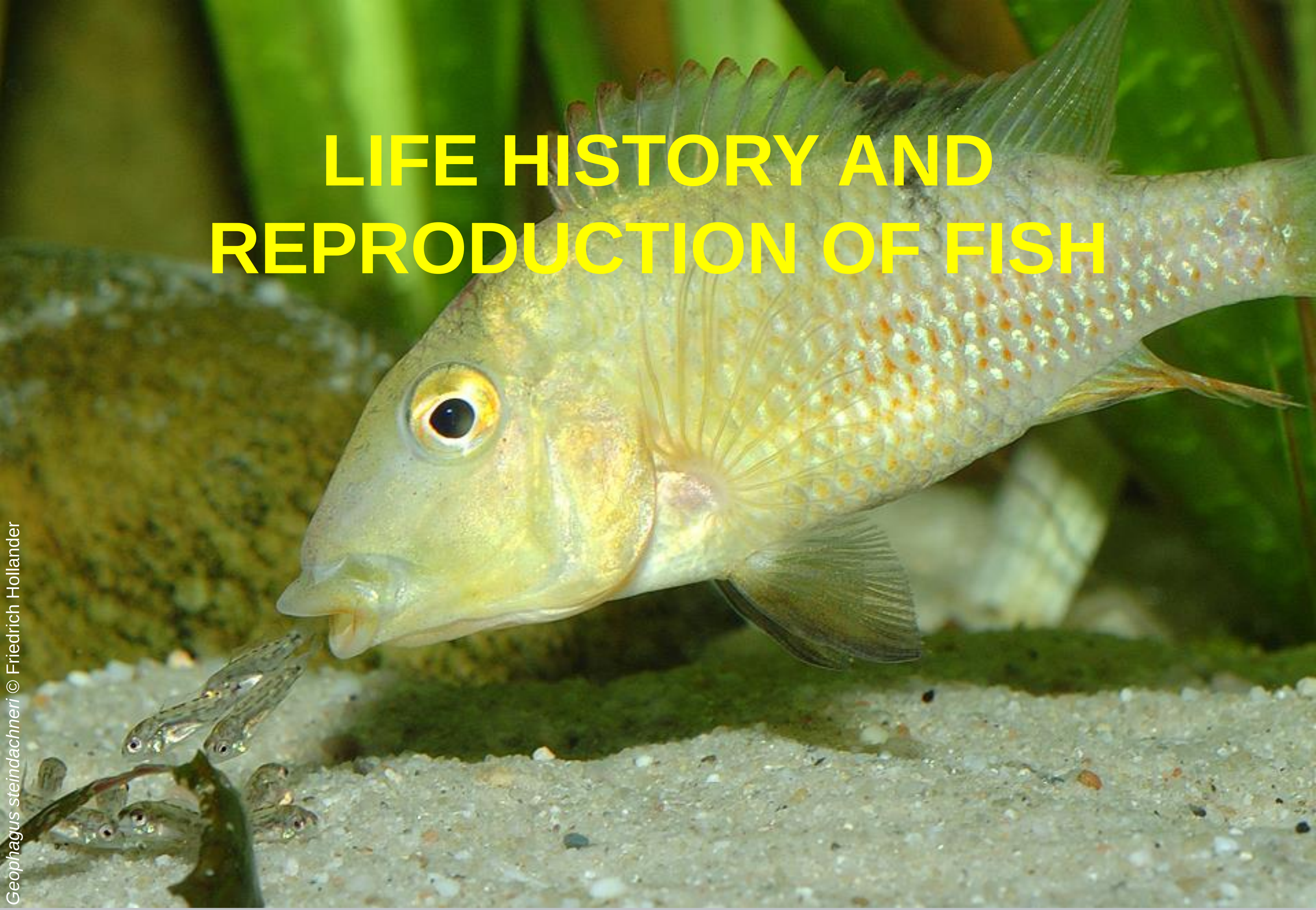
LIFE HISTORY AND REPRODUCTION OF FISH



Geophagus steindachneri © Friedrich Hollander

Royal Museum for Central Africa (RMCA Tervuren)

FishBase and Fish Taxonomy Training
Session 2017

Introduction

-fish are typically gonochoristic and oviparous, with a genetic sex-determining system and cross-fertilization.

sequential hermaphrodites
simultaneous (true) hermaphrodites

ovoviviparous
viviparous (known in 13 teleost families)

-some parthenogenetic species known, but these require sperm from closely related species to activate egg development

Modes of reproduction

Classification of life-history styles

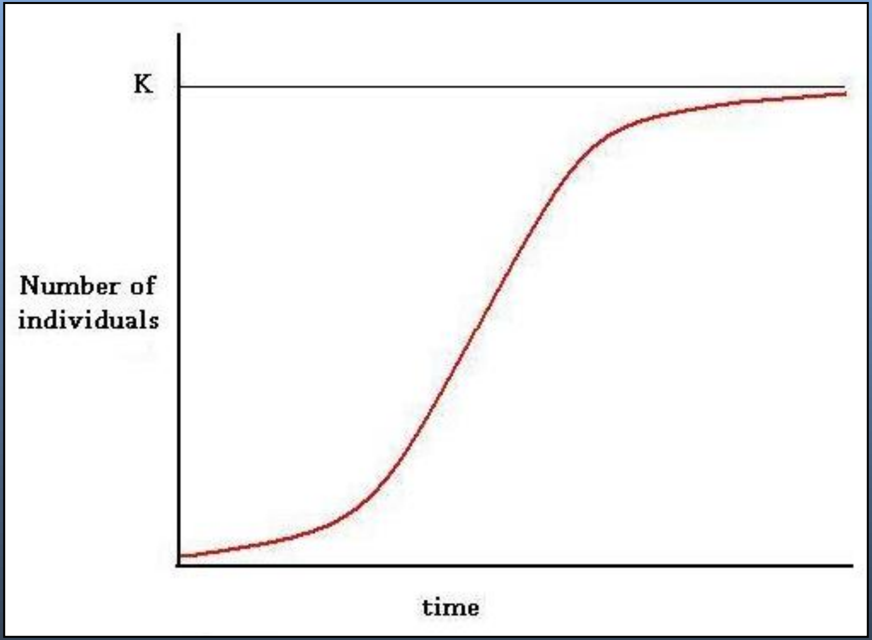
Five modes of reproduction based on relations between zygote(s) and parents:

- Ovuliparity: external fertilization, external egg development;
- Oviparity: internal fertilization; external egg development, eggs with large vitellus;
- Ovoviviparity: internal fertilization; eggs retained but no feeding interactions between egg and parents; embryos depend upon their yolk for survival.
- Viviparity:
  - Histotrophic viviparity: internal fertilization; eggs retained, embryos survive by eating other eggs or unborn siblings.
  - Hemotrophic viviparity: internal fertilization; eggs retained, provided with nutrients, often through some form of placenta.

