puffer-fish-white-fungus-growth-

3468/#ixzz3rNlAXVYm). Similarly dwarf puffer fry have been found to be affected with white "cotton" over his/her eyes (http://www.pufferfish.net/showthread.php?t=40594-PufferFish.net).

- ***Treatment for Cotton Wool Disease:*** It includes salt baths or the antifungal agent, phenoxyethanol. In some instances, the entire tank is treated. For individual infections, treating the fish in a separate hospital tank is preferable. Individual topical application of the antifungal and antibacterial agent Gentian Violet is also a treatment option.
- ***Fin Rot Disease:*** This disease develops when the fish nip each other's fins or during the process of netting. Poor water quality and overstocking in aquarium may also be factors for this problem. Pufferfish species such as Figure 8 puffer and *Colomesus* sp. have been reported to be affected by fin rot disease.
- ***Identification (Symptoms) of Fin Rot Disease:*** One of the first signs of a fin rot infection is the appearance of red streaks on the fish's fins. As the infection progresses, the fin membrane decays, making the edge of the fin distinctly ragged. Severe fin rot infections may completely destroy fins Additional symptoms of severe finrot infections include ulcers and lesions on the body, abdominal swelling (edema) and, ultimately, death. Fin rot often develops alongside fungal infections.



Tail fin affected *Colomesus* sp.

- ***Pathology of Fin Rot****:* Fin rot is caused mainly by opportunistic bacteria, in particular *Aeromonas hydrophila* and *Aeromonas liquefaciens*.

- ***Triggering Factors for Fin Rot:*** Though the bacteria that cause fin rot are present in all aquariums, they do not normally cause any harm. It is only when aquarium fish are stressed or damaged that fin rot infections develop. Further, poor water quality associated with enhanced ammonia and nitrite levels may damage the skin and fins, causing them to bleed.
- ***Treatment for Fin Rot:*** Antibiotics such as Erythromycin, Minocycline. Trimethoprim and Sulfadimidine may be used for treating fin rot disease. A cocktail of antibiotics has ben found to be very effective for this disease. Alternatively, salt (sodium chloride) is a useful preventative when used to treat salt-tolerant freshwater pufferfish with which doses of up to 1 ounce per gallon can be used safely.

7.5 BACTERIOLOGICAL AND VIRAL AGENTS

These agents find their way into the tank in much the same way as parasites do. At times of stress or illness, these micro-parasites will often take advantage of the puffer's fragile nature.

- ***Bacteriological Agents:*** Several species of pufferfish have been found to be affected by bacterial flora.

Bacterial Flora of Pufferfish

Pufferfish	Bacterial species	Site of occurrence	Causes
Arothron hispidus	*Chrysobacterium hominis*	Liver	–
Arothron hispidus	*Ferrimonas senticii*	Mucus slime	–
Takifugu niphobles	*Lactococcus lactis*	Intestine	–
Takifugu obscurus	*Vibryo harveyi*	Skin	Ulcer, mortality and pathogenicity
Takifugu rubripes	*Vibryo harveyi*	Liver, spleen and kidney	Mortality and pathogenicity

Source: Buller (2014); Chen, et al. (2013).

- ***Treatment for Bacterial Agents:*** Antibiotics are usually not prescribed for most common types of bacterial gastroenteritis in pufferfish. However, the affected fish have been reported to recover from these problems in a couple of days.

7.6 VIRAL AGENTS: BETANODAVIRUS

The diseases caused by these viruses are commonly known as "viral nervous necrosis (VNN) "or "viral encephalopathy and retinopathy (VER)". These viruses damage the central nervous system in susceptible pufferfish species and typically affect both younger stages of fish and older, market-sized fish. In the case of tiger puffer (*Takifugu rubripes*), the betanodavirus, "Tiger puffer nervous necrosis virus (TPNNV)" has been reported to infect the fish and cause disease at 20°C (68°F) (Yanong, https://edis.ifas.ufl.edu/fa180).

- ***External and Internal Signs of Viral Diseases****:* In the case of viral diseases, the nervous system of puffers is targeted. In addition to mortalities of up to 100%, the infected larvae and juvenile stages often show abnormal swimming behavior, including vertical positioning and spinning; flexing of the body; and muscle tremors. Betanodavirus causes hyperinflation of the swim bladder and hence the diseased fish are found primarily at the surface. Affected fish may also have traumatic lesions due to uncontrolled swimming/spinning. The most common clinical sign in adults is abnormal swimming. Changes in skin pigmentation, either darkening or lightening depending upon species may also be seen.
- ***Treatment for Betanodavirus Infections****:* Presently there are no effective treatments for most viral infections of fish, including those caused by betanodavirus. Depopulation followed by disinfection, however, is recommended. The following preventive measures may, however, be followed to safeguard the fish population from betanodavirus infections.
    - Good husbandry and biosecurity.
    - Betanodavirus vaccines have been developed internationally to reduce disease incidence and mortalities associated with betanodavirus infections.
    - Producers/hobbyists should quarantine new fish in a separate building or area and follow appropriate biosecurity protocols before adding them to existing farm populations.
    - Use of a water source that may have contained other fish or other potential sources of pathogens may increase risk as

well. It is therefore wise to use water from "protected" water sources, such as deep wells, or water that has been processed with adequate ultraviolet (UV) sterilization or chlorinated and dechlorinated (https://edis.ifas.ufl.edu/fa180).

Nutritional Deficiencies: It is always easy to treat diseases associated with nutritional deficiencies. Varying the puffer's diet prevents it from falling to malnutrition (http://puffernet.tripod.com/pathology.html).

Environmental Cause of Illness: It is an illness and it is usually chemical in nature. That is, the puffer is ill either because of unfavorable water conditions, or some toxin which has found its way into the tank.

Parasitic Infections: In nature and aquariums, a myriad of different organisms like trematodes and copepods looking to feed on puffers as parasites. These organisms find their way into the aquarium tanks through other fish, plants, nets, and food.

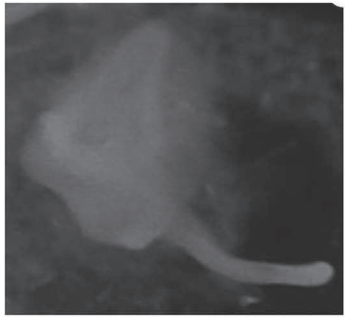
7.7 COMMON PARASITES INFECTING PUFFERFISH

(a) Host fish: ***Colomesus psittacus***

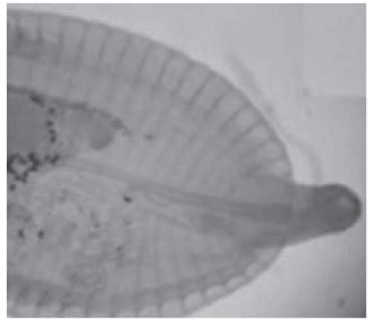
Locality of host fish: Brazil

Species of parasite: *Rohdella* sp. (Trematoda, Aspidogastrea)

Diagnosis of the parasite: The larvae of this species have a posterior sucker, a pharynx and a simple or bifurcate intestine. Excretory pores are paired and are located at the level of the anterior margin of the posterior sucker, connected to two excretory ducts each with three flame bulbs.



***Rohdella* sp.**



Retractable anterior region

Internal/external: Internal.

Infection site: Mucous membrane of the fish's intestine.

Symptoms in host: The fish did not present clinical symptoms of parasitosis, but in the infected specimens, reddish areas could be observed in the interior of the intestine.

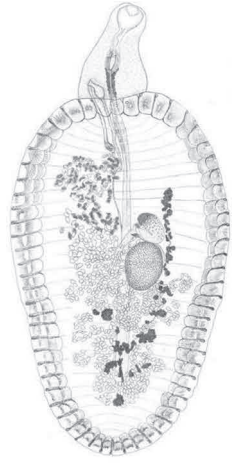
Remarks: The prevalence of the parasite was 76.4%; mean intensity of infection was 8.0 and mean abundance was 6.2. The parasitism provoked chronic enteritis with diffused inflammatory infiltration. The adherence of the parasite to the mucous membrane of the intestine resulted in strangulation and hyperplasia of the region, as well as causing hypertrophy of the muscle of the mucous membrane (da Silva et al., 2013).

(b) Host fish: *Colomesus psittacus*

Locality of host fish: Tocantins River, Brazil

Species of parasite: *Rohdella amazonica* n. sp. (Trematoda, Aspidogastrea)

Diagnosis of the parasite: The new taxon is distinguishable by the presence of esophageal glands, teguments covered by ciliated papillae, and the position and shape of the hermaphroditic duct. Body of this species is slightly longer than wide, narrow at the posterior region. Tegument is with small papillae distributed irregularly throughout the entire body. Adhesive disc is occupying the entire ventral region composed of 29 rows of transverse alveoli separated by two longitudinal septa. Pharynx is oval and large, surrounded by pharyngeal glands ((Giese et al., 2015).



Rohdella amazonica

Internal/external: Internal.

Infection site: Small intestines

Remarks: This parasite is a new species and further studies are needed about its infection in the host fish

(c) Host fish: *Lagocephalus inermis*

Locality of host fish: South-west coast of India

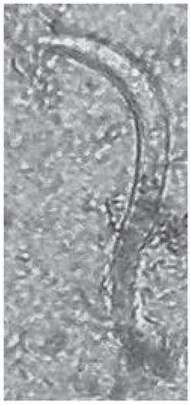
(i) ***Species of parasites:*** *Heterolebes maculosus, Opistholebes diodontis, Tetrochetus coryphaenae, Prosorhynchus* sp. (Trematoda, Digenea)

Diagnosis of the parasites for **Heterolebes maculosus:** Body of this species is distinctly rounded in outline and its forebody occupies 55% of the total body length. It has a ventral sucker which is separated from the posterior end of body. The testes are symmetrical and both the testes and ovary are located posterior to the ventral sucker.

