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# POISONOUS CRABS OF INDO-WEST PACIFIC CORAL REEFS, WITH SPECIAL REFERENCE TO THE GENUS DEMANIA LAURIE

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## ABSTRACT

Workers in Japan, Singapore, and the Philippines within the last 10 years have documented fatal cases of crab poisoning in man and domestic animals, have tested the toxicity of the crabs responsible for these poisonings, and have identified crab toxin with saxitoxin. Of twelve poisonous species tested by the junior author in the Philippines, six proved to be highly toxic. Among the six were two new species subsequently described by the senior author. These belong to the genus Demania Laurie, until 1967 known from a single species from Ceylon, but now known from ten species ranging from Ceylon to New Hebrides (fossil) and from Japan to northern Queensland. With few exceptions, poisonous crabs are brightly colored members of the family Xanthidae confined to shallow water and associated with coral reefs. They are distributed throughout the Indo-west Pacific from the Red Sea and East Africa to Japan, Hawaii, and Tahiti. Their depth ranges and ecological (substrate) preferences are given. Illustrations of seven highly toxic species are provided for quick recognition by physicians, veterinarians, pharmacologists, collectors, fishermen, SCUBA divers, agricultural inspectors, and others likely to encounter them.

KEY WORDS: Coral Reefs, Crab Poisoning, Family Xanthidae, Genus Demania, Indo-Pacific, Philippines, Saxitoxin, Toxicity

# POISONOUS CRABS OF INDO-WEST PACIFIC CORAL REEFS, WITH SPECIAL REFERENCE TO THE GENUS DEMANIA LAURIE

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## Introduction

Although the documentation of clinical cases of crab poisoning has had to await the last third of the Twentieth Century, the crab-poisoning syndrome was well known to Europeans residing in South Sea island communities one hundred years ago. The Rev. W. Wyatt Gill, a missionary to the Hervey (Cook) Islands, wrote in 1876: "Many cases of accidental crab-poisoning have come under my own observation. An affecting instance was that of an aged member of the church and his daughter. With difficulty their mouths were forced open to admit a strong emetic; the old man died the same night, but the daughter survived. Another case was of a middle-aged man who ate a "white-shelled" crab whilst his wife was at early morning service, which never exceeds an hour. To her horror, upon her return home she found her husband dead." Gill adds that "Occasionally a native in a fit of passion or jealousy commits suicide by eating the "white-shelled" crab."(1). Unfortunately, it has proved impossible to identify the "white-shelled" crab from the crude illustration given.

## Clinical Histories

Two cases of crab poisoning in which both human and animal victims died were reported from the Ryukyu and Amami Islands by Hashimoto et al. (2). In 1928 a man, his wife and their son ate miso soup for breakfast prepared from a red-eyed crab with equal-sized chelae and hairy ambulatory legs [undoubtedly Eriphia sebana, below]. Both husband and wife and a pig that had been fed remnants of the soup died within hours; the son, who had eaten only meat of the chelae and a small quantity of the soup, was hospitalized with numbness of the limbs and loss of consciousness. Forced by an injection to vomit what he had eaten, he recovered. In 1965 a woman and her son ate crabs described as oval in shape, brown in color, with purple or deep blue speckles and deep purple chelae [probably Zosimus aeneus, below]. These were also boiled in miso soup and served for breakfast. The mother, who ate only the soup, developed numbness of the tongue and mouth, followed by paralysis of the limbs. After medical treatment, received in early afternoon, she recovered following five days' confinement. The son, who ate the meat as well as the soup, felt numbness of the limbs and vomited vigorously. Although more seriously afflicted than his mother, he also recovered.

Two similar cases of crab poisoning resulting in death were reported from Palau by Mote et al. (3). These occurred in 1930 and in 1942, but in neither case were the crabs seen by a zoologist. A 33-year-old male ate four pieces of boiled crab and fed the scraps to the chickens. He developed itching and stiffness of the joints, followed by paralysis of the arms and legs. Force fed coconut milk and given medication, he recovered after eight days, during which he was unable t eat and extremely debilitated. The chickens died He identified the crabs by the vernacular name as Zosimus aeneus. As reported by a Japanese physician, two Japanese soldiers boiled some crabs and ate the meat. Within minutes their hands and arm were covered with "an erythematous maculopapular rash and intense pruritus" that spread over their entire bodies. Within 20 minutes they were unabl to move or speak, and within 45 minutes they became cyanotic and lost consciousness. Death followed. The crabs involved were either Eriphia sebana or Zosimus aeneus.