Modes of reproduction

Classification of life-history styles

- r- *versus* K-selection
  - terms derived from: dN/dt = (rN(K-N))/K (logistic growth curve)
  - carrying capacity of environment related to K; r is an expression of selection for high population growth in uncrowded environments



Modes of reproduction

Classification of life-history styles

- contrast between these 2 life-history styles has been expressed in terms of selection pressures operating in different environments:

	K-selection	r-selection
Environment	stable and crowded	less stable, uncrowded
Life history strategy	efficient exploitation of resources	productivity; maximal population growth
Development	slow	rapid
Reproduction	delayed	early
Size	large	small
Resource threshold	low	high

- most species have an intermediate life-history style

Modes of reproduction

Classification of life-history styles

- generalists *versus* specialists (or eurytope *versus* stenotope)

Favoured in impoverished milieu

Adapted to its environment; lives in rich milieu with abundant resources

Modes of reproduction

Classification of life-history styles

-altricial *versus* precocial

-produce small, incompletely developed young, with small yolk volume not sufficient to produce definitive phenotype

-generalists in unpredictable and uncrowded environments, with mainly density-independent mortality

-produce large and well-developed young

-specialists in stable and crowded environments with density-dependent mortality

-e.g. *Labeotropheus*

Labeotropheus trewavasae
© Filip Grotkowski

Modes of reproduction

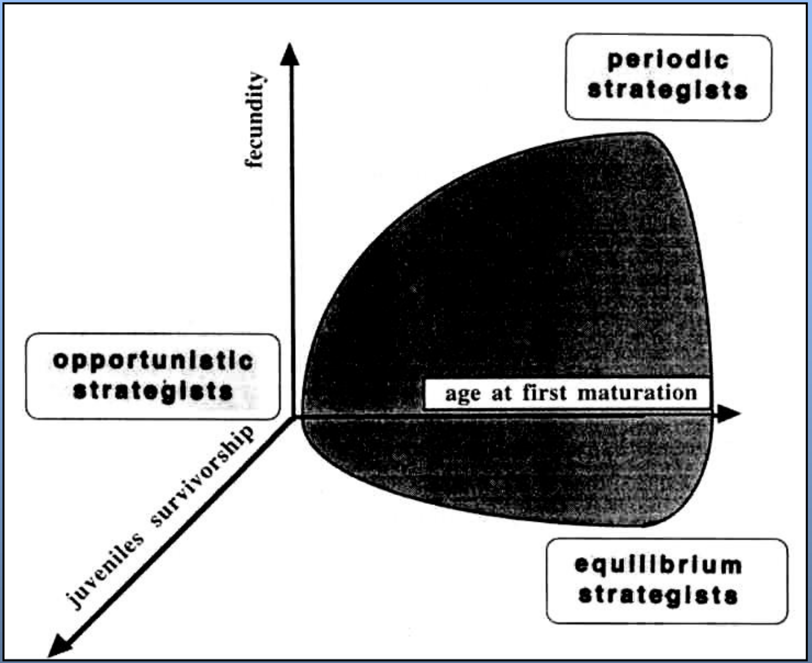
Classification of life-history styles

- opportunistic, periodic and equilibrium strategies

opportunistic strategists: small, rapidly maturing short-lived fish, e.g. killifish

periodic strategists: larger, highly fecund fish with longer life spans, e.g. *Alestes baremoze*, *Schilbe mystus*; maximize age-specific fecundity; often associated with long-distance spawning migrations to productive, wet season floodplains

equilibrium strategists: intermediate size, often exhibit parental care and produce fewer but larger offspring, e.g. cichlids; often associated with local sedentary populations, stable adult food resources and prolonged breeding seasons

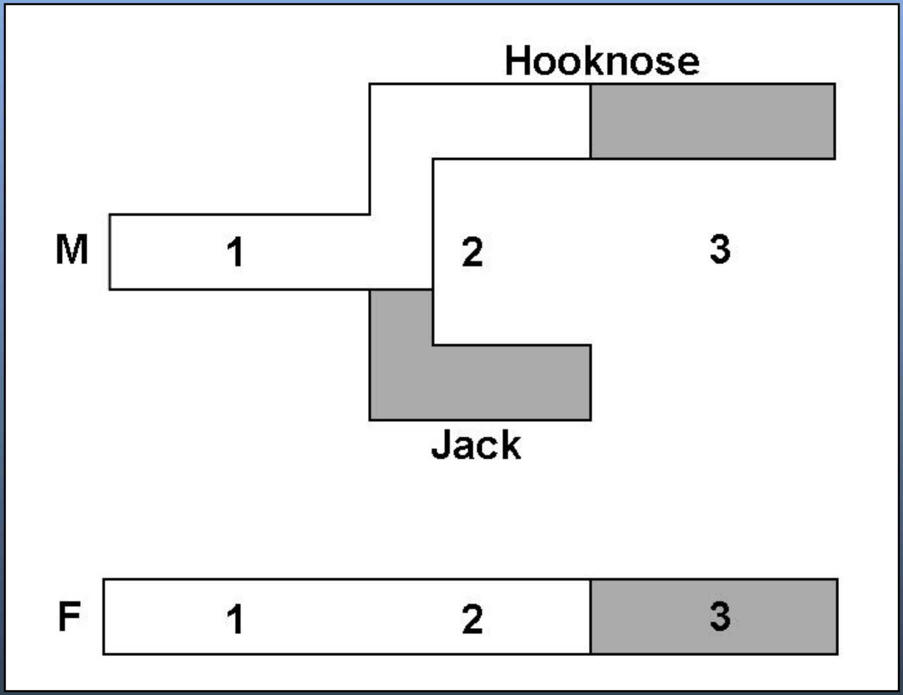


Different life-history strategies for fish (from Winemiller 1992)

Modes of reproduction

Alternative reproductive strategies

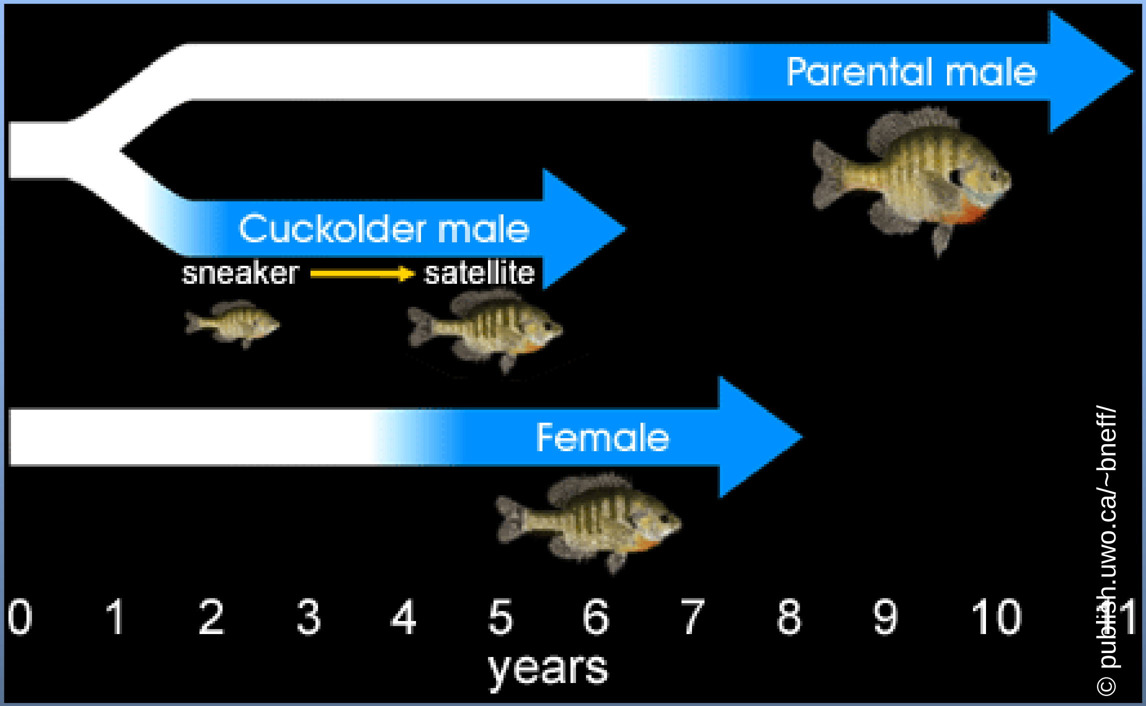
- a mixed strategy can be stable if there is a negative, frequency-dependent selection, i.e. the fitness obtained by playing a particular strategy is a function of the frequencies of strategies in the population, and the fitness of each strategy declines as the portion of the population adopting that strategy increases