Heterolebes maculosus

Infection locus: External surface

Diagnosis of the parasites for **Opistholebes diodontis:** In this species, the ventral sucker shifts from near the mid-level to the posterior end of the body and other rearrangements occur as a result of differential growth. It has a well developed glandular disc but it may be distinguished from *O. cotylophorus* and *O. adcotylophorus,* by the position of the cirrus sac which is well removed from the ovary, and the vitelline zones which neither coalesce anteriorly nor overlap the gonads posteriorly.



Opistholebes diodontis

Infection locus: External surface

Diagnosis of the parasites for **Tetrochetus coryphaenae:** This species is typically thin, slender, much elongated, with sides almost parallel and the size of the testes as compared to the body is small.

Tetrochetus coryphaenae

Infection locus: External surface

Diagnosis of the parasites for* Prosorhynchus *sp.: Body of this species is elongated and is fully covered by spines Rhynchus is conical and is strongly muscular. Rhynchus cone is with two lateral bands of transverse muscles and two central bands of dorso-ventral muscles surrounding the central funnel. Rhynchus cone is surmounted by disc formed by radial muscles and two antero-lateral fields of dorso-ventral muscles. Mouth is located at the anterior end. Pharynx is slightly preequatorial. Intestinal is caecum sac-like and is anterior to pharynx. Testes are rounded to oval, opposite to slightly diagonal and are located midway between intestinal caecum and posterior body end. Cirrus sac is thick-walled and sinistral.

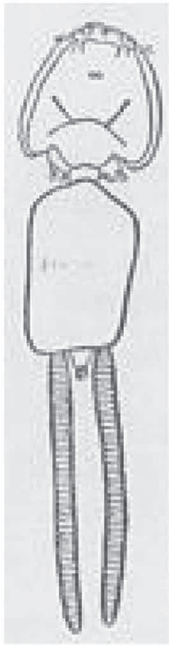
***Prosorhynchus* sp.**

Infection locus: External surface

(ii) ***Species of parasite:*** *Pseudocaligus laminatus* (Crustacea, Caligidae)

Diagnosis of the parasite: Body of this species is 2.84 mm long, excluding setae on caudal ramus. Cephalothoracic shield is subtriangular and as long as wide, 1.30 × 1.30 mm, excluding marginal hyaline membranes. Abdomen is small, 1-segmented, and is distinctly wider than long,

113 × 219 μm. Caudal ramus is small, also wider than long (16 × 40 μm), and is armed with 3 short and 3 very long, plumose setae.



Pseudocaligus laminates

Infection locus: External surface

(iii) ***Species of parasites:*** *Taeniacanthus lagocephali* (Crustacea, Caligidae)

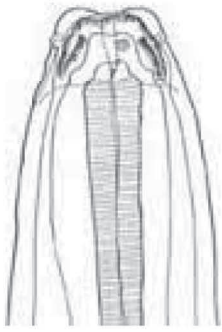
Diagnosis of the parasite: Body of the females is having cephalothorax and 3 metasomal segments which are swollen and subequal in length. Urosome is 6-segmented and is abruptly narrowed and short, almost as long as or slightly shorter than last metasomal segment. All segments are much wider than long. Body of the males is narrow, having 5-segmented urosome. First urosomal segment is much wider than long. Genital segment is longer than wide and is gently swollen at the middle, with a pair of cuticular slits representing genital pores. Third and fourth urosomal segments are wider than long and naked. Anal segment is longer than wide and is ornamented with 3 transverse rows of spinules.

***Taeniacanthus* sp.**

Infection locus: External surface

(iv) ***Species of parasites:*** *Amplicaecum tetradonti* (Nematoda, Ascaridae)

Diagnosis of the parasite: It is a long, stout worm. Body is 11.81 mm long and 0.55 mm in maximum breadth. Mouth is not clearly divided into anterior and posterior regions and is without deeply indented anterior margin. Oesophagus is long (2.25 mm) and intestine is without posterior bulb but with, intestinal caecum.



Amplicaecum tetradonti

Infection locus: External surface

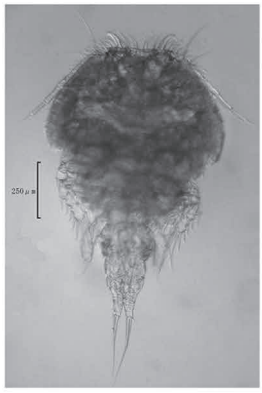
Remarks: Among the different species of parasites of this host species, the most prevalent parasite was the copepod, *Taeniacanthus lagocephali* (prevalence = 89.1%) (Prasad and Radhakrishnan, 2010).

(d) Host fish: *Lagocephalus lunaris*

Locality of host fish: Lake Temsah, Ismailia Province.

(i) ***Species of parasite:*** *Bomolochus* sp. and *Caligus* sp. (Crustacea, Caligidae)

Diagnosis of* Bomolochus *sp.: It has a more or less cyclopoid body. The second thoracic somite is only slightly narrower than the cephalic somite, never forming a neck. In females, rostrum is well developed and is represented by a distinct rostral plate, the base of which is usually visible between the antennules. The apical portion of the plate is curved, being rounded or bifurcated. Legs (2 to 4) are with 3-segmented rami. Abdomen is composed of 5 somites preceded by the 5th thoracic somite. The genital somite is composed of the fused first and second abdominal somites. Male is smaller than the female and is attached to the abdomen of the female by means of the strongly developed maxillipedes.



***Bomolochus* sp.**

Infection locus: External surface

(ii) **Caligus *sp.:*** Cephalothorax of this unidentified species is suborbicular or subovate; longer than wide and is dorsoventrally flattened. Abdomen is cylindrical and its caudal ramus is with 6 setae.

***Caligus* sp.**

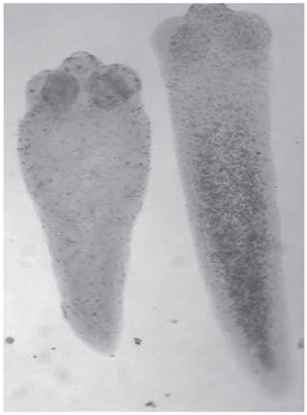
Infection locus: External surface

(iii) ***Species of parasite:*** Larva of *Cucullanus* sp. (Nematoda, Cucullanidae)

Larva of *Cucullanus* sp.

Infection locus: Gills

(iv) ***Species of parasite:*** Unidentified immature cestode



Immature cestodes

Infection locus: Gills

Remarks: The recorded signs and lesions of this host fish species were excessive mucous secretion, congestion, marbling appearance, pale gills and destruction of gill filaments in case of crustacean infestation; and pale enlarged liver with haemorrhages in case of nematode larvae infestation. Intestine was found inflamed in cases with immature cestode infestation. The total infestation rate was 40.8% and autumn displayed the highest seasonal prevalence. Crustacean parasites represented the highest prevalence (34.6%) followed by immature cestodes (6.1%) and nematode larvae (4.1%). The highest prevalence of crustacean parasites and nematode larvae were recorded in summer while the highest prevalence of immature cestodes was recorded in autumn (El-Lamie and Abdel-Mawla, 2012; Morales-Serna and Gómez, 2010).

(e) Host fish: *Marilyna meraukensis* and *M. darwinii*

Locality of host fish: Brackish waters in northern Australia.

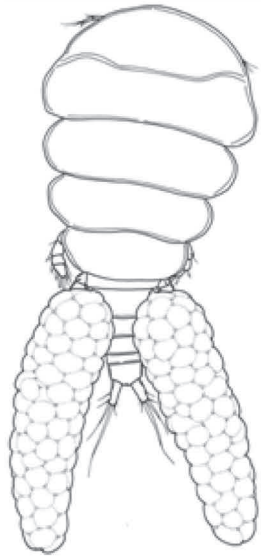
(i) ***Species of parasite:*** *Majalincola buthi* Tang & Kalman, 2008 (Copepoda, Ergasilidae)

Diagnosis of the parasite: The adult female of this new genus is characterized by the presence of four tagmata (antennary, neck, postantennary cephalothoracic region and trunk region); a five-segmented antennule; and a free exopod segment armed with two setae on its fifth leg (Tang and Kalman, 2008).

Image not available.
Infection locus: Gills.
Locality of host fish: Australian waters.

(ii) ***Species of parasite:*** *Taeniacanthus kiemae* Tang, 2011 (Copepoda, Taeniacanthidae).

Diagnosis of the parasite: This new species differs from its congeners by having the following combination of characters (in the adult female): (a) maxilla armed with a stout terminal process and two small elements; (b) multiple rows of spinules on the large pectinate process of the antenna; (c) an extremely long and thin maxilliped claw; (d) second exopodal segment of leg 1 with eight setae; (e) third exopodal segment of leg 3 with three spines and four setae; (f) third exopodal segment of leg 4 with three spines and two setae; and (g) each spine on the free exopodal segment of leg 5 with a subterminal flagellum (Tang, 2011).

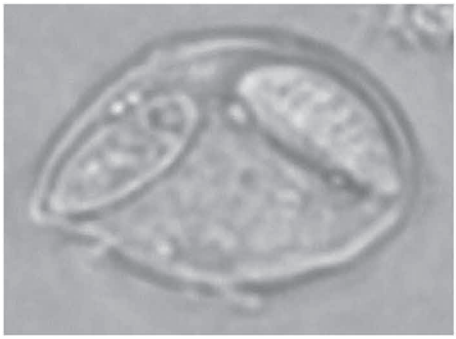


Taeniacanthus kiemae

Infection locus: Branchial cavity wall.

(iii) ***Species of parasite:*** *Enteromyxum leei (=Myxidium leei)* (Protozoa: Myxosporea).

Diagnosis of the parasite: It is histozoic species and forms small plasmodia that give rise to 2 spores each. The average size of fixed spores is 14.7 μm in length and 6.9 μm in width. Their shape is arcuate. They are elongated polar capsules (average size 3.2 × 7.4 μm, with 7 turns of the polar filament) open at one side of the spore.



Spore of *Enteromyxum leei*

Infection locus: Digestive tract.

Symptoms in host fish: Diseased fish exhibits characteristic severe emaciation including sunken eyes and bony ridges on the head. Mucous liquid in the digestive tract and a flimsy intestinal wall were evident.