The first documented report of a human fatality resulting from the ingestion of a crab in the Philippines was that of Alcala and Halstead (4), who described events leading to the death of a 42-year-old Filipino male. After ingesting a crab at 8:00 a.m. he developed severe diarrhea, nausea, and vomiting, accompanied by hypersalivation and frequent expectoration. He also complained of muscular exhaustion. At noon he was unable to take solid food and had to lie down. Finding it increasingly difficult to speak or breathe, he developed convulsions and ceased respiring. Death came at 3:00 p.m. in the absence of treatment, which was unavailable. A dog and cat fed fragments of the same crab died that evening. Part of the crab (described as a mandible; actually a cheliped) was identified by R. Serène of UNESCO as Demania sp. near D. splendida Laurie. The species was subsequently described as Demania toxica Garth (5).

A hitherto unreported fatal intoxication, also in the Philippines, was that of two adult males, ages 35 and 37, who breakfasted on soup made from crabs caught the same morning. Within 30 minutes both suffered intense abdominal pain and vomited profusely. Taken to the rural health center, they were pronounced dead on arrival. The crabs used in making the soup were brought to Silliman University. Of the four species eaten

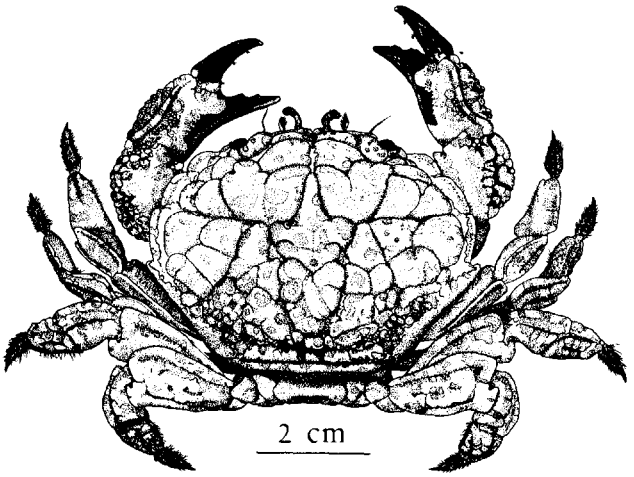


Fig. 1. Zosimus aeneus (Linnaeus)

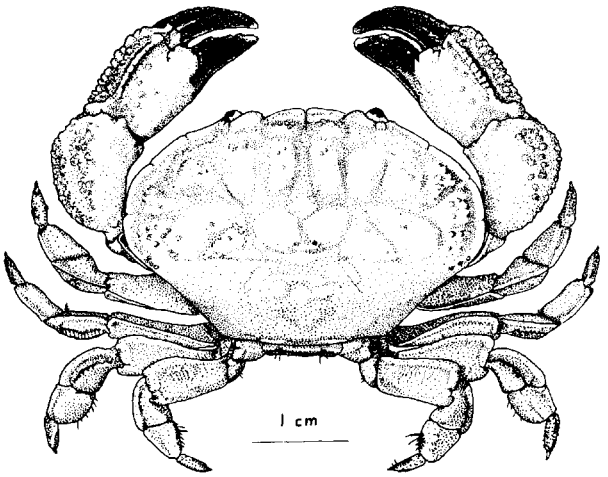


Fig. 2. Platypodia granulosa (Rüppell)

three were non-toxic, as proven by tests on white mice, using the technique developed by Hashimoto et al. (6). The fourth, Lophozozymus pictor, previously shown by Teh and Gardiner (7), (8) to be lethal, and subsequently tested by Gonzales and Alcala (9), proved to be the sole causative agent. These deaths bring to three within a span of six years the number of fatal crab poisonings in Negros, Philippines.