Coho salmon (*Oncorhynchus kisutch*) reproduction strategies

Modes of reproduction

Alternative reproductive strategies



Lepomis macrochirus reproduction strategies

Lepomis macrochirus mating

Modes of reproduction

Unusual reproductive strategies

Environmental sex determination (ESD)

- usually genotypic sex determination (GSD)

- ESD is irreversible

- ESD adaptive when environment that the offspring enter has an effect on fitness that depends on gender

Atlantic silverside (*Menidia menidia*)
© M. Walsh

Modes of reproduction

Unusual reproductive strategies

Hermaphroditism/Intersexes

- sequential (=successive): sex change usually induced behaviourally, either by disappearance of individual of dominant sex or by change in sex ratio in a social group; favoured if fish can reproduce more effective as one sex under given circumstances and as the other sex under other circumstances; e.g. protogynous, monandric *Cheirodon schoenleinii*

Choerodon schoenleinii © J.E. Randall

Modes of reproduction

Unusual reproductive strategies

Hermaphroditism/Intersexes

- simultaneous (=synchronous): if energy cost of gonad development in synchronous hermaphrodite is not much more than in the male and female of a gonochoristic species, in habitats where reproductive contacts are few or ova production is limited, than synchronous hermaphroditism may be advantagous because it leads to two batches of fertilised eggs when 2 individuals meet; e.g. *Aulopus bajacali*

Aulopus bajacali © Pedro Jimenez Prado

Modes of reproduction

Unusual reproductive strategies

Parthenogenesis

- asexual reproduction rare in fishes
- parthenogenesis leads to a growth in abundance at twice the rate of the sexual form
- potential disadvantages:
    - lack of genetic variability
    - accumulation of lethal mutations

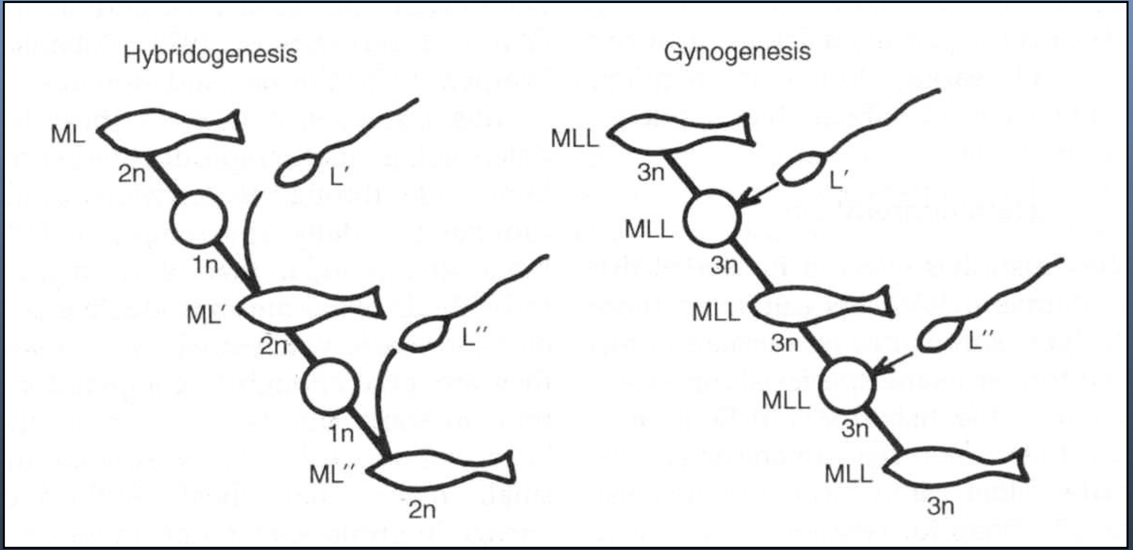
Modes of reproduction

Unusual reproductive strategies

Parthenogenesis

Hybridogenesis: diploid hybridogenetic females transmit a haploid, non-recombinant, maternal genome to their ova; hemiclonal M genome is combined with a new recombined L genome in each generation; only maternal genes and chromosomes are perpetuated across generations of the unisexual biotype; variation from species L is phenotypically expressed by hybridogenetic lineage, but is substituted in each generation and is not heritable.

Gynogenesis: unreduced eggs produced by an all-female species, but egg development triggered by allospecific sperm from males of related species; sperm does not contribute any genetic material to the offspring; sperm-dependent parthenogenesis, sometimes called "sperm parasitism".



Timing of reproduction

Age and size at first maturity

-wide range of ages/sizes at first maturity:

*Cyprinodonts: a few weeks

Hippoglossus, Hippoglossoides: up to 15 years; reproductive life span in flatfishes correlated with age at maturity

-intraspecific and interpopulation differences:

Hippoglossoides platessoides: females: 7.8-15.2 years
males: 5.3-7.5 years

*Tilapias mature at smaller sizes in unfavourable environments or in bad physiological condition

Hippoglossoides platessoides

Timing of reproduction

Age and size at first maturity

-semelparous life-history: fish reaching sexual maturity die either while breeding or soon after (e.g. *Oncorhynchus*); characteristic of r-strategists.

Sockeye salmon
Oncorhynchus nerka

-iteroparous life-history: individuals survive to breed again in the next season; characteristic of K-strategists.

-mean age/size at maturity = age/size class at which 50% of the individuals in that age/size class are mature.

Timing of reproduction

Seasonal timing of reproduction

- a fish should reproduce at that time of the year that tends to maximize its lifetime production of offspring.

- 2 general strategies:
  - synchronous breeding: might be a predation response: presence of a large number of young could reduce chance of predation, and young may benefit from collective defence by parents.
  - asynchronous breeding: might be an important mechanism for maximizing the use of available resources.

- Timing at high and low latitudes triggered by seasonal changes: thermal regime, photoperiod, food abundance and supply, water level, wet and dry season, freshwater run-off from the land, conductivity,…

Site of reproduction

-lack of mobility of early life stages means they display little or no behavioral response to hazards → spawning site largely determines intensity and nature of hazards (lack of oxygen, silt smothering, infection by microorganisms, predation) and accessibility to appropriate nursing areas.

-classification of Balon (1975, 1981) partly based on site of reproduction.