Pathology: Proliferation and sloughing of the intestinal epithelia have been observed. As a result, the osmoregulatory and nutrition system may be impaired, causing the emaciation of a host.

Health hazard: Since this parasite is not infectious to human, it is harmless in food hygiene.

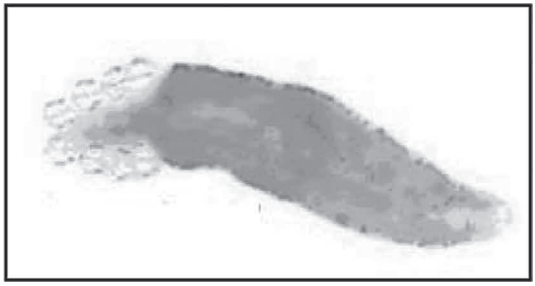
Remarks: Outbreaks of this disease usually occur in summer to late autumn and cease by the end of winter. This may be because the development of *E. leei* is suppressed by low water temperature (<15° C). There are no effective methods to treat this disease. It is recommended to remove infected fish before introduction of fish by detecting the parasite using the PCR (http://fishparasite.fs.a.u-tokyo.ac.jp/Enteromyxum-leei/Enteromyxum-leei-eng.html).

(f) Host fish: *Sphoeroides annulatus*

Locality of host: Sinaloa, Mexico.

(i) ***Species of parasite:*** *Heterobothrium ecuadori (= Tagia ecuadori)* (Monogenea, Diclidophoridae)

Diagnosis of the parasite: Body of this species is elongated, robust and tapering anteriorly. Isthmus is absent. Oesophagus is with diverticula. The intestine is bifurcated at the level of gonopore. Caeca are with lateral and median diverticula extending to the anterior margin of the heptor.

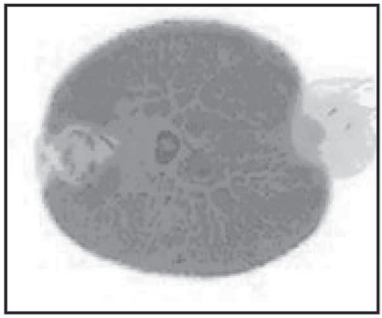


Heterobothrium ecuadori

Infection locus: Gills; it is feeding on the fish blood.

(ii) ***Species of parasite:*** *Neobenedenia melleni* (Monogenea, Capsalida)

Diagnosis of the parasite: The juvenile of this species has anterior attachment pads at the top, four pigmented eyes, two excretory vessels and gut in the middle. Further, it has the presence of a large and complex posterior attachment organ or haptor, which features tiny marginal hooks, two pairs of major hooks in the middle, and a valve or seal flap around the edge.



Neobenedenia melleni

Infection locus: Ectoparasite

Remarks: It is a pesky monogenean parasite on the skin and gills of tropical and subtropical fishes. It probably hails from the Caribbean, but will infect pretty much any warmwater marine fish with scales. It can be damaging because it has a direct life cycle (no intermediate host). So in dense host populations like aquariums and aquaculture pens, it multiplies rapidly. It mostly eats skin and mucus and as a result the fish suffers from salt and water imbalances and can die quickly or succumb to secondary infections.

(iii) ***Species of parasite:*** *Homalometron longisinosum* (Trematoda, Apocreadiidae)

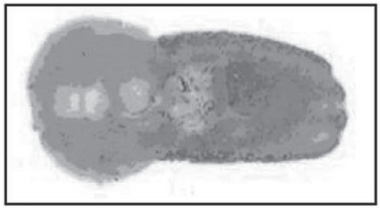
Diagnosis of the parasite: This species has the following characters. Extensive vitelline follicles, eye-spot pigment dispersed in forebody, I-shaped excretory vesicle, no cirrus-sac and genital pore opening immediately anterior to the ventral sucker (usually) or immediately posterior to it.

Homalometron longisinosum

Infection locus: Ectoparasite

(iv) ***Species of parasite:*** *Bianium plicitum* (Trematoda, Lepocreadiidae)

Diagnosis of the parasite: This parasitic worm is hermaphroditic and can produce both male and female germ cells. This species lives in very humid conditions.



Bianium plicitum

Infection locus: Ectoparasite

(v) ***Species of parasite:*** *Phyllodristomum mirandai* (Trematoda, Gorgoridae)

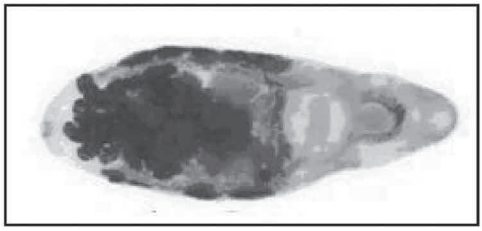
Diagnosis of the parasite: Unknown

Phyllodristomum mirandai

Infection locus: Ectoparasite

(vi) ***Species of parasite:*** *Lintonium vibex* (Trematoda, Fellodistomidae)

Diagnosis of the parasite: Body is plump with smooth tegument. Eye-spot pigment is absent. Ventral sucker is with transverse opening which is 60–69% (65%) of body width. Prepharynx is absent. Esophagus is long. There is an intestinal bifurcation near mid forebody. Caeca are blind, not reaching posterior end of body. Gonads are located in mid third of body. Testes are symmetrical, chiefly interracial. Cirrus sac is ovoid, containing bipartite spherical or ovoid seminal vesicle. Posterior segment is larger than anterior one. Cirrus is short. Ovary is weakly trilobed and is anterior to right testis.



Lintonium vibex

Infection locus: The worms were from the pharynx, attached to the wall around the entrance to the ventral pouch. This species is species-specific.

Remarks: *B. plicitum* and *H. ecuadori* were more likely to be present on fish in water within the temperature ranges of 21–25° C and 23–24.5° C, respectively. *Neobenedenia melleni* was also more likely to be present when other parasites were present (Fajer-Avila et al., 2004).

(vii) ***Species of parasite:*** *Kudoa dianae Dyková, Fajer & Fiala, 2002* (Protozoa: Myxosporea)

Diagnosis of the parasite: In apical view, the mature spores are quadrate with rounded edges. Four polar capsules are equalsized, pyriform, 2.0 µm in length and 1.5 µm in width. The two turns of the polar filament are not clearly seen in fresh spores, but are counted in electron micrographs. The average length of spores in lateral view is 5 µm and the width (as well as thickness) is 6 µm. Mature spores can reach lumen of the digestive tract directly by disruption of plasmodial wall or via macrophage transport to the oesophageal epithelium.

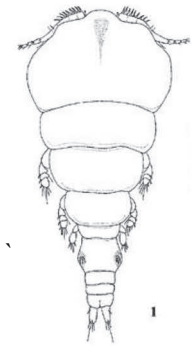
Kudoa dianae

Infection locus: Extramuscular sites, in the wall of oesophagus and on mesenteries.

Locality of host fish: Northwestern coast of Mexico (Dyková et al., 2002).

(viii) ***Species of parasite:*** *Acantholochus zairae* (Copepoda, Bomolochidae)

Diagnosis of the parasite: The females of this species can be distinguished from other *Acantholochus* species by the presence of one seta (instead of two) on the second endopodal segment of leg 2 and by the strong, large claw of the maxilla.

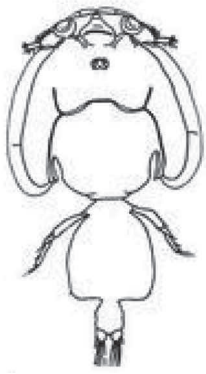


***Acantholochus* sp.**

Infection locus: Ectoparasite

(ix) ***Species of parasite:*** *Caligus serratus* (Copepoda, Caligidae)

Diagnosis of the parasite: This species has the following characters. (a) short abdomen (approximately 0.2 times as along as cephalothorax); (b) pointed posteromedial process on the first segment of the antenna; (c) sternal furca with bluntly pointed, diverging tines; and (d) leg 4 exopod with 3 unequal, distal spines (the shortest 0.2 times the length of the longest).



Caligus serratus

Infection locus: Ectoparsite

(x) ***Species of parasite:*** *Lepeophtheirus simplex* (Copepoda, Caligidae)

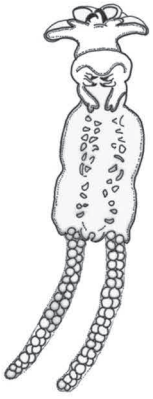
Diagnosis of the parasite: This species is distinguished from its congeners by the possession of (1) a maxillule with simple dentiform process; (2) a sternal furca with sharply pointed, curved tines; (3) a 2-segmented exopod of leg 3 with simple, slender spine on proximal segment; (4) a 3-segmented exopod of leg 4 with a long proximal, outer spine; and (5) the terminal claw of male antenna with a large, tridentate, medial protuberance.

***Lepeophtheirus* sp.**

Infection locus: Ectoparsite

(xi) ***Species of parasite:*** *Pseudochondracanthus diceraus* (Copepoda, Chondracanthidae)

Diagnosis of the parasite: It has an average length of 3 mm and average width of 1 mm. Females have large bodies with a pair of strong claw antennae capable to attach to the gill filaments, whose locking mechanism and feeding activities damage the gill tissue of the bulls-eye pufferfish.

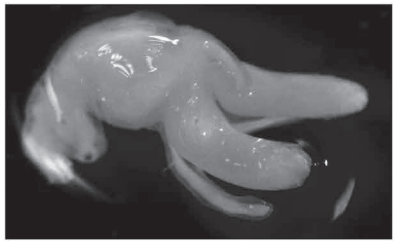


Pseudochondracanthus diceraus

Infection locus: Anterior and posterior sectors of the gill arch

(xii) ***Species of parasite:*** *Parabrachiella* sp. (Copepoda, Lernaeopodidae)

Diagnosis of the parasite: The morphology of the bulla of this species show s great variability within the lernopodids. It is produced by the frontal gland of the cephalothorax during the larval stage and, once inserted into the tissue of the host, it fuses with the second maxillae and becomes a permanent attachment organ which allows the lernaeopodid to obtain its food.