The above case histories have several common features: (a) the crabs were boiled in soup and eaten for breakfast, indicating a heat-stable, water-soluble poison; (b) they were with one exception freshly caught, indicating lack of spoilage; (c) fragments were fed to domestic animals (cat, dog, pig, chickens), which served as untreated controls; (d) symptoms were locomotory and neurological, suggesting a "neuro-toxin"; (e) their onset was immediate, suggesting a high degree of toxicity; (f) death occurred in untreated cases, usually within hours; (g) domestic animals, also untreated, invariably died; (h) those receiving treatment, consisting of an emetic, usually recovered after prolonged debility, with prognosis more favorable in the young. From these empirical observations, it was possible to develop methods for testing the toxicity of crabs known or suspected to be poisonous, using experimental animals (cats, mice), to determine the lethal dosage of the poison, and ultimately to establish its identity.

## Toxicity Experiments

In the initial toxicity experiments by Hashimoto et al. (2), macerated portions of crab were extracted in a boiling water bath for 30 minutes. After cooling, the mixture was centrifuged and filtered and the residue extracted similarly. The supernatants were combined and diluted with water, and by injecting a 0.5 ml portion into a 20-g mouse, the dilution needed to kill mice in 15-20 minutes was determined. From the average death time observed and the dose-death time curve plotted, the minimum lethal dose was determined. To indicate the amount of toxin, the total weight in g of mice killed was expressed as a mouse unit (M.U.). When a 0.5 ml portion of the extract failed to kill mice, the tissue was regarded as non-toxic.

In the initial tests (2) specimens of Zosimus aeneus (fig. 1) and Platypodia granulosa (fig. 2) showed marked individual variations in toxicity, from highly toxic to non-toxic. The toxin was found to be extremely localized, with exoskeleton and muscles of the appendages highly toxic (10,000 -15,000 M.U./g body weight), while parts within the cephalothorax, such as muscle, viscera, and gill, were weakly toxic (360-400 M.U./g body weight) or non-toxic. These conclusions appeared to rule out the possibility of a poison caused by ingestion of a dinoflagellate, as in the case of Emerita analoga, in which the poison is concentrated in the digestive tract (10), (11). Japanese investigators (12) subsequently found the toxin of Atergatis floridus (fig. 3) to be similar to that of Zosimus aeneus in chromatographic behavior and

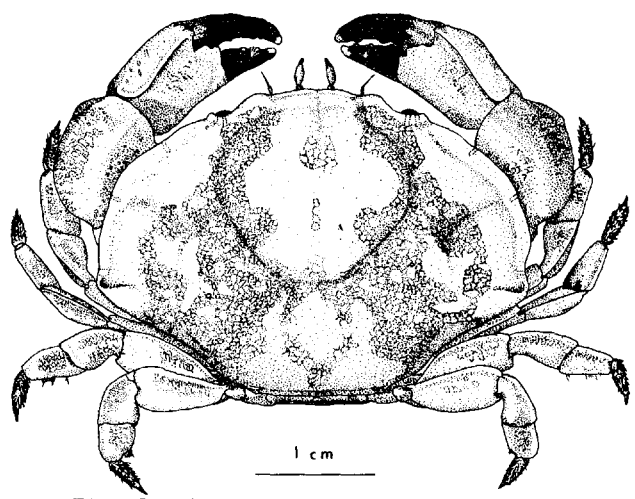


Fig. 3. Atergatis floridus (Linnaeus)

pharmacological action in mice, with results clearly indicating that both toxins were the same chemical compound. Crab toxin showed a similarity in pharmacological actions to tetrodotoxin and saxitoxin, suggesting a modification of experimental techniques to follow more closely those used for these toxins. Subsequently, the Japanese group (13), by means of paper and thin-layer chromatography, and from lethality studies in mice, were able to distinguish crab toxin from tetrodotoxin, but were unable to distinguish it from saxitoxin, suggesting that crab toxin was closely related to saxitoxin, if not identical with it. Singaporean investigators (7, 8) found the toxin of Lophozozymus pictor to be neither tetrodotoxin nor saxitoxin, but a basic substance containing free primary amino groups.