I. Non-guarders of eggs and young
- A. Open substrate spawners
  - 1. Pelagic spawners, e.g. *Mola mola*
  - 2. Benthic spawners
    - a. Spawners on coarse substrates (rocks, gravels, etc.)
      - (1) Pelagic free embryo and larvae, e.g. *Morone saxatilis*
      - (2) Benthic free embryo and larvae, e.g. *Phoxinus phoxinus*
    - b. Spawners on plants
      - (1) Non-obligatory, e.g. *Rutilus rutilus*
      - (2) Obligatory, e.g. *Esox lucius*
    - c. Spawners on sandy substrates, e.g. *Gobio gobio*
- B. Brood hiders
  - 1. Benthic spawners, e.g. *Oncorhynchus nerka*
  - ● 2. Cave spawners, e.g. *Anoptichthys jordani*
  - ● 3. Spawners on invertebrates, e.g. *Rhodeus amarus*
  - 4. Beach spawners, e.g. *Leuresthes tenuis*
  - 5. Annual fishes, e.g. *Nothobranchius guentheri*

II. Guarders
- A. Substrate choosers
  - 1. Rock spawners, e.g. *Chromis chromis*
  - ● 2. Plant spawners, e.g. *Pomoxis annularis*
  - 3. Terrestrial spawners, e.g. *Copeina arnoldi*
  - 4. Pelagic spawners, e.g. *Ophiocephalus* spp.
- B. Nest spawners
  - 1. Rock and gravel nesters, e.g. *Ambloplites rupestris*
  - ● 2. Sand nesters, e.g. *Cichlasoma nicaraguense*
  - 3. Plant material nesters
    - a. Gluemakers, e.g. *Gasterosteus aculeatus*
    - b. Non-gluemakers, e.g. *Micropterus salmoides*
  - 4. Bubble nesters, e.g. *Betta splendens*
  - 5. Hole nesters, e.g. *Cottus aleuticus*
  - 6. Miscellaneous materials nesters, e.g. *Lepomis macrochirus*
  - ● 7. Anemone nesters, e.g. *Amphiprion* spp.

III. Bearers
- A. External bearers
  - 1. Transfer breeders, e.g. *Oryzias latipes*
  - 2. Forehead breeders, e.g. *Kurtius gulliveri*
  - 3. Mouthbrooders, e.g. *Oreochromis mossambicus*
  - 4. Gill-chamber brooders, e.g. *Typhlichthys subterraneus*
  - 5. Skin brooders, e.g. *Bunocephalus*
  - 6. Pouch brooders, e.g. *Syngnathus abaster*
- B. Internal bearers
  - 1. Ovi-ovoviviparous, e.g. *Glandulocauda inequalis*
  - 2. Ovoviviparous, e.g. *Sebastes marinus*
  - 3. Viviparous, e.g. *Poecilia reticulata*

Fecundity

fecundity = number of eggs an animal produces during each reproductive cycle; the potential reproductive capacity of an organism or population. Usually increases with age and size.

batch fecundity: number of eggs per spawning

breeding season fecundity: depends on the number of spawnings in a season

lifetime fecundity: depends on breeding season fecundity and life-span

relative fecundity: number of eggs per unit body weight; allows to compare between fish; often clearly related to length; absolute fecundity increases with fish size

fertility = reproductive performance of an individual or a population, often measured as number of viable offspring produced per spawning season.

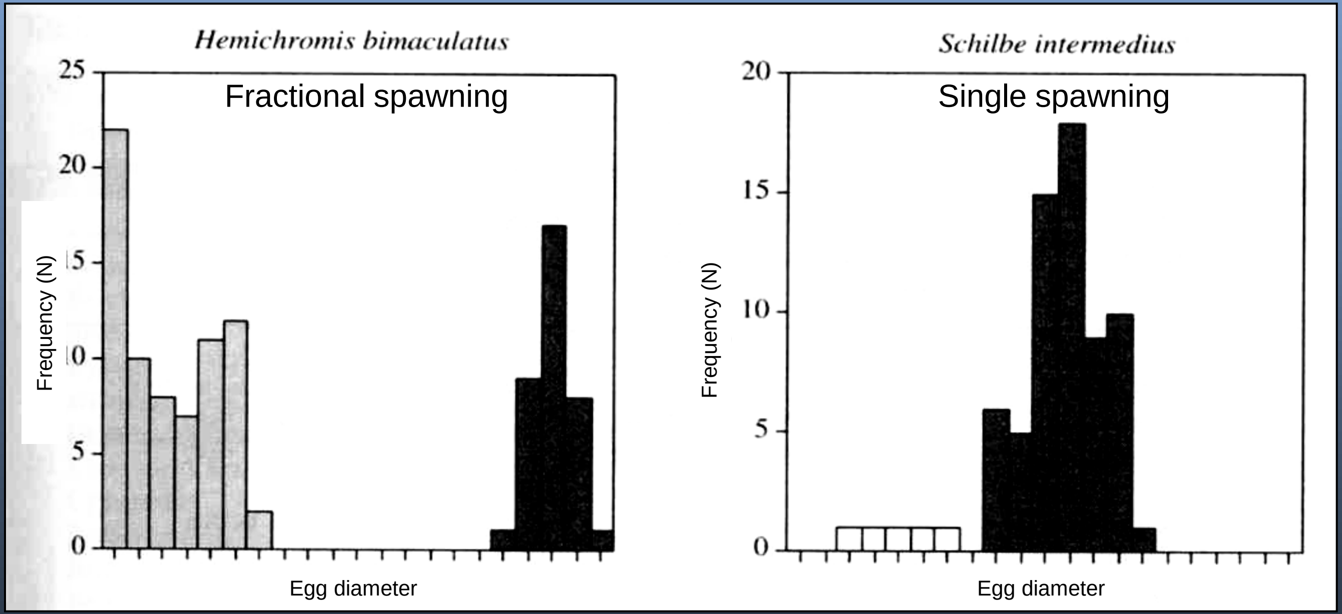
Spawning

-spawning strategies:

1) species with short annual spawning period: *total spawners*: all ova ripe at the same time; usually fecund fish; spawning stimulated either by local rains or floods coming downriver.

2) *multiple spawners* with long annual breeding season: eggs ripe in batches and are laid at intervals; advantageous if one of the batches may be endangered by unsuitable environmental conditions.

3) *small-brood spawners*: brood smaller when parental care is present (less eggs).