***Parabrachiella* sp.**

Infection locus: Ectoparasite

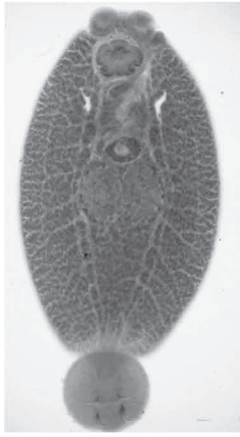
Remarks: The most common species of copepod parasites of this host species (*Sphoeroides annulatus*) were *L. simplex, P. diceraus,* and *C. serratus* (overall prevalence, 59, 53, and 35%, respectively), which significantly varied in prevalence and mean intensity between sampling months. A seasonal pattern was only observed for *L. simplex*, with higher infection levels in the warmest month than in the coldest month. Statistical analyses indicated that the intensity of *L. simplex* was positively correlated with water temperature. There were no significant differences in prevalence and intensity of infection among female and male hosts. A significant positive association was detected between number of individuals and water temperature and between host size and both species richness and number of individuals. *L. simplex* posed a threat for the culture of *S. annulatus* (Morales-Serna et al., 2011; Ho et al., 2001).

Loclaity of host fish: Tank reared

(xiii) ***Species of parasite:*** *Lepeophtheirus simplex* (Cyclopoida, Family: Caligidae)

Diagnosis of the parasite: Given already
Infection locus: Ectoparasite

(xiv) ***Species of parasite:*** *Neobenedenia* sp. (Monogenea, Capsalidae)
Diagnosis of the parasite: This unidentified species is distinguished by the presence of two attachment organs located anteriorly and one larger posterior attachment organ called the haptor (principal anchoring organ). A marginal valve on the haptor allows the organ to create suction on the host.



***Neobenedenia* sp.**

Infection locus: External surfaces of the host
Remarks: Fish experimentally infected with monogeneans or sea lice were exposed to freshwater for 10 to 60 min and 15 to 90 min, respectively. All sea lice nauplii and copepodids were found killed by freshwater dips at 2.5 and 14 min, respectively. For pre-adult and adult sea lice, 30 and 60 min of freshwater exposure significantly reduced up to 95 and 99%, respectively. Immature and adult populations of monogeneans showed a significant reduction (95%) at 20 min of exposure. These results suggest that freshwater baths may be an efficient alternative to control mixed ectoparasite infections on bullseye pufferfish reared in tanks (Fajer-Avila et al., 2008).
Locality of host fish: Mexico

(xv) ***Species of parasite:*** *Acantholochus zairae* (Copepoda, Bomolochidae)
Diagnosis of the parasite: Given already
Infection locus: Ectoparasite

(xvi) ***Species of parasite:*** *Pseudochondracanthus diceraus* (Copepoda, Chondracanthidae)
Diagnosis of the parasite: Given already
Infection locus: Gills.
Remarks: The damaged gill tissue of the host fish was caused by the large and strong antennae of *P. diceraus* that is modified as a claw to attach to the host gills. This study also suggests that a high prevalence and intensity of this parasitic copepod could become a potential health risk to the culture of this pufferfish (Josefina et al., 2011).

(g) Host fish: *Sphoeroides nephelus*
Locality of host fish: Mississippi Gulf coast.
(i) ***Species of parasite:*** *Bucephalus* sp. (Trematoda, Bucephalidae)
Diagnosis of the parasite: The cercaria of this unidentified species has a forked tail (furcae) which is horn-like. Tentacles are found associated with the anterior sucker. All the genus members have their mouth in the middle of the body.

***Bucephalus* sp.**

Infection locus: Reproductive tissues.
(ii) ***Species of parasite:*** *Prosorhynchus* sp. (Trematoda, Bucephalidae)
Diagnosis of the parasite: Given already

***Prosorhynchus* sp.**

Infection locus: Intestine (http://www.sms.si.edu/irlspec/Sphoeroides_nephelus.htm).

(h) Host fish: *Sphoeroides testudineus*

Locality of host: Mexico

Species of parasite: *Heterobothrium lamothei* Vidal-Martinez & Mendoza-Franco, 2008 (Monogenea, Diclidophoridae)

Diagnosis of the parasite: In wet mount preparation, the adult worms have an elongated body with anterior pointed and posterior broad ends. The adult worm measures 1.15–1.76 mm in length and 0.30–0.42 mm in width. There are two buccal organs situated anteriorly around the mouth opening. The opisthohaptor is subdivided into four pairs of clamps but has no isthmus separating it from the body proper. The present *Heterobothrium* species differs from all other described species in the genus, by its lower dimensions of the worm measurements and the presence of a copulatory organ armed with 12–15 genital hooks. Furthermore, it is easily distinguished from *Heterobothrium tetrodonis and H. okamotoi* by the absence of a distinct isthmus, and resembles *H. lamothei* described from the gills of *Sphoeroides testodineus* in Mexico in its general appearance and the presence of rectangular haptor with the fourth pair of clamps smaller than the previous ones (Morsy et al., 2012).

Heterobothrium lamothei

Infection locus: Gills (Vidal-Martinez and Mendoza-Franco, 2008).

(i) Host fish: *Takifugu pardalis*

Locality of host fish: Seto Inland Sea, western Japan

Species of parasite: *Pseudocaligus fugu (= Caligus fugu)* (Copepoda, Caligidae)

Diagnosis of the parasite (female): Female genital complex and abdomen are combined nearly twice as long as cephalothorax. Body length is 3.0–3.7 mm. Genital complex is large, and it lacks distinct postero-lateral lobes. Abdomen is 2-segmented and the first segment is just over twice as long as second. Maxilliped is with large tapering process proximally on medial margin. Exopod of leg 1 has seta at inner distal angle as long as longest distal spine. Outer margin of second endopodal segment of leg 2 is densely ornamented with fine spinules. Second exopodal segment of leg 4 is with short outer margin spine and 3 long distal margin spines, increasing in length slightly towards terminal spine.

Female adult of *Pseudocaligus fugu*

Infection locus: Body surface

Remarks: This parasite has been reported to accumulate TTX which could have been acquired by feeding on the toxic mucus and skin tissues of host pufferfish (Ikedaa, 2006).

(j) Host fish: Tiger puffer, ***Takifugu rubripes*** (Non-toxic, farmed)

Locality of host fish: Japan

(i) ***Species of parasite:*** *Pseudocaligus fugu* (Copepoda, Caligidae)

Diagnosis of the parasite: Given already

Infection locus: Body surface

Remarks: It causes commercial loss of cultured *Takifugu rubripes* in Japan.

(ii) ***Species of parasite:*** *Myxidium fugu* (= *Enteromyxum fugu*) and *Myxidium* sp. (Protozoa:Myxosporea)

Diagnosis of the parasite: Spores of *M. fugu* n. sp. having 2 club-shaped polar capsules are bean-shaped, 14.0 µm in length and 9.0 µm in width. Plasmodia of this species are located on the epithelium of intestine.

Spores of *Myxidium* sp.

Infection locus: Intestinal epithelium of only *Takifugu rubripes* (species-specific)

Tiger puffer showing myxosporean emaciation disease

Symptoms in host: Emaciation disease

Tiger puffer showing myxosporean emaciation disease

Remarks: *Myxidium fugu* attached to the surface of the epithelium, caused no noticeable effects on the host tissue. *Myxidium* sp., which proliferated in the epithelium, induced severe pathological changes including accumulation of cell debris between the epithelium and lamina propria and resultant detachment of the epithelium. It is evident histologically that, unlike epicellular *M. fugu*, histozoic *Myxidium* sp. is highly pathogenic to host fish. This strongly suggests that the latter is the causative agents of the emaciation disease (Tun et al., 2002).

(k) Host fish: *Takifugu* spp.

Locality of host: Japan.

Species of parasite: *Pseudocaligus fugu* (Copepoda, Caligidae)

Diagnosis of the parasite: Given already

Infection locus: Body surface.

Remarks: This parasite has been reported to harbor TTX producing bacterial colonies of *Roseobacte*r sp. Further, this parasite is host specific to *Takifugu niphobles, T. pardalis, T. poecilonotus,* and *T. rubripes* (Maran et al., 2009; Maran, http://www.envismadrasuniv.org/nl20123-tetrodotoxin-producing.htm; Maran, 2012).

(l) Host fish: *Tetractenos hamiltoni*

Species of parasite: *Naobranchia variabilis* (Copepoda, Lernaeopodidae)

Diagnosis of the parasite (female): The corrugated lobes on the head of this species females are interpreted as novel structures involved with temporary attachment during feeding. Cephalothorax is long, cylindrical, tapering gradually towards rounded frontal margin. Head is small, bearing oral cone and mouthparts anteroventrally plus pair of corrugated lobes Junction between base of cephalothorax and trunk is marked by a collar-like swelling. Trunk is dorsoventrally flattened, with rounded corners. Egg sacs occupying the entire lateral margins of trunk.

***Naobranchia* sp.**

Infection locus: Gill arches

Remarks: This parasite has been implicated in the damage of up to 3.4% (avg. 0.72%) of total gill filament length and 8.6% (avg. 2.1%) of gill filaments of the host species (Shao et al., 2014; Roubal, 1999).

m) Host fish: *Tetraodon lineatus*

Locality of host: River Nile at Qena Governorate, South Valley, Egypt

Species of parasite: *Heterobothrium lamothei* Vidal-Martinez & Mendoza-Franco, 2008

Diagnosis of the parasite: Given already

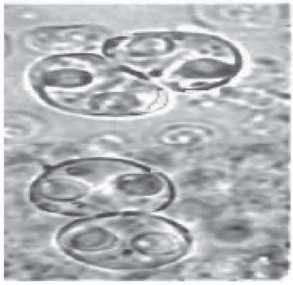
Infection locus: Gill parasite infecting the gills and wall of the bronchial cavity (Morsy et al., 2012).

(n) Host fish: *Tetraodon palembangensis*

Locality of host: Sumatra and, Thailand (Southeast Asla).