In a follow-up study by Hashimoto et al. (6) a large number of crabs from the Ryukyu and Amami Islands were screened for toxicity, using the modified technique. The results showed Atergatis floridus, Zosimus aeneus, and Platypodia granulosa to be highly toxic, while others, including Carpilius convexus, said to be toxic in the Gilbert Islands (14), and Etisus splendidus, believed to be highly toxic by Amami islanders, to be non-toxic, at least in the Ryukyu and Amami Islands.

## Current Investigations

This was the situation when the junior author and his associates (15) began a survey of the marine crabs in coastal waters of southern Negros Island, Philippines, in September, 1971, that lasted until July, 1974. Crabs used in the study were found in rocks and coral reefs of the subtidal zone at depths of .5 to 37.5 m. A total of 92 specimens representing 30 species were screened for toxicity, following the method developed by Hashimoto et al. (6). Of this number four species were found to be highly toxic to white mice, namely, Lophozozymus pictor (fig. 4) (two of two specimens), Demania alcalai (five of five specimens), Atergatis floridus (one of two specimens) and Zosimus aeneus (four of 13 specimens). Of these, Zosimus aeneus and Demania alcalai were found to remain toxic the year 'round, the others possibly so. Six other species were found to be mildly toxic, causing body twitchings and abdominal muscular spasms in mice lasting 30 minutes or more, followed by complete recovery. Mildly toxic species were Etisus splendidus, Atergatis dilitatus, A. integerrimus, Carpilius convexus, Eriphia sebana, and Daldorfia horrida. It is upon these mildly toxic species that subsequent work will be attempted with a view toward quantifying the results.

## Systematics and Distribution

The senior author's interest in poisonous crabs dates from 1956, when he was asked by Bruce W. Halstead to identify from an illustration the white-shelled sea crab of the Hervey [= Manuae (Cook)] Islands reported by the Rev. W. Wyatt Gill in 1876 as Portunus (Angatea) (1). Unfortunately, the illustration was so poor that it proved impossible to determine whether the crab belonged in the family PORTUNIDAE or in the family CALAPPIDAE, subfamily Matutinae, although specialists in Australia, New Zealand, and Hawaii were consulted. In 1968 he received from Dr. Halstead a crab that had caused the death of several people in Palau (3) that he identified as Eriphia sebana (Shaw & Nodder) (fig. 5), of which E. laevimana (Latreille) is a synonym. In 1967 he identified for A. H. Banner two species of crabs reported as toxic from Tarawa, Gilbert Islands (14) as Zosimus aeneus (Linnaeus) and Etisus dentatus (Herbst). Meanwhile, through field work in the Marshall Islands (1957, 1959), in South India and Ceylon (1963), and in Queensland (1973) he gained experience in recognizing the numerous xanthid crabs in Indo-Pacific coral reefs, both poisonous and non-poisonous species.

With the exception of Daldorfia horrida, a a member of the family PARTHENOPIDAE, the poisonous or mildly poisonous crabs investigated belong to the XANTHIDAE, a family of cancroid or catometopous crabs that finds its greatest development in the tropics. The poisonous crabs are not coral symbionts, as are the coral crabs of the subfamily Trapeziinae, but rather free-living inhabitants of coral reefs and their rocky substrates. Nor do they belong to a single subfamily, although with the exception of Etisus (subfamily Chlorodiinae) and Eriphia (subfamily Menippinae), the remaining genera find lodgment in the subfamily Xanthinae. Within this typical subfamily are Carpilius (alliance Carpilioida) and the four genera Zosimus, Lophozozymus, Platypodia, and Atergatis (alliance Zozymoida). These stand next one another in the systematic ordering, suggesting that among them and related genera other toxic species may be found. Poisonous species range widely throughout the tropical Indo-west Pacific from the Red Sea and East Africa to Japan, Hawaii, and Tahiti, although the range of Lophozozymus pictor is restricted to the area between Singapore and the Philippines, and the eastward advance of Atergatis integerrimus stops at the Philippines and Japan.