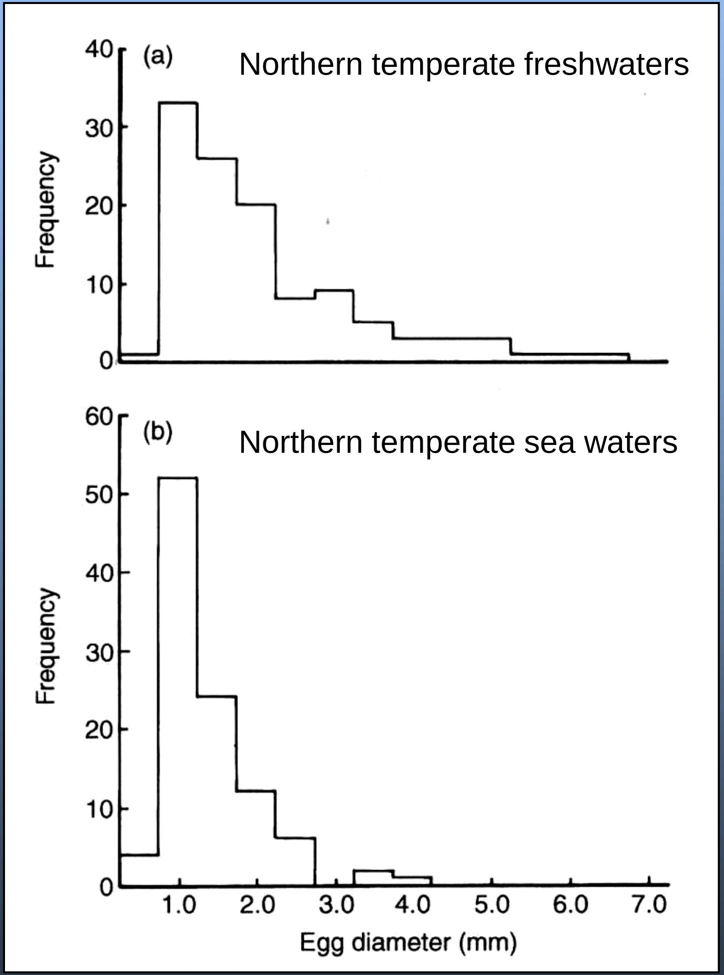
Egg characteristics and development

Egg size

optimal egg size = size at which (fecundity x survival) is maximum

larger egg → larger larvae → wider prey size range, better survival of food shortage and fewer predators, but also decrease of fecundity
→ trade-off between fecundity and juvenile survival

As parental care reduces instantaneous egg mortality, optimal egg size increases



Egg characteristics and development

Egg size

- large eggs are advantageous if food supply for larvae is sparse or variable, or if period spent in egg phase is relatively long and unpredictable.

- inter- and intraspecific variations are related to season, population, female body size and food availability.

- African species:

  small eggs in proliferating species (Cyprinidae, Alestiidae, Schilbeidae), often pelagic and migratory

  large eggs in Bagridae, Mormyridae (which only have a left gonad) and Cichlidae; in the latter substrate spawners have smaller and more eggs than mouthbrooders

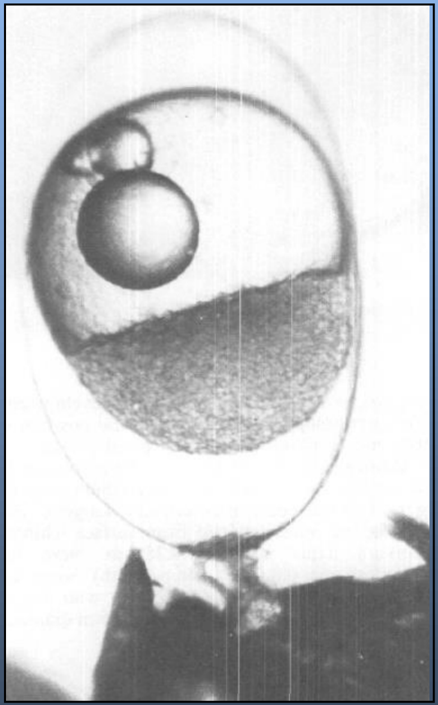
Egg characteristics and development

Pelagic and demersal eggs

pelagic: characteristic of off-shore marine species and most coral reef fish, and some freshwater species (carps); spawning at sites that ensure dispersal of eggs; little danger of anoxic or silty conditions, but sometimes large predation

Trachipterus eggs (pelagic)

demersal: characteristic of most freshwater species and many inshore marine fish; danger of siltation and deoxygenation unless water current is sufficient for eggs on substratum; burried eggs are protected from predation, but with the risk of deoxygenation; often parental care



Attached demersal egg of *Chromis dispilus* (from Kingsford & Leigh 1985)

Egg characteristics and development

Egg development

-embryonic stage: starts at fertilization; exclusively endogenous feeding on yolk.

-larval stage: starts at gradual but quick change of endogenous to exogenous feeding; presence of temporal larval organs.

-juvenile stage: starts when fins are well-developed; all temporary organs are replaced by final organs; ends with maturation of first gametes; usually a period of rapid growth, sometimes with a specific color(pattern).

-adult stage: starts with the maturation of the first gametes; decrease of growth rate.

-senescent stage: sometimes distinguished.

-diapause = arrest in development; occurs in annual fish (Cyprinodonts).

3 (obligate or facultative) diapause stages, counteracting environmental unpredictability: temporal hatching pattern decreases the risk that all eggs of a clutch hatch at an inappropriate time

Egg characteristics and development

Egg development

-2 main types of ontogenetic trajectories:

-altricial: many small eggs, resulting in small, incompletely developed larvae with little yolk, insufficient to produce the final phenotype; larvae must feed on exogenous small particles and are very vulnerable (e.g. *Alestes baremoze*)

-precocial: limited number of large eggs with a lot of yolk, producing larvae that are well-developed; larval stage is reduced or suppressed; juveniles are less vulnerable (e.g. *Labeotropheus*)

Reproductive behaviour

Mating systems

- defined by the number of members of the opposite sex with which an individual mates;

1) monogamy: individual mates with 1 member of the opposite sex, even if they do not stay together outside the breeding season; e.g. cichlid substrate spawners

2) polygamy:

   polygyny: 1 male fertilizes ova of multiple females
   polyandry: 1 female mates with several males
   promiscuity: both sexes mate with multiple partners

Broadcast spawning: large number of fish congregate at breeding grounds and spawn simultaneously; no courtship, no mate choice.

Reproductive behaviour

Courtship and recognition

- one of the functions is to synchronize spawning readiness in order that the gametes are extruded simultaneously.
- courtship may be a barrier against hybridization; color pattern serves species recognition.
- duration and level of complexity are similarly related to parental care.
- use of electric organ discharges in *Pollimyrus isidori.*

P. isidori

Reproductive behaviour

Territorial behaviour

- defending of optimal breeding site.

- hypothesis: territory is a resource required for spawning; suitable spawning sites are a resource of limited availability.

Territorial fight in male *Melanochromis auratus*

Neolamprologus cylindricus defending territory

Reproductive behaviour

Nest building

to protect eggs and larvae from predation.

Examples:

- *Protopterus annectens*: U-shaped, 40cm in substrate, with enlarged chamber between vertical arms

- *Heterotis niloticus*: circular miniature lagoon in 60cm deep water in thick and high grass, 2-10m from open water

- *Gymnarchus niloticus*: elliptical, made of plants, floating in open water or swampy areas

- *Hepsetus odoe*: one of the few non-cichlid nest-guarding freshwater fish species in Africa; builds foam nests among emergent reeds

Reproductive behaviour

Brood mixing

-fry displaced by predator attacks or territorial fights between parents may readily approached or be retrieved by unrelated adults.

-large schools of fry being guarded by 2-3 pairs of adults (one species, *T. rendalli*; also mixed schools).

-*Synodontis multipunctatus*: spawns eggs in mouth of host cichlid; cuckoo behaviour also in Lake Malawi cichlids.

Tilapia rendalli

Synodontis multipunctatus

Reproductive behaviour

Brood mixing

- farming out (*Perissodus microlepis*): fry taken up and released into a neighbouring conspecific brood (e.g. if one of the parents has left).

Neolamprologus brichardi

Perissodus microlepis

- helpers at the nest (e.g. *Neolamprologus brichardi*): young of different size classes found in breeding territories of parents, actively assisting in brood rearing.

Parental care

-all parental help to ameliorate the survival of eggs after fertilization.

-non-gametic contribution that enhances reproductive success and offspring survival; main function: protect young from predators and promote favourable conditions for growth and development.

-more prevalent in freshwater.

-in only 22% of teleost families, 60% of freshwater families.