Species of parasite: *Sinuolinea tetraodoni* El-Matbouli & Hoffmann, 1994 (Protozoa: Myxosporea)

Diagnosis of the parasite (Spore characteristics): In the sutural plane, spores appeared ellipsoid in shape but in plane perpendicular to the suture, they appeared triangular. The suture line is quite sinuate. There are two spherical polar capsules near the narrow end of the spore, opening near the suture but in opposite directions. The sporoplasm has two nuclei.



Mature spores of *Sinuolinea tetraodoni*

Internal/external: Internal

Infection site: Lumen of the kidney tubules and renal corpuscles

Clinical signs: Dilatation of glomerular capillaries and Bowman's space (El-Matbouli and Hoffmann, 1994).

Diagnosis and treatment: The actual diagnosis and treatment of pufferfish may become tricky. Misdiagnosis may often complicate already stressful tank conditions leading to zero effect on the disease or illness. Further, pufferfish are scaleless, which means certain medications may be worse than the original disease.

Internal parasites: Prevention and treatment: Generally, most puffers carry a small load of parasites. However, when the fish is ill or under stress, the parasites may reproduce to levels that actually harm their host, causing the fish to lose weight, become more susceptible to illness and eventually stop eating and die.

Origin of Internal Parasites: Many pufferfish species, are wild-caught. In the wild, they are exposed to many parasites. The stress of the capture and subsequent transport of fish may lower the immune system of

even the strongest fish, making them more susceptible to the ravages of parasites. When a newly purchased fish is brought to home, it should be quarantined. Treating a few fish in a quarantine tank is much easier, safer and more cost effective than trying to treat the entire display. So, quarantine time is the right time to treat for internal parasites as it prevents infection of the entire display.

Spotting the signs: Most fish already carry a parasite load without showing any external signs. However, if the parasites start to multiply, the following are some of the signs.

- Wasting away – often gradually;
- Frantic for food (more than usual of course);
- Red or white worms being purged from the anus; and
- Loss of appetite.

It is always advisable to begin the treatment immediately after noticing the signs. Such an exercise would lead to higher chances of a full recovery. If the parasite load progresses to a point that the fish is no longer eating, then it becomes more difficult to get the proper medications to treat for the parasites.

Treatment and Prevention: If the fish is carrying internal parasites and is still eating willingly, it is better to feed such fish with a commercially prepared antiparasitic food such as Pepto or Discomed. De-worming may also be initiated in such cases.

De-worming: It is also better to make the "de-worming" recipe and soak the fish's favorite food in it. This method has yielded better results for most puffers, as deworming treatments are often unpalatable. The food mixed in with the medications should be something that will hold together well when wet and is a tempting food to the fish. Pelleted foods and frozen foods thawed in the medication mixture may give better results. If the fish is not eating, the tank may be treated with a prolonged treatment. If the above exercise fails, then the last resort is tube feeding the puffers.

Caution: If the fish is carrying a very large parasitic load, the levels of medication should be reduced and do several small treatments. The death of a large amount of internal parasites can be very traumatic for the fish. In

situations like these, a longer quarantine period and multiple, lower, dosages are a good precautionary measure.

7.8 MEDICATIONS TO DEWORM THE PUFFERS

Metronidazole (a freshwater fish medication) and Levamisole Hydrochloride (a livestock dewormer): In the USA, Metronidazole and Levamisole are commonly sold by most fish retailers. Again, it is better to find these medications in the powder form that is soluble in water. If the fish is eating, a small container or cup is taken and about a teaspoon of tank water is added. One measure of the Metronidazole powder is added using the measuring scoop, and one measure of the Levamisole powder. The water and medication mix are stirred well until most of the medication is dissolved, and the food of choice is added. The food is then allowed to soak for a few minutes (longer is better) and the normal amount is fed to the fish. If the fish is not eating, 1/4 teaspoon of the Levamisole powder per 10 gallons of quarantine tank water is an ideal initial dosage to treat a fish which is no longer eating. It is believed that Levamisole remains in the water longer at a neutral or less pH.

Praziquantel: Praziquantel (brand name, Droncit in US) is another alternative for de-worming. This medication is best provided orally.

Fenbendazole: Fenbedazole is another medication and the following dosages are recommended for de-worming applications:

Oral dosage: 11 mg/lb of body weight for 3 days or 23 mg/lb once a week for 2 weeks or by tube feeding 23 mg/lb.

Warning: All the above medications are harmful to invertebrates, and will decimate micro-fauna. Hence, a quarantine tank for treatment is strongly recommended. It is advisable to de-worm the pufferfish every 4 months as a preventative http://www.thepufferforum.com/forum/library/hospital/internal-parasites-prevention-and-treatment/).

Freshwater treatment of ectoparasites of bullseye pufferfish: If used properly, freshwater baths constitute an efficient alternative to control the mixed ectoparasite infections of pufferfish reared in tanks (Fajer-Avila et al., 2008).

KEYWORDS

- **cotton wool disease**
- **disease indications**
- **fin rot disease**
- **freshwater white spot**
- **marine ich**
- **nutritional deficiencies**
- **stress line**
- **viral diseases**

CHAPTER 8

NUTRITIONAL VALUES OF PUFFERFISH

CONTENTS

8.1 INTRODUCTION

Pufferfish species have been shown to become non-toxic when their diets are TTX-free and when they are grown in an environment where the organisms which bear TTX are not present in the food web (Arakawa et al., 2010). Of the several thousands of tons of Fugu that are consumed each year in Japan, considerable quantities come from farms, where the fish are not allowed to incorporate the TTX toxin through their diets. The farmed pufferfishes are fed fresh fish until they reach market size. Aquaculture of several species of Fugu is practiced in Japan as full-scale farming by artificial insemination.

The pufferfish is a popular delicacy in several countries including China and Japan. In Japan, the pufferfish is also one of the most expensive foods. Despite the high price, the fish is increasingly popular in this country. Cooks are required to take a first taste before serving to their clients. Even if the taster okays, the dish can be brought to the table only after 10 minutes. Every cook has to follow rigorous cooking methods. Only by following strict procedures, the dish is considered safe to eat. To qualify for a license, the cooks willing to serve pufferfish should attend a training class and pass both theoretical and practical exams.

Usually the puffer is cut open by its belly, to prevent the toxin from polluting the flesh. Then the internal organs should be taken out. Finally, the fish should hang upside down to drain the blood. The fish should also be braised for at least 40 minutes. Although the pufferfish are used on every family's table, it is quite a luxury to treat the honored guests with a puffer especially at feasts (http://www.whatsonxiamen.com/wine_msg.php?titleid=1064).

According to Chinese, the nutritional importance of these fish is as follows:

- "No food is tasty after eating the puffer."
- "The man that eats fugu is stupid; the man that does not eat fugu is also stupid." (Cohen and Law-Yone, http://www.imagequest3d.com/pages/general/news/puffertoxin/).

Edible Parts of Pufferfish Species

Species	Muscle	Skin	Male gonad
Takifugu niphobles	Yes	–	–
T. poecilonotus	Yes	–	–
T. pardalis	Yes	–	–
T. snyderi	Yes	–	Yes
T. vermicularis	Yes	–	–
T. porphyreus	Yes	–	Yes
T. obscurus	Yes	–	Yes
T. chrysops	Yes	–	Yes
T. rubripes	Yes	Yes	Yes
T. chinensis	Yes	Yes	Yes
T. xanthopterus	Yes	Yes	Yes
T. stictonotus	Yes	–	Yes
Lagocephalus inermis	Yes	Yes	Yes
L. wheeleri Yes	Yes	Yes	
L. gloveri	Yes	Yes	Yes
Sphoeroides pachygaster	Yes	Yes	Yes
T. flavidus	Yes	–	–

Yes, Edible; –, non-edible.

Source: Noguchi and Arakawa (2008).

In is important to learn that out of 197 species of pufferfish recorded so far in the world seas, nutritional assessment has been made only for about 5% of the species (i.e., 11 species) viz. Chelonodon patoca, Lagocephalus inermis, Lagocephalus lunaris, Lagocephalus sceleratus.Lagocephalus spadiceus, Sphaeoroides oblongus, Takifugu flavidus, Takifugu obscurus, Takifugu rubripes, Tetraodon cutcutia and Xenopterus naritus. The edible organs of the common pufferfish species are given in the following table.

Nutritional Facts of *Lagocephalus inermis*

Proximate composition	
Protein:	8.92%
Carbohydrate:	1.87%
Fat:	11.98%
Ash:	86.05%
Moisture:	1.27%

Polyunsaturated fatty acids (PUFA)	
n–3:	31.19%
n–6:	7.29 %

Source: Eswar et al. (2014).

Nutritional Facts of *Lagocephalus lunaris*

Proximate composition	
Protein:	9.22 %
Carbohydrate:	1.96 %
Fat:	11.25 %
Ash:	80.32 %
Moisture:	0.96 %

Polyunsaturated fatty acids (PUFA)	
n–3:	31.17 %
n–6:	7.26 %

Source: Eswar et al. (2014).

Nutritional Facts of *Lagocephalus lunaris*

Seasonal percentage composition of the biochemical constituents of *L. lunaris.*

Month	Moisture	Protein	Carbohydrate	Lipid	Ash
January	77.50	10.40	1.37	8.34	2.40
February	77.65	10.65	2.80	7.00	1.90
March	78.32	8.50	1.70	10.50	0.98
April	67.94	15.31	3.56	10.67	2.54
May	No data				
June	64.99	15.14	3.40	12.62	3.86
July	65.89	13.93	2.42	15.62	2.15
August	80.54	13.05	1.21	3.80	1.41
September	70.63	14.70	1.82	12.00	0.85
October	68.15	14.26	3.51	9.56	4.53
November	69.25	13.73	2.65	8.71	5.66
December	77.58	12.93	1.08	3.99	4.44

Source: Rao and Sirisha (2013).