Of the six highly poisonous species, with the exception of the two Demania species discussed below, four were described in the late eighteenth or early nineteenth century: Zosimus aeneus (Linnaeus, 1758), Atergatis floridus (Linnaeus, 1767), Lophozozymus pictor (Fabricius, 1798), and Platypodia granulosa (Rüppell, 1830). Of the five mildly poisonous species, four were described before 1804: Daldorfia horrida (Linnaeus, 1758), Carpilius convexus (Forskål, 1775), Atergatis integerrimus (Lamarck, 1801), and Eriphia sebana (Shaw & Nodder, 1803), the exception being Etisus splendidus Rathbun, 1906. Type localities of these species, where known (and with the exception of E. splendidus, type locality Hawaii), are the Red Sea, the extension of the Indo-Pacific most accessible to Europeans. It may there-

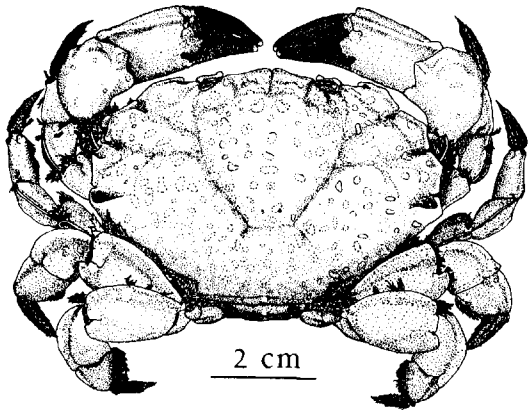


Fig. 4. Lophozozymus pictor (Fabricius)

fore be said that the poisonous crabs have been known to zoologists as long as any in the Indo-Pacific region. But although Eriphia sebana was reported (as Cancer rubris oculis or Cancer noxius) as poisonous in 1705 by Rumphius (16), Zosimus aeneus has a long history of toxicity among native peoples (16), (17), and Eriphia norfolcensis was reported by Norfolk islanders (18), the poisonous nature of the crabs was slow to be recognized by the scientific community. In fact, as recently as 1968 there appeared in our respected carcinological journal, Crustaceana, an article entitled "Are there poisonous crabs?" After summarizing the information then available (19), (20), the author concluded that there were not, or at least that the question was still an open one (21).

## Ecology

Of the six highly poisonous species, again excepting the two Demania species, three: Zosimus aeneus, Platypodia granulosa, and Lophozozymus pictor, are said by Sakai (22) to inhabit coral reefs, the latter rocky bottoms as well. The fourth, Atergatis floridus, is said to inhabit hard beaches, at or below tide levels. Of the mildly poisonous species, three are said by Sakai to inhabit corals: Etisus splendidus coral reefs, Eriphia sebana crevices in rocks or coral reefs, and Carpilius convexus rocky beaches or coral reefs, while Atergatis integerrimus is found on rocky bottoms and Daldorfia horrida on bottoms of rocks, sandy mud, or broken shells. It may therefore be said that the coral reef is the preferred habitat for the majority of the poisonous species, although not the exclusive habitat of some of them. Depth ranges for poisonous species are given by Sakai as: Daldorfia horrida 33-125 m, Carpilius convexus and Atergatis integerrimus 10-30 m, and Lophozozymus pictor 0-30 m. The senior author has collected D. horrida and C. convexus intertidally in the Marshall Islands and L. pictor subtidally in northern Queensland.

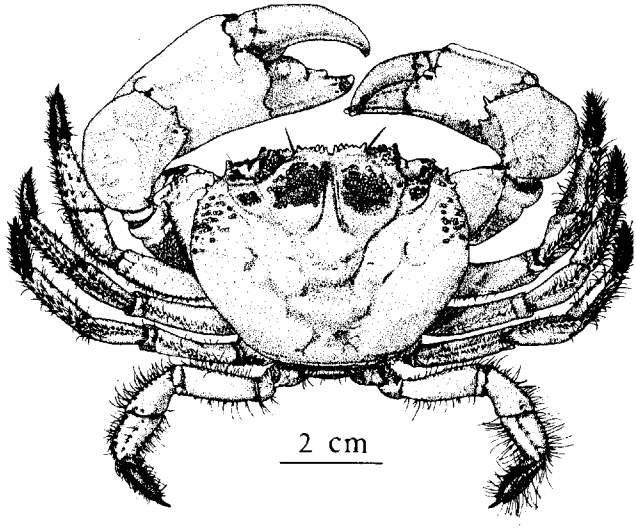


Fig. 5. Eriphia sebana (Shaw & Nodder)