-males 11%, females 7%, and both parents in 4% of the (known) cases.

Parental care

-types of parental care: pre-fertilisation activities (nest building), egg and fry guarding, egg ventilation, mouthing.

Nile tilapia © http://www.acuacultura.org/admin/paginas/galeria/galeria.php

© Foster and Smith Inc.

Dragonface pipefish

Examples

Agnatha

Unpaired gonad without gonoduct; eggs and sperm shed in body cavity and extruded through abdominal pores

-lampreys: eggs laid in nests (redds); hatch in about a fortnight as small pro-ammocoeta larvae; change soon in active ammocoeta stage burrowing in silt-banks to filter feed for 5 years or more, followed by metamorphosis to adults; larval stages resemble K-selection, but actually r-selection

top: Lamprey ammocoete: blind; lives in burrows
middle: life-stage that migrates to sea
lower left: enlargement showing the large eyes and seven gill-pouches
lower right: The oral disk, used for attachment to the host, with teeth inside used to rasp tissue.

Examples

Agnatha

Unpaired gonad without gonoduct; eggs and sperm shed in body cavity and extruded through abdominal pores

-hagfish: few eggs hatching after 2 months as small versions of adults; probably functionally dioecious, but gonads pass hermaphrodite stage; K-selected species

Eptatretus stoutii

© Johnny Jensen

Hagfish eggs

© www.uoregon.edu

Head of *Eptatretus cirrhatus*, with keratinous teeth in jawless mouth

© Carl Struthers / Museum of New Zealand Te Papa Tongarewa.

Examples

Elasmobranchiomorpha

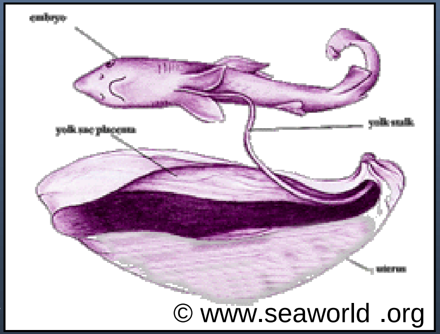
Elasmobranchs and holocephalans: fertilisation in oviduct; eggs retained or laid on sea bed; K-selected

- oviparity: restricted to chimaeras, skates and 4 shark families; incubation times vary from 2.5 to 12 months; egg sizes vary from about 1cm to 30x25cm, young < 30cm
- viviparity: generally produce large young (30-70cm); rate of reproduction much reduced; adults large; placental (hammerheads and grey sharks) *versus* aplacental (yolk-sac dependent or egg-eating young in sharks, placental analogues in rays)

Spiraled egg of oviparous horn shark

Aplacental viviparity in spiny dogfish

Placental viviparity in hammerhead embryo



Placental viviparity

Examples

Freshwater teleosts

-flood-plain rivers: spawning related to rains in tropics, which is main feeding and growing season; many larger species spawn just before or during floods

populations fluctuate markedly through migrations, seasonal spawning and mortality: strong selection pressures for high fecundity, rapid development and growth, short life cycles and rapid population turnover

-Great Lakes: less seasonal, more stable; cichlids spawn year-round, sometimes with seasonal peaks

stable populations: selection for reduced fecundity, longer life cycles and lower population turnover

Examples

Freshwater teleosts

-eggs: non-buoyant (except gouramis and grass carp); burried, attached to vegetation, placed in nest, carried, brooded; generally relatively large, resulting in larger larvae than those of marine fish (better able to stay in river to maintain local populations)

Bubble nest with bouyant eggs of *Trichogaster trichopterus* (three spot gourami)

Examples

Marine teleosts

-producers of bouyant eggs: dispersal of bouyant eggs and larvae, and post-larvae with small gas-filled swimbladder; post-larval stage hunts for small food (e.g. copepod nauplii); metamorphosis changes body form and inner organisation, but not body size, resulting in adult appearance

-producers of non-bouyant eggs: gobies, blennies and certain damselfish (eggs scattered over bottom, or attached and guarded)

-marked cline towards production of large grounded eggs when moving from tropics to polar regions:

tropics: mainly pelagic eggs

temperate areas: no marked difference between pelagic egg producers and others

arctics: K-selected species; large, yolky eggs laid on sea floor, resulting in large larvae; either a short larval stage exploiting short growing season, or more common a demersal larvae living near the bottom where seasonal changes are minimal

Life History in FishBase

1. Introduction

Accessible both from the Search Page and the Species Summary Page

Search Page

Species Summary Page

Information by Topic

Trophic ecology
- Diet
- Food items
- Food consumption
- Ration
- Predators

Physiology/Behavior
- Metabolism
- Gill area
- Brains
- Vision
- Fish sounds
- Swim. speed

Life history
- Growth
- L-W relationship
- Length frequencies
- Recruitment
- Reproduction
- Maturity
- Spawning
- Fecundity
- Eggs
- Egg dev.
- Larvae
- Larval dynamics
- Abundance

More information

Countries	Common names	Age/Size	References	Collaborators
FAO areas	Synonyms	Growth	Aquaculture	Pictures
Ecosystems	Metabolism	Length-weight	Aquaculture profile	Stamps, Coins
Occurrences	Predators	Length-length	Strains	Sounds
Introductions	Ecotoxicology	Length-frequencies	Genetics	Ciguatera
Stocks	Reproduction	Morphometrics	Allele frequencies	Speed
Ecology	Maturity	Morphology	Heritability	Swim. type
Diet	Spawning	Larvae	Diseases	Gill area
Food items	Fecundity	Larval dynamics	Processing	Otoliths
Food consumption	Eggs	Recruitment	Mass conversion	Brains
Ration	Egg development	Abundance	Vision	

2. REPRODUCTION Table

Reproduction of *Oreochromis esculentus*

Main Ref.	Trewavas, E., 1983
Mode	dioecism
Fertilization	in mouth
Spawning frequency	no obvious seasonal peak
Batch spawner	**Ref.**
Reproductive guild	bearers external brooders
Parental Care	
Description of life cycle and mating behavior	Reproduction probably triggered by the rains (Ref. 2771), with the time of maximum spawning activity coinciding with the wettest months of the year (Ref. 363). Males form a crater-like spawning nest without a distinct wall (Ref. 27292). The pit is about 30cm in diameter and 10cm deep, and is probably made in the early morning (Ref. 27292). Ovaries show that a female may have a succession of three or more broods in a spawning period; brooding females often shelter in weed beds and swampy places (Ref. 2, 363). Males defend their breeding territory (Ref. 2) for weeks or on and off for several months, while females only make short visits to the spawning grounds and leave the territory immediately after spawning (Ref. 363). Males eat little while actively guarding the nest (Ref. 363). Papyrus swamp channels (Ref. 363, 34921, 55020) and beaches with weed grown swamps (Ref. 34921) function as nursery areas. Young become independent at a length of about 1.5cm (Ref. 2, 363)by which size the yolk sac is occluded and they have strated to feed (Ref. 363), and at about 12cm TL they move from the nursery areas to the open water (Ref. 2).
Search for more references on reproduction	Scirus

Refers to where the egg and sperm meet, which may be external, internal (in the oviduct), in the mouth, in a brood pouch or similar structure, or elsewhere.