Nutritional Facts of *Lagocephalus lunaris*

Biochemical composition of fresh and dried puffer fish

Parameters	Fresh fish	Dried fish
Moisture (%)	78	17.5
Protein (%)	18.2	43
Lipid (%)	9.0	2.34
Ash (%)	0.64	9.6
Carbohydrate (%)	7	–
Potassium (mg/100 g)	569	610
Sodium (mg/100 g)	256	266
Calcium (mg/100 g)	2541	2560
Magnesium (mg/100 g)	98	112
Iron (mg/100 g)	39	40
Zinc (mg/100 g)	26	29
Copper (mg/100 g)	1.8	2.0

Parameters	Fresh fish	Dried fish
Phosphorus (mg/100 g)	14.2	19.4
TMA-N (mg/100 g)	6.8	11.53
TVB-N (mg/100 g)	13.48	28.11
FFA (%-as oleic acid)	2.3	6.99

Source: Santa et al. (2015).

Nutritional Facts of *Lagochepalus lunaris*

Chemical composition banana puffer fish

	Meat		Skin	
Chemical composition	**Wb (%)**	**Db (%)**	**Wb (%)**	**Db (%)**
Moisture	79.39	–	74.00	–
Ash	0.62	3.01	1.81	6.96
Fat	0.15	0.73	0.49	1.88
Protein	18.92	91.80	23.08	88.78
Carbohydrates	0.92	4.46	0.61	2.35

Wb, Wet weight; Db, Dry weight.

Mineral and heavy metal contents of banana pufferfish

	Meat	Skin
Mineral macro (ppm)		
Ca	146.96	25.21
Mg	216.62	126.69
Na	20.61	145.86
K	1469.34	495.32
Mineral micro (ppm)		
Fe	6.85	22.07
Zn	73.63	41.80
Cu	0.43	0.25
Heavy metals (ppm)		
Pb	0.51	0.05
Cd	0.02	0.02

Source: Nurjanah et al. (2015).

Nutritional Facts of *Lagocephalus sceleratus*

Proximate composition	**(%)**
Moisture:	78.47
Fat:	0.33
Protein:	21.62
Ash:	1.63
Total saturated fatty acid:	24.22–29.46%
Monounsaturated fatty acid:	7.87–13.94%
Docosahexaenoic acid (DHA):	24.17–32.65%
Eicosapentaenoic acid (EPA) + DHA (edible muscle):	80.93 mg/100 g

Source: Aydın et al. (2013).

Fatty Acid Composition of *L. sceleratus* Muscle

Fatty acids		**(%)**
C 12:0	Lauric acid	0.40
C 14:0	Myristic acid	1.15
C 15:0	Pentadecanoic acid	0.85
C 16:0	Palmitic acid	20.74
C 17:0	Margaric acid	0.51
C 18:0	Stearic acid	16.27
C 20:0	Arachidic acid	0.90
C 14:1	Miristoleic acid	0.74
C 16:1	Palmitoleic acid	1.09
C 18:1	Oleic acid	14.52
C 20:1	Eicosanoic acid	0.73
C 22:1	Erusic acid	1.52
C 16:2	Hexadecadienoic acid	1.42
C 18:2	Linoleic acid	7.08
C 22:2	Docosadienoic acid	1.86
C 18:3	Linolenic acid	3.14
C 20:4	Arachidonic acid	0.40
C 20:5	Eicosapentaenoic acid (EPA)	6.08
C 22:5	ω6 cis-4.7.10.13.16-Docosapentaenoic acid	1.34
C 22:5	ω3 cis-7.10.13.16.19-Docosapentaenoic acid	3.01

Fatty acids		(%)
C 22:6	Docosahexaenoic acid (DHA)	15.68
	Undefined	0.57
	Total	100
ω3 fatty acids (%)		
C 18:3	Lauric acid	3.14
C 20:5	Eicosapentaenoic acid (EPA)	6.08
C 22:5	ω3 cis-7.10.13.16.19-Docosapentaenoic acid	3.01
C 22:6	Docosahexaenoic acid (DHA)	15.68
	Total	27.91

Source: Nurullahoğlu and Ulusoy (2013).

The nutritional facts of the different species of pufferfish (both wild and farmed) are given below.

8.2 LAGOCEPHALUS SCELERATUS (PROXIMATE COMPOSITION AND SEASONAL CHANGES)

The proximate composition and fatty acid profile and seasonal changes of *Lagocephalus sceleratus* from the Mediterranean Sea have been studied. Significant variations in the proximate composition were observed during the months of the study. The highest moisture, fat, protein, and ash contents of this species were found to be 78.47, 0.33, 21.62, and 1.63%, respectively. Total saturated and monounsaturated fatty acid values were similar throughout the year. However, individual variations of these parameters were 24.22–29.46 and 7.87–13.94%, respectively. Significant variations were noted in total polyunsaturated fatty acids as well as significant differences between sexes ($p < 0.05$) with some exceptions. The major fatty acid was found to be docosahexaenoic acid (DHA) which was between 24.17 and 32.65%. Due to the low fat content of this species, the highest eicosapentaenoic acid (EPA) + DHA values found to be 80.93 mg/100 g of edible muscle. These results indicate that this species pos-

sesses high nutritional properties in terms of its protein content and fatty acid values (Tufanb et al., 2013). Juveniles of *Lagocephalus sceleratus* as food item:

As previously stated, the different internal organs of *L. sceleratus* and even its muscles and skin may contain lethal doses of TTX. Nevertheless, several studies have revealed that younger specimens (Total Length < 16 cm) contain low amount of TTX or even no toxin at all (Sabrah et al., 2006). *L. sceleratus* individuals range from not toxic at all to strongly toxic and this difference is dictated by size, with smaller individuals being less toxic than large ones and with toxicity increasing with age. Further studies are therefore needed in the Mediterranean in order to determine the exact size range at which toxicity becomes lethal in the various organs. If a certain range can be identified as nontoxic, then several initiatives for commercial use can be foreseen. In this way, a capture based aquaculture industry and/or a fishery can be established where juveniles are harvested and commercialized.

Nutritional Facts of *Lagocephalus spadiceus*

Seasonal percentage composition of the biochemical constituents (common values for both male and female) of L. spadiceus.

Month	Moisture	Protein	Carbohydrate	Lipid	Ash
January	85.17	9.23	0.94	3.77	0.89
February	75.18	20.72	1.15	1.77	1.20
March	76.78	17.00	1.13	3.00	1.70
April	77.36	16.00	1.79	1.73	2.50
May	No data				
June	70.42	19.43	2.42	4.62	3.13
July	80.51	15.00	0.88	2.31	1.31
August	81.95	11.99	1.38	3.28	1.41
September	71.85	22.74	1.52	3.06	0.85
October	82.99	12.25	1.27	2.64	0.86
November	78.41	15.00	2.57	2.70	1.33
December	82.15	12.22	1.42	2.94	1.28

Source: Rao and Sirisha (2013).

Nutritional Facts of *Fugu flavidus* (=*Takifugu flavidus*) (farmed)

Proximate composition	
Crude protein:	17.8 g/100 g
Crude fat:	0.73 g/100 g
Minerals:	
K:	287 mg/100 g
Fe:	1.52 mg/100 g
Total amino acid (TAA): 51.7 g/100 g	

Source: Tao et al. (2012).

Nutritional facts of *Takifugu obscurus* (farmed)

Proximate composition (g/100 g, wet wt.)

	Moisture	**Crude Protein**	**Crude Fat**	**Ash**
Meat	79.73	18.44	1.31	1.42
Testes	79.53	17.15	1.82	2.22
Liver	29.81	3.89	63.86	0.64

Amino acids composition (%, dry wt.)

	Meat	**Testis**	**Liver**
Asp*	5.92	4.39	0.42
Lys*	7.79	7.19	0.42
Thr*	3.78	3.01	0.27
His	1.99	1.17	0.15
Ser	3.61	3.14	0.30
Arg**	5.64	8.63	0.39
Glu**	11.97	5.99	0.69
Pro	3.69	2.92	0.29
Gly**	5.38	5.92	0.52
Trp*	0.54	1.06	0.14
	Meat	**Testis**	**Liver**
Ala**	4.86	4.27	0.35
Cys	1.82	1.19	0.15
Val*	4.12	3.05	0.30
Met*	3.24	2.07	0.21
Ile*	3.48	2.20	0.18

	Meat	Testis	Liver	
Leu*	6.80	4.35	0.45	
Tyrd	2.74	1.75	0.20	
Phe*	2.76	1.99	0.23	
TAA	80.08	63.33	5.66	
EAA	32.51	24.91	2.21	
UAA	47.57	38.42	3.45	
NEAA	33.72	29.21	2.36	
TEAA/TAA	40.60	39.33	39.05	
TEAA/TNEAA	68.34	62.21	64.06	
TUAA/TAA	42.1	1 46	0.12	41.76

TAA: total amino acids; * TEAA: total essential amino acids; TNEAA: total nonessential amino acids;** TUAA: total umami amino acids.

Mineral contents (mg/100 g, dry wt%)

Mineral	Meat	Testes	Liver
K	1462.39	1534.16	102.10
Na	720.81	862.04	89.87
P	302.26	466.50	32.03
Mg	134.79	75.44	8.76
Ca	33.00	16.63	6.37
Fe*	2.88	6.60	4.94
Zn*	7.06	11.88	3.68
Cu*	0.22	0.24	0.51
Se*	0.12	0.12	0.001
K/Na	1.61	1.78	1.14
Ca/P	0.11	0.04	0.20

Vitamins and minerals (per 80 g)

Vitamins	
A (RE)	5.6 μg
D	4.8 μg
E(AT)	0.48 mg
B1	0.03 mg

Vitamins	
B2	0.14 mg
Niacin	5.6 mg
B6	0.4 mg
B12	2.4 µg
Folate	2.4 µg
Pantothenic acid	0.18 mg
Minerals	
Na	66.4 mg
K	376 mg
Ca	4 mg
Mg	19.2 mg
P	208 mg
Fe	0.16 mg
Zn	1.2 mg
Cu	0.02 mg

RE: Retinol Equivalents; AT: Alpha Tocopherol); *, Microelements.