## The Genus Demania

The genus Demania stands a little apart from the other poisonous crabs, both systematically and ecologically. It also differs in having species of restricted range. Originally described from Ceylon by Laurie (23), it is now known to contain ten species that range from Ceylon to the Philippines and Japan to northern Queensland. A fossil Demania has been reported from the New Hebrides (24). The senior author's interest in the genus dates from October, 1969, when he received from Bruce W. Halstead a fragment (claw) of a crab that was responsible for a human death in the Philippines. Unable to identify it, he sent it to Raoul Serène, UNESCO taxonomic expert for S.E. Asia, then at Singapore, who identified it as Demania sp. near D. splendida Laurie (4). Subsequently he obtained from the junior author a complete specimen, which he described as a new species, Demania toxica Garth (fig. 6) (5). A second species, also responsible for a human fatality, forwarded by the junior author in July,

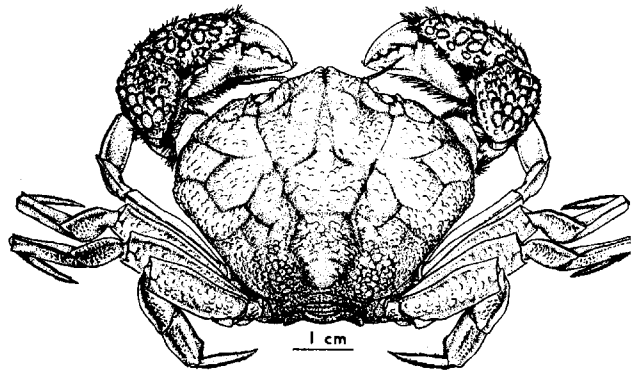


Fig. 6. Demania toxica Garth

1971, was described as D. alcalai Garth (fig. 7) (25). Meanwhile, during a visit to the Australian Museum, Sydney, in 1973, the senior author recognized an unnamed species of Demania from northern Queensland that he described as D. macneilli Garth (26). Although not known to be toxic, this species is highly suspect because of the poisonous nature of its congeners. These are, in addition to the type species, D. splendida Laurie, 1906, and the three recently described species above: D. reynaudii (Milne Edwards, 1834), type locality Indian Ocean; D. scaberrimus (Walker, 1887), type locality Singapore; D. cultripes (Alcock, 1898), type locality Singapore; D. baccalipes (Alcock, 1898), type locality Ceylon; D. rotundata (Serène, 1969), type locality Taiwan; and D. intermedia Guinot, 1969, type locality New Guinea. Of the above D. reynaudii has been reported as poisonous in the Gulf of Tonkin (27). The poisonous nature of the others has yet to be ascertained. With the exception of the last named, all were originally described in the genus Xantho Leach, 1815, where they remained until placed in Demania by Guinot (28), (29).

With the exception of Demania alcalai, collected in 1 m, crabs of the genus Demania, where depth is known, are from deeper water, and are more likely to be encountered by SCUBA divers than by reef walkers. Sakai (22) gives for D. scaberrimus, D. baccalipes, and D. intermedia 15-35 m, for D. rotundata 100-200 m, while Garth gives for D. toxica 27 m and for D. macneilli 21-36 m. No depth records exist for D. splendida, D. cultripes, or D. reynaudii.