Choices are dioecism, protandry, protogyny, true hermaphroditism and parthenogenesis

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Search for more references on reproduction	Scirus

Based on the classification of Balon (1990):

Balon, E.K., 1990. Epigenesis of an epigeneticist: the development of some alternative concepts on the early ontogeny and evolution of fishes. Guelph Ichthyol. Rev. 1:1-48.

2. REPRODUCTION Table

I. Non-guarders of eggs and young
  A. Open substrate spawners
    1. Pelagic spawners, e.g. *Mola mola*
    2. Benthic spawners
      a. Spawners on coarse substrates (rocks, gravels, etc.)
        (1) Pelagic free embryo and larvae, e.g. *Morone saxatilis*
        (2) Benthic free embryo and larvae, e.g. *Phoxinus phoxinus*
      b. Spawners on plants
        (1) Non-obligatory, e.g. *Rutilus rutilus*
        (2) Obligatory, e.g. *Esox lucius*
      c. Spawners on sandy substrates, e.g. *Gobio gobio*
  B. Brood hiders
    1. Benthic spawners, e.g. *Oncorhynchus nerka*
    2. Cave spawners, e.g. *Anoptichthys jordani*
    3. Spawners on invertebrates, e.g. *Rhodeus amarus*
    4. Beach spawners, e.g. *Leuresthes tenuis*
    5. Annual fishes, e.g. *Nothobranchius guentheri*

II. Guarders
  A. Substrate choosers
    1. Rock spawners, e.g. *Chromis chromis*
    2. Plant spawners, e.g. *Pomoxis annularis*
    3. Terrestrial spawners, e.g. *Copeina arnoldi*
    4. Pelagic spawners, e.g. *Ophiocephalus* spp.
  B. Nest spawners
    1. Rock and gravel nesters, e.g. *Ambloplites rupestris*
    2. Sand nesters, e.g. *Cichlasoma nicaraguense*
    3. Plant material nesters
      a. Gluemakers, e.g. *Gasterosteus aculeatus*
      b. Non-gluemakers, e.g. *Micropterus salmoides*
    4. Bubble nesters, e.g. *Betta splendens*
    5. Hole nesters, e.g. *Cottus aleuticus*
    6. Miscellaneous materials nesters, e.g. *Lepomis macrochirus*
    7. Anemone nesters, e.g. *Amphiprion* spp.

III. Bearers
  A. External bearers
    1. Transfer breeders, e.g. *Oryzias latipes*
    2. Forehead breeders, e.g. *Kurtius gulliveri*
    3. Mouthbrooders, e.g. *Oreochromis mossambicus*
    4. Gill-chamber brooders, e.g. *Typhlichthys subterraneus*
    5. Skin brooders, e.g. *Bunocephalus*
    6. Pouch brooders, e.g. *Syngnathus abaster*
  B. Internal bearers
    1. Ovi-ovoviviparous, e.g. *Glandulocauda inequalis*
    2. Ovoviviparous, e.g. *Sebastes marinus*
    3. Viviparous, e.g. *Poecilia reticulata*

- Most fish: non-guarding, egg-scattering pelagic spawners.
- More specialised guilds:
  - low fecundity but large-yolked ova;
  - spawn in specially prepared nests;
  - exercise expensive parental care;
  - embryos with accelerated differentiation;
  - precocial forms produce well-developed young.
- Great African Lakes: mainly guarders and bearers (predictable physico-chemical regimes).
- African rivers and wet zones: mainly non-guarders and -bearers (non-predictable physico-chemical regimes).

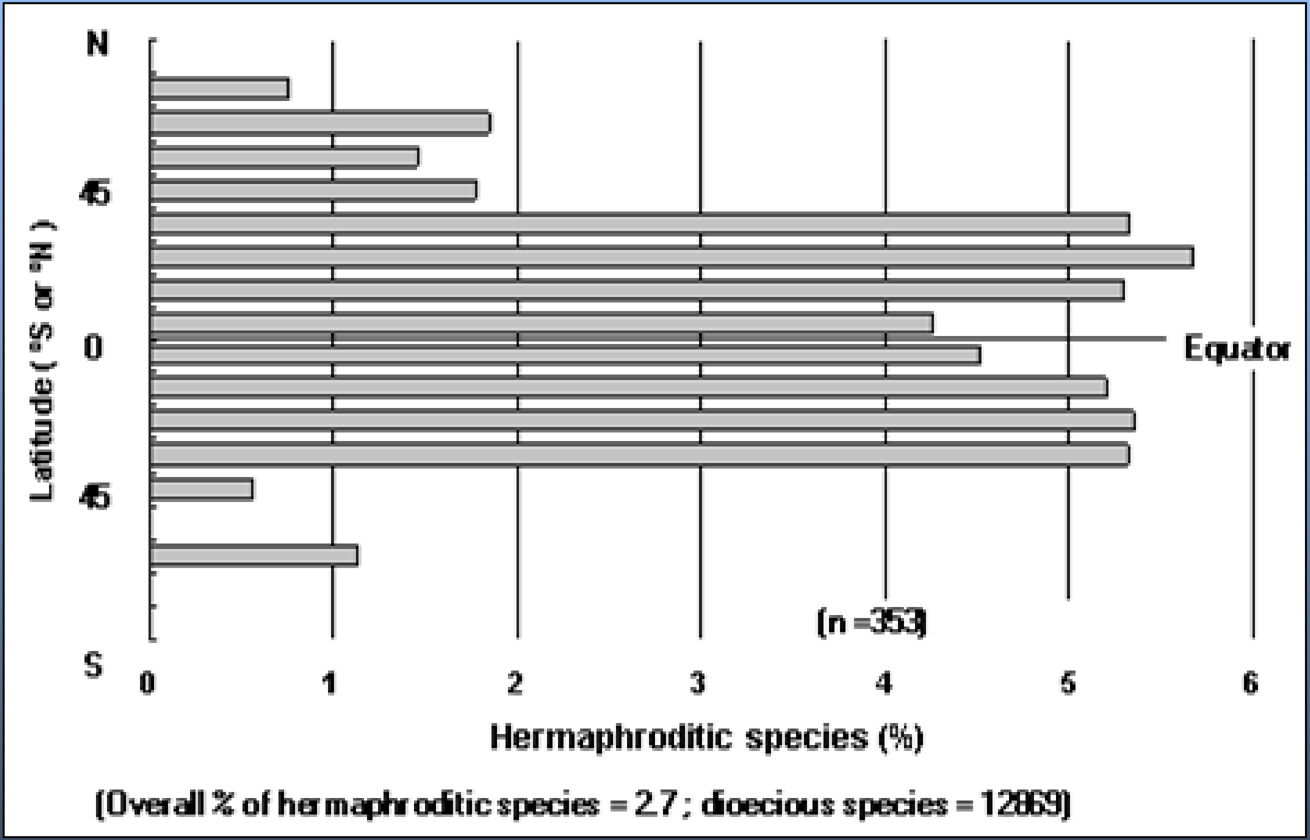
2. REPRODUCTION Table

Reproduction of *Oreochromis esculentus*

Main Ref.	Trewavas, E., 1983
Mode	dioecism
Fertilization	in mouth
Spawning frequency	no obvious seasonal peak
Batch spawner	**Ref.**
Reproductive guild	bearers external brooders
Parental Care	
Description of life cycle and mating behavior	Reproduction probably triggered by the rains (Ref. 2771), with the time of maximum spawning activity coinciding with the wettest months of the year (Ref. 363). Males form a crater-like spawning nest without a distinct wall (Ref. 27292). The pit is about 30cm in diameter and 10cm deep, and is probably made in the early morning (Ref. 27292). Ovaries show that a female may have a succession of three or more broods in a spawning period; brooding females often shelter in weed beds and swampy places (Ref. 2, 363). Males defend their breeding territory (Ref. 2) for weeks or on and off for several months, while females only make short visits to the spawning grounds and leave the territory immediately after spawning (Ref. 363). Males eat little while actively guarding the nest (Ref. 363). Papyrus swamp channels (Ref. 363, 34921, 55020) and beaches with weed grown swamps (Ref. 34921) function as nursery areas. Young become independent at a length of about 1.5cm (Ref. 2, 363)by which size the yolk sac is occluded and they have strated to feed (Ref. 363), and at about 12cm TL they move from the nursery areas to the open water (Ref. 2).
Search for more references on reproduction	Scirus

2. REPRODUCTION Table

Percentage of hermaphroditic fishes in relation to latitudinal range:



3. MATURITY Table

Search Page

List of species with maturity information

Species Summary Page

Maturity studies for *Oreochromis esculentus*

n = 17

Lm vs Linf graph

(Loading may take 2-3 mins.)

Distributions

Sort by ◉ Lm ○ Country ○ Locality ○ tm

	Lm (cm)	Length (cm)			Age range (y)			tm (y)	Sex of fish	Country	Locality
☐		25.0	-	26.0		-			unsexed	Uganda	Jinja area, Lake Victoria
☐		17.0	-			-			mixed	Tanzania	Lake Nyumba ya Mungu
☐		25.0	-	26.0		-			unsexed	Uganda	Lake Victoria
☐		22.0	-			-			mixed	Tanzania	Speke Gulf, Lake Victoria
☐		19.0	-			-			unsexed	Tanzania	Malya Dam
☑		20.0	-		2.0	-	3.0		unsexed		Lake Victoria
☐	22.0 TL	19.0	-			-			mixed	Kenya	Kavirondo Gulf, Lake Victoria
☐	22.0 TL		-	26.0		-			unsexed	Kenya	Kavirondo Gulf, Lake Victoria
☐	22.5 TL		-			-			unsexed	Uganda	Jinja area, Lake Victoria.
☐	23.0 TL		-			-			unsexed	Kenya	Kavirondo Gulf, Lake Victoria.
☐	23.8 TL		-			-			unsexed	Tanzania	Southern (Mwanza) area, Lake Victoria
☐	25.0 TL	21.0	-	27.0		-			mixed	Uganda	Hannington Bay, Jinja region, Lake Victoria
☐	26.0 TL		-			-			unsexed	Tanzania	Mwanza area, Lake Victoria
☐	26.0 TL	21.0	-			-			mixed	Tanzania	Smith Sound, Lake Victoria
☐	26.0 TL	20.0	-			-			mixed	Uganda	Pilkington Bay, Lake Victoria
☐	28.0 TL	26.0	-			-			mixed	Uganda	Sesse Islands, Lake Victoria
☐	28.0 TL	23.0	-			-			mixed	Tanzania	Lake Victoria

Distributions | Show Genus | Show Family

3. MATURITY Table

Maturity Information for *Oreochromis esculentus*

Main Ref.	Lowe-McConnell, R.H., 1982		
Sex of fish	unsexed		
Age range (y)	2	-	3
tm (y)			
Age Ref.			
Length (cm)	20	-	
Lm (cm)	TL		
Length Ref.			
Locality	Lake Victoria		

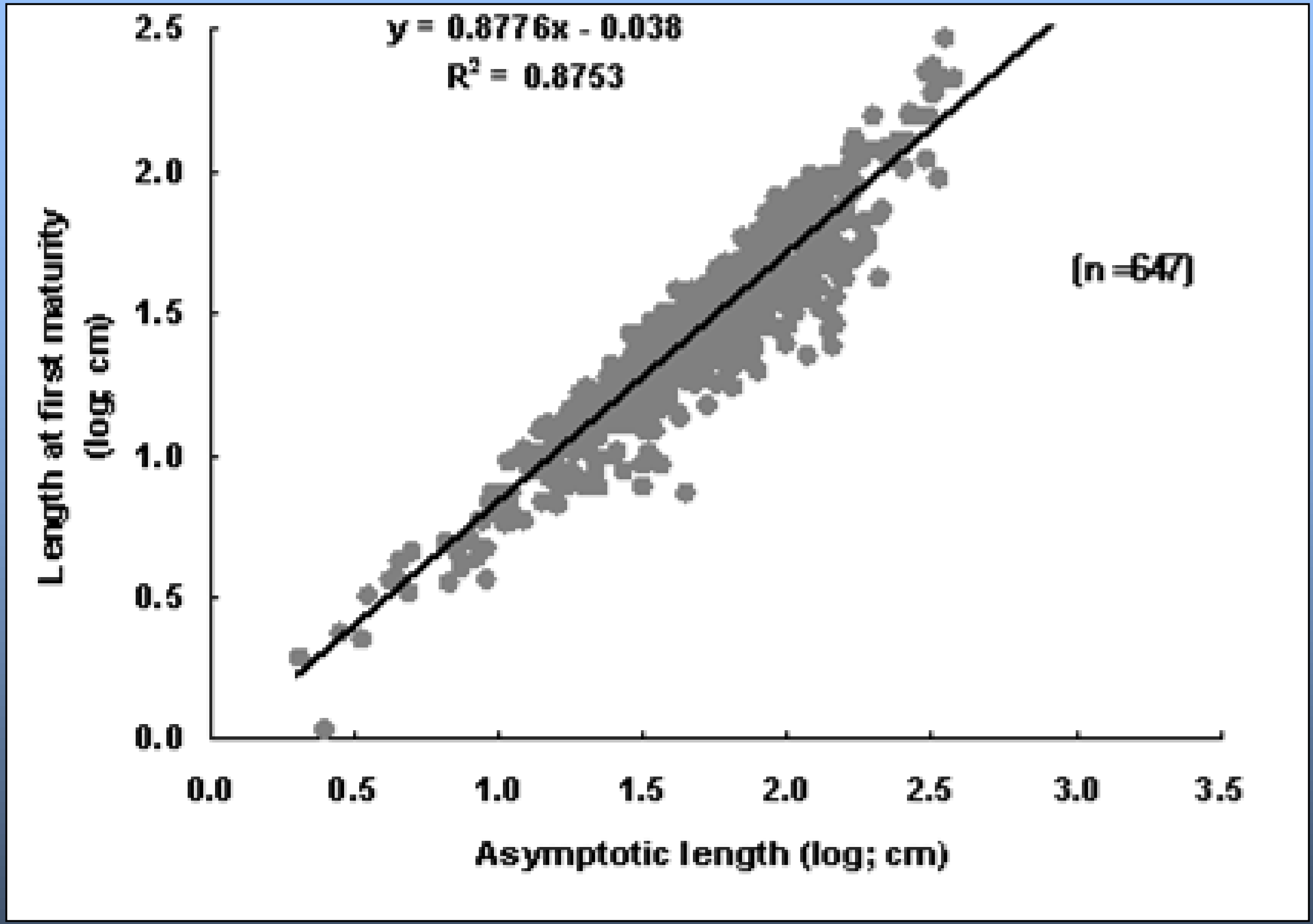
Age and length range at which all studied specimens were found to be mature

Maturity