Source: Li et al. (2014).

Nutritional facts *Fugu obscurus* (=*Takifugu obscurus*) (farmed)

Proximate composition	
Crude protein:	17.8 g/100 g
Crude fat:	0.73 g/100 g
Minerals	
K:	287 mg/100 g
Fe:	1.52 mg/100 g
Total amino acid (TAA):	51.7 g/100 g

Source: Li et al. (2014).

Nutritional facts of *Takifugu obscurus*

Nutritional aspects	80 g
Proximate composition	
Protein	15.12 g

Fat	0.32 g
Carbohydrate	0 g
Vitamins	
A (Retinol equivalent)	2.4 µg
D	3.2 µg
E (alpha tocopherol)	0.64 mg
B1	0.05 mg
B2	0.17 mg
Niacin	4.72 mg
B6	0.36 mg
B12	1.52 µg
Folate	2.4 µg
Pantothenic acid	0.29 mg
Minerals	
Sodium	80 mg
Potassium	344 mg
Calcium	4.8 mg
Magnesium	20 mg
Phosphorus	200 mg
Iron	0.16 mg
Zinc	0.72 mg
Copper	0.02 mg
Manganese	0.01 mg

Source: http://slism.com/calorie/110236.

Nutritional Facts of *Takifugu rubripes* (per 80 g)

Proximate composition	
Protein	15.44 g
Fat	0.24 g
Carbohydrate	0.16 g
Vitamins	
A (Retinol equivalent)	5.6µg
D	4.8 µg
E (alpha tocopherol)	0.48 mg

B1	0.03 mg
B2	0.14 mg
Niaci-	5.6mg
B6	0.4mg
B12	2.4 µg
Folate	2.4 µg
Pantothenic acid	0.18 mg
Minerals	
Sodium	66.4 mg
Potassium	376 mg
Calcium	4 mg
Magnesium	19.2 mg
Phosphoru	208 mg
Iron	0.16 mg
Zinc	1.2 mg
Copper	0.02 mg

Source: http://slism.com/calorie/110236/.

Nutritional Facts of *Fugu rubripes* (= *Takifugu rubripes*) (farmed)

Proximate composition	
Crude protein:	18.9 g/100 g
Crude fat:	0.83 g/100 g
Minerals	
K:	402 mg/100 g
Fe:	2.11 mg/100 g
Total amino acid (TAA):	62.9 g/100 g

Source: Tao et al. (2012).

Nutritional Facts of *Fugu rubripes* (= *Takifugu rubripes*) (farmed)

Vitamins and minerals (per 80 g)	
Vitamins	
A (RE)	2.4 µg
D	3.2 µg

E(AT)	0.64 mg
B1	0.05 mg
B2	0.17 mg
Niacin	4.72 mg
B6	0.36 mg
B12	1.52 μg
Folate	2.4 μg
Pantothenic acid	0.29 mg
Minerals	
Na	80 mg
K	344 mg
Ca	4.8 mg
Mg	20 mg
P	200 mg
Fe	0.16 mg
Zn	0.72 mg
Cu	0.02 mg
Mn	0.01 mg

RE: Retinol Equivalents; AT: Alpha Tocopherol.

Source: Li et al. (2014)

Nutritional Facts of *Tetraodon cutcutia*

Moisture, ash, oil and protein contents of the different parts

Part	Moisture (gm%)	Ash (gm%)	Oil (gm%)	Protein (gm%)
Dorsal	30.94	9.1	35.6	23.39
Ventral (including liver)	19.2	8.19	48.8	23.45
Tail	53.63	9.25	21.25	15.62
Head	51 4.	1 24	.83 19	.23

Polysaccharides and free sugar

Part	Polysaccharides (gm%)	Free Sugar (gm%)
Dorsa	0.051	0.072
Ventral (including liver)	0.042	0.0625
Tail	0.0675	0.077
Head	0.048	0.0645

Mineral contents

Part	Calcium (mg%)	Phosphorous (mg%)	Iron (mg%)
Dorsal	40.5	52.5	46.5
Ventral (including liver)	14.0	21.0	32.0
Tail	39.5	47.5	48.5
Head	166.5	178.5	101.5

Source: Uddin et al. (2012).

Nutritional Facts of *Xenopterus naritus*

Proximate composition of the muscle	(% of dry weight)
Moisture (% ww):	79.97
Crude protein (% dw):	88.22
Crude fat (% dw):	0.47
Crude fibre (% dw:	0.25
Ash (% dw):	5.8

Source: Azman et al. (2015).

Nutritional Facts of *Chelonodon patoca, Sphaeroides oblongus, Lagocephalus lunaris* and *Lagocephalus inermis*

Lipids: 40.1–48.8% (an amount similar to cod liver lipid content – 39.5–55%)
Neutral lipids: >80%
Triglycerides: 277–674 mg/g
Cholesterol: 0.6–3.1 mg/g
Fatty acids (mostly saturates and monosaturates)
EPA & DHA: 7–12%

Source: Hazra et al. (1998).

These results suggest that the puffer livers are qualitatively and quantitatively comparable to other commercially important marine fish oils. Further, these livers may be a potential source for the commercial utilization as an unconventional, cheap and easily available source.

Nutritional facts of Korean Japanese Puffer Fish (Serving Size 100 g)

Total fat:	0.98 g
Saturated fat:	0.227 g
Polyunsaturated fat:	0.275 g
Monounsaturated fat:	0.219 g
Cholesterol:	69 mg
Sodium:	81 mg
Potassium:	409 mg
Total carbohydrates:	0 g
Dietary fiber:	0 g
Sugars:	0 g
Protein:	18.79 g
Vitamin A:	3%
Vitamin C:	0%
Calcium:	2%
Iron:	5%

Source: Fatsecret (http://www.fatsecret.com/calories-nutrition/generic/korean-japanese-puffer-fish).

KEYWORDS

- **amino acids**
- **edible parts of pufferfish**
- **lipids**
- **nutritional values**
- **polyunsaturated fatty acids**
- **proximate composition**
- **vitamins and minerals**

CHAPTER 9

PHARMACEUTICAL VALUES OF PUFFERFISH TOXINS

CONTENTS

9.1 INTRODUCTION

The pufferfish toxin, TTX has been found to be an important tool in modern neurological research. TTX has been found to be useful in the treatment of pain from such diverse problems as migraines, neuralgia, arthritis, rheumatism, and heroin withdrawal (Santhanam, 1990a; Nader et al., 2012). The viscera of pufferfish produces the valuable TTX and this toxin may serve as a potential anaesthetic, a promising neuropathic pain drug, a formulation to treat heroin addiction and a cancer cell suppressor (Kohane et al., 2003; http://www.practicalfishkeeping.co.uk/content.php?sid=469).

9.2 PHARMACEUTICAL VALUES OF TTX

As a sodium channel blocker, the TTX can play a very significant role in neurophysiology. The results relating to the evaluation of the analgesic activity of TTX for cancer patients have shown that the TTX can be used

as an effective pain reliever. It has also been reported to relieve severe, treatment resistant cancer pain in the majority of the patients. In addition, blocking of fast Na+ channels it has the potential medical uses in treating some cardiac arrhythmias.

9.3 TETRODOTOXIN (TTX) AS A THERAPEUTIC AGENT FOR PAIN: PRECLINICAL STUDIES

Effects of TTX in acute pain: Certain experiments conducted on the effects of TTX in acute pain suggest that the administration of TTX might have little impact on acute pain, although to elucidate this issue, further studies using different routes of administration may be required.

Effects of TTX in inflammatory pain: TTX could be useful attenuating the neurogenic inflammatory response to an injury. Reports on this aspect, although few in number, are promising, and given the major role in inflammatory pain attributed to TTX-sensitive voltage-gated sodium channels (VGSCs) further studies are warranted on the effects of TTX in inflammatory pain.

Effects of TTX in neuropathic pain: TTX-sensitive VGSCs play a key role in neuropathic pain states. Further research however, is required to elucidate this issue (Nieto et al., 2012).

Clinical Studies: Three clinical trials have already been made on the usefulness of TTX to alleviate pain. In an open-label multicenter dose escalation study of TTX in severe cancer-related pain, 24 patients underwent 31 treatment regimens with intramuscular TTX at doses of 15–90 μg/day administered in divided doses over four days. Out of the 31 regimens, 17 yielded clinically significant reductions in pain intensity, with the pain relief persisting for up to 2 weeks. The authors concluded that a dosage of 30 μg twice daily for 4 days was a regimen with an acceptable toxicity and analgesic profile. Further, out of the 41 evaluable patients, the analgesic effect was found sustained in 21 patients, whose cancer pain relief remained constant over successive treatment cycles up to and beyond 12 months, with no evidence of tolerance and an anti-nociceptive effect for an average of 3 weeks. However, only 50% of the patients responded to TTX and the reason for this remains unknown. The authors suggested that

further research is warranted on the use of TTX for moderate-to-severe cancer pain (Nieto et al., 2012).

Tetrodotoxin and its derivatives for the treatment of central-nervously derived neuropathic pain: The "central-nervously derived neuropathic pain" is a neuropathic pain which is initiated or caused by a primary lesion, dysfunction or transitory perturbation in the central nervous system. Tetrodotoxin of pufferfish is a well-known compound acting as analgesic as well as in the treatment of drug addiction. In human therapeutics, the favorable dose of TTX, and its derivatives or its analogues to be administered for such treatments is normally between 10 and 4000 μg/day. Routes of administration of these toxins include intramuscular injection, intravenous injection, subcutaneous injection, sublingual, bucal, patch through skin, oral ingestion, implantable osmotic pump, collagen implants, aerosols or suppository (http://www.google.ga/patents/WO2006032481A1?cl=en).

TTX and Chemotherapy: The TTX derived from the pufferfish has been reported to treat chronic pain, such as that related to chemotherapy. Researchers at the John Theurer Cancer Center (USA) have found that this toxin is 3,000 times more potent than the pain-killer morphine, without the crippling side-effects of addiction and nausea. They have also tested this pain reliever in a small group of cancer patients to ensure its safety and effectiveness (http://edition.cnn.com/2013/07/18/health/toxin-treatments-time/).