## Conclusion

It is highly remarkable that the genus Demania, until 1967 known from but a single species (splendida), by description of four new species (intermedia, toxica, alcalai, macneilli) and by transfer of five species from a related genus (reynaudii, scaberrimus, cultripes, baccalipes, rotundata), by 1977 should be known from ten species, and that this taxonomic expansion should have occurred during the same decade as the toxicological investigations in which several of them were implicated. One wonders whether the events were entirely coincidental. Rather, it would appear that the discoveries by the toxicologists of unnamed poisonous species contributed to the activity of the taxonomists, who were hard-pressed to provide names for the crabs in advance of publication of the toxicological results. It is not beyond the realm of possibility that the "white-shelled" crab of the Hervey Islands may yet prove to be still another species of Demania.

## Acknowledgments

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## References

(1) Gill, W. W., 1876. Notes on natural history. In: W. W. Gill, Life in the Southern Isles: 273-274. Religious Tract Society, London., England.

(2) Hashimoto, Y., S. Konosu, T. Yasumoto, A. Inoue, & T. Noguchi. 1967. Occurrence of toxic crabs in Ryukyu and Amami Islands. Toxicon, 5: 85-90.

(3) Mote, G. E., B. W. Halstead, & Y. Hashimoto. 1970. Occurrence of toxic crabs in the Palau Islands. Clin. Toxicol., 3: 597-607.

(4) Alcala, A. C., & B. W. Halstead. 1970. Human fatality due to ingestion of the crab Demania sp. in the Philippines. Clin. Toxicol., 3: 609-611.

(5) Garth, J. S. 1971. Demania toxica, a new species of poisonous crab from the Philippines. Micronesica, 7: 179-183.

(6) Hashimoto, Y., S. Konosu, A. Inoue, T. Saisho, & S. Miyake. 1969. Screening of toxic crabs in the Ryukyu and Amami Islands. Bull. Jap. Soc. Scient. Fish., 35: 83-87.

(7) Teh, Y. F., & J. E. Gardiner. 1970. Toxin from the coral reef crab, Lophozozymus pictor. Pharmacol. Res. Commun. 2: 251.

(8) _____. 1974. Partial purification of Lophozozymus pictor toxin. Toxicon, 12: 603-610.

(9) Gonzales, R. B., & A. C. Alcala. 1977. Fatalities from crab poisoning on Negros Island, Philippines. Toxicon, 15: In press.

(10) Sommer, H. 1932. The occurrence of paralytic shell-fish poison in the common sand crab. Science, 76: 574.

(11) _____, & K. F. Meyer. 1937. Paralytic shell-fish poisoning. Arch. Pathol., 24: 560.

(12) Inoue, A., T. Noguchi, S. Konosu, & Y. Hashimoto. 1968. A new toxic crab, Atergatis floridus. Toxicon, 6: 119-123.

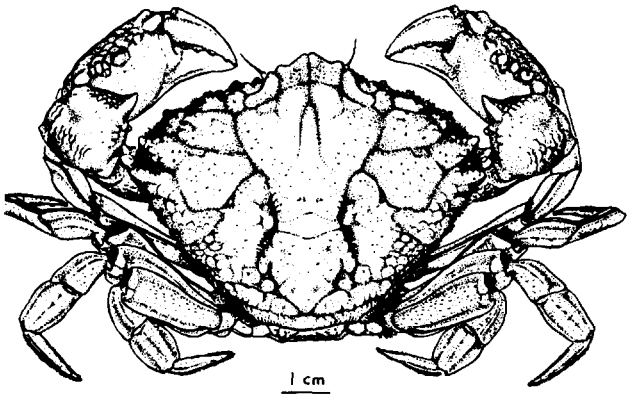
(13) Konosu, S., A. Inoue, T. Noguchi, & Y. Hashimoto. 1968. Comparison of crab toxin with saxitoxin and tetrodotoxin. Toxicon, 6: 113-117.

(14) Cooper, M. J. 1964. Ciguatera and other marine poisoning in the Gilbert Islands. Pac. Sci., 18: 411-440.

(15) Carumbana, E. E., A. C. Alcala, & E. P. Ortega. 1976. Toxic marine crabs in southern Negros, Philippines. Silliman Jour., 23: 265-278.

(16) Rumphius, G. E. 1705. D'Amboinsche rariteitkamer . . . die in d'Amboinsche en zommige omleggende eilanden gevonden worden: 14-19. Halma, Amsterdam, Netherlands.

(17) Banner, A. H., & J. E. Randall. 1952. Preliminary report on marine biology study of Onotoa Atoll, Gilbert Islands. Atoll Res. Bull., 13: 43-62.




D. alcalai Garth (fig. 7)

(18) Grant, F. E., & A. R. McCulloch. 1907. Decapod Crustacea from Norfolk Island. Proc. Linn. Soc. New S. Wales. 32: 151-156.

(19) Halstead, B. W., & D. A. Courville. 1965. Poisonous and venomous marine animals of the world. 1: 905-913. U.S. Govt. Printing Office, Washington, D.C.

(20) Guinot, D. 1967. Les crabes comestibles de l'Indo-Pacifique: 1-145. Edit. Fond. Singer-Poliqnac, Paris, France.

(21) Holthuis, L. B. 1968. Are there poisonous crabs? Crustaceana, 15: 215-222.

(22) Sakai, T. 1976. Crabs of Japan and the adjacent seas. English text vol.: 388-478. Kodansha Ltd., Tokyo, Japan.

(23) Laurie, R. D. 1906. On the Brachyura. In: W. A. Herdman (ed.), Report to the Government of Ceylon on the Pearl Oyster Fisheries of the Gulf of Manaar, Part 5. Suppl. Rept. 40: 349-432. Royal Society, London, England.

(24) Mallick, D.I.J., & D. Greenbaum. 1975. The Navaka fossiliferous sands and the Kere shell bed. Ann. Rept. Geol. Surv., New Hebrides Condominium, 1973: 8-12. Vila, New Hebrides.

(25) Garth, J. S. 1975. Demania alcalai, a second new species of poisonous crab from the Philippines. Philip. Jour. Sci., 104: 1-6.

(26) _____. 1976. Demania macneilli, a new species of xanthid crab from northern Queensland. Rec. Aust. Mus., 30: 113-117.

(27) André, M. 1931. Crustacés Décapodes provenant de l'Institut Oceanographique de Nha-Trang (Annam). Bull. Mus. natn. Hist. nat. Paris, (2) 3: 638-650.

(28) Guinot, D. 1967. Recherches préliminaires sur les groupements naturels chez les Crustacés Décapodes Brachyoures. 4. Observations sur quelques genres de Xanthidae. Bull. Mus. natn. Hist. nat. Paris, (2) 39: 695-727.

(29) _____. 1969. Sur divers Xanthidae, notamment sur Actaea De Haan et Paractaea gen. nov. Cahiers Pacif., 13: 223-267. (See especially p. 234).

## Addendum

The bio-assay of toxic crabs from western Pacific coral reefs described in the foregoing article has been accomplished at three active research centers. One is the Laboratory of Marine Biochemistry, Faculty of Agriculture, University of Tokyo, Japan, where the late Yoshiro Hashimoto headed a team of workers. A second is the Department of Pharmacology, Faculty of Medicine, University of Singapore, Republic of Singapore, where Y. F. Teh and J. E. Gardiner are active. A third is the Department of Biology, Silliman University, Dumaguete City, Philippines, where A. C. Alcala and Esther Carumbana are associated. Crabs used in toxicological studies were identified for the Japanese group by S. Miyake of Kyushu University, Fukuoka, for the Singaporean group by R. Serène of UNESCO, and for the Filipino group by the senior author. Areas surveyed for toxic crabs by the Japanese included the Ryukyu and Amami Islands (2), (6), (12) and Palau Islands (3), by the Singaporean group the reefs of Singapore (7), (8), and by the Filipino group the island of Negros (15). It should be emphasized that while undocumented reports of crab poisoning are attributed to numerous Pacific islands and atolls, the only clinically documented cases, supported by toxicological tests on the crabs responsible for the human and domestic animal deaths reported, come from the areas surveyed by, and the tests conducted in, these laboratories. It should be further emphasized that the crabs affected are not those ordinarily marketed, other than locally at their sites of origin, and that commercially available crabs, such as the mud crab or Samoan crab, Scylla serrata (Forskål), are in no way implicated.