TTX as a systemic analgesic and long-acting anesthetic: The Japanese researchers have done intensive research which involved the experimental use of TTX in humans as a powerful non-addictive systemic analgesic. In this exercise, large numbers of heroin addicts suffering from typical withdrawal pain symptoms undertook treatment with purified TTX. Research done at Beijing Medical University, China and other major institutions has resulted in a highly purified TTX which appears to be more potent with fewer side effects as compared to commercially-available TTX used in neurophysiology research. International Wex Technology (IWT), a publicly traded Canadian bio-pharmaceutical company that has licensed and patented this technology for clinical applications, manufactures this compound under the name Tetrodin™.

Tetrodin™ has been tested in Beijing, China for chronic malignant pain in open-label studies. Patients who were suffering from metastatic cancer from various primaries (liver, stomach, and rectal), and complaining of high levels of pain (despite opioid treatment such as round-the-clock meperidine injections) were treated with Tetrodin™. In such patients, the pain relief was noted at 5–30 minutes after the first injection. They were treated for only three days, and reported dramatic improvement and virtually no pain, with quality-of-life measurements assessed to be at much improved levels. These patients reported continued pain relief without known administration of additional analgesic agents at follow-up periods of 2–3 weeks. Phase II double blind studies, however, would phase l help confirm the significance of these findings.

IWT is currently completing North American Phase I safety studies for Tetrodin™. Significant side effects have included perioral/lingual paresthesia in all subjects, as well as mild nausea in some patients. Phase II trials would test the drug for malignant and neuropathic pain, and also seek to confirm the Chinese experience in using the drug to treat withdrawal symptoms in opioid-dependent patients. Pre-clinical testing for the use of Tetrodin™ as a long-acting anesthetic is also currently in progress. These data suggest that TTX could represent a unique alternative to currently available analgesics without the risk of addiction. It appears to be long-acting and its mechanism of action may prove useful in managing both somatic/visceral as well as neuropathic pain states (Cohen and Law-Yone, http://www.imagequest3d.com/pages/general/news/puffertoxin/).

Antinociceptive effects of tetrodotoxin (TTX): The TTX was found to decrease pain behavior of rodents in the formalin test at the highest dose and in the writhing test at 3 and 6 μg/kg. It also reduced mechanical allodynia and thermal hyperalgesia with an ED50 of 1.08 and 0.62 μg kg−1, respectively. These results suggest that the systemic injections of TTX could reduce pain behavior in a dose-dependent manner in models of inflammatory, visceral and neuropathic pain without causing adverse events, unlike morphine analgesia which was associated with heavy sedation. Therefore, the TTX may be a very promising substance for the treatment of various types of pain but needs further evaluation (Marcil et al., 2006).

Antitumor effects of tetrodotoxin: Tetrodotoxin (TTX) has been reported to show a powerful inhibitor effect on Ehrlich ascites carcinoma (EAC)-bearing mice (El-Dayem et al., 2013).

Saxitoxin as a pharmaceutical agent: Although saxitoxin is a potent neurotoxin to humans, it could serve as a pharmaceutical agent. Since the STX blocks at site 1of the sodium ion channel, it has the therapeutic potential as a potent, resilient blocker of nerve conduction that can produce prolonged anesthesia without myo- and neurotoxic effects. Diluted concentrations of the toxin produce a temporary paralytic state, which helps in the treatment of anal fissures and chronic tension headaches requiring longer durations of anesthesia. Studies have also concluded on the synergic potential of this toxin with other anesthetics. The synthesis of STX as a pharmaceutical agent has the potential to be extremely lucrative, but the chemical's possible systemic toxicity is preventing the toxin from making it past clinical trials (Faber, 2012).

9.4 PHARMACEUTICAL VALUES OF PUFFERFISH SPECIES

9.4.1 AROTHRON HISPIDUS: ANTIMICROBIAL AND CYTOTOXIC ACTIVITIES OF LIVER, MUSCLE AND SKIN EXTRACTS

Antibacterial activity: The crude liver, muscle and skin extracts of *Arothron hispidus* were screened against human pathogenic bacteria viz. *Bacillus cereus, Staphylococcus aureus, Escherichia coli, Klebsiella pneumoniae Pseudomonas aeruginosa, Proteus vulgaris* and *Vibrio chlorae* for testing their antibacterial activities. The inhibition zones of the extracts were compared with standard Ampicilin for bacterial culture. The maximum inhibition zone was observed against the *E. coli* in the skin extract of *A.hispidus* and the minimum zone was observed against *P. vulgaris* in the liver extract. The mean values of antibacterial activities of the different tissue extracts are shown in the table given in the next page.

Antibacterial Activities of the Different Tissue Extracts

Organisms	STD-Ampicilin	Skin	Liver	Muscle
E. coli	12.8	11.9	11.1	10.4
K. pneumoniae	10.6	10.1	9.50	9.10
S. aureus	11.8	11.1	10.7	10.0
B. cereus	11.1	10.7	10.1	9.60
P. aeruginosa	10.2	9.80	9.20	8.80
P. vulgaris	11.7	10.1	9.60	10.0
V. cholerae	10. 2	9.80	9.20	8.70

Source: Priya and Khora et al. (2013).

Antifungal activity: The crude liver, muscle and skin extracts of *Arothron hispidus* were screened against human pathogenic fungi viz. *Candida albicans, Aspergillus niger, Aspergillus fumigatus, Trichophyton rubrum* and *Trichophython viridae* for testing their antifungal activities. The inhibition zones of the extracts were compared with standard Flucanozole for fungal culture. The maximum inhibitory zone was observed against *A. niger* in the skin extract of *A. hispidus* and the minimum inhibitory zone was observed against *T. virdae* in the liver extract. The mean values of antifungal activities of the different tissue extracts are shown in the following table.

Antifungal Activities of the Different Tissue Extracts

Tested Strains	STD-Flucanozole	Skin	Liver	Muscle
A. fumigatus	12.1	11.7	11.5	11.3
A. niger	12.1	12.0	11.9	11.7
A. flavus	11.8	11.3	11.0	11.6
C. albicans	11.8	11.6	11.4	11.1
T. viridae	12.3	11.8	11.6	11.0
T. rubrum	12.2	11.8	11.5	11.1

Source: Priya and Khora et al. (2013).

Cytotoxicity: The viability of HeLa cells was observed upon adding the crude tissue extracts. The maximum activity against the HeLa cell line was with the skin tissue extract of *A. hispidus*. When compared to other tissue extracts, the IC50 values of the skin extract against the HeLa cell line was found to be 1.78 mg/ml (Priya and Khora et al., 2013).

Arothron diadematus: The tetrodotoxin (TTX) has been extracted from the skin of *Arothron diadematus* for use in chemoprevention of cancer studies. This species is also utilized in research due to its very small genome (Shao, et al., 2014r). The tetrodotoxins extracted from the skin of this species have shown antitumor activity (Fouda, 2005).

Effect of TTX treatment on the mean survival time (MST) and the increase in the lifespan of EAC tumor-bearing mice

Treatment	MST (days)	Increase in lifespan %
EAC *only	14 days	–
EAC + 1/10 LD50	20 days	46.6
EAC + 1/20 LD50	18 days	26.7

*Ehrlich Ascite Carcinoma.
Source: Fouda (2005).

***Arothron immaculatus*—Antimicrobial values:** Skin and liver extracts of *Arothron immaculatus* were subjected for antimicrobial assay. It was found that maximum antimicrobial effect against *Staphyloccocus aureus* (inhibition zone, 2.5 mm) was with the liver extract and against *Vibrio cholerae* (inhibition zone, 9.8 mm) with the skin extract (http://www.sciencedirect.com/science/article/pii/S1875536411600915; Kumaravel et al., 2011).

***Lagocephalus wheeleri*—Antioxidant activity of pufferfish sauce:** The antioxidant activity (i.e., the peroxyl radical elimination capacity) of the pufferfish, *Lagocephalus wheeleri* sauce as oxygen radical absorbance capacity (ORAC) was measured. It showed high oxygen radical absorbance capacity (ORAC value) (8,365 μmol TE/100 ml) and the highest hydroxyl radical scavenging activity (0.081). Further, the IC50 value of this sauce was found as 0.081% (Harada et al., 2010).

Lagocephalus sceleratus: Considering the benefits of TTX of this species in the pharmaceutical industry, laboratories are to be established in East Mediterranean countries for the purification and subsequent use of the toxin (Nader et al., 2012).

***Sphoeroides parvus*—Pharmaceutical use:** The tetrodotoxin extracted from *Sphoeroides parvus* may be used as an ingredient in the creation of Haitian Zombie powder (Matsuura, et al., 2014) which may

have medical uses, particularly in the field of anaesthesiology (http://zombies.monstrous.com/the_bokor_and_magic_powder/page-3.htm).

Sphoeroides testudineus: The tetrodotoxin extracted from *S. testudineus*, is a key ingredient in the creation of Haitian Zombies (Shao et al., 2014a).

Takifugu orbimaculatus: This fish is used in traditional Chinese medicine (Zhao, 2011).

Takifugu rubripes: In Chinese medicine, this species is largely used. Collagens (acid-solubilized and pepsin-solubilized collagens) have been prepared from the skin of this species. The yields of these acid-solubilized and pepsin-solubilized collagens were found to be very high, that is, 10.7% and 44.7%, respectively, on a dry weight basis. These results suggest that the ocellate puffer fish skin has immense potential as an alternative source of collagen for use in various fields (Nagaia et al., 2002).

Takifugu vermicularis: This species is used in Chinese medicine (FishBase).

Takifugu xanthopterus: species is used in Chinese medicine (FishBase).

KEYWORDS

- **antifungal**
- **antimicrobial**
- **antinociceptive effects**
- **antioxidant**
- **antitumor effects**
- **chemotherapy**
- **cytotoxic**
- **long-acting anesthetic**
- **pharmaceutical values**
- **systemic analgesic**
- **therapeutic agent**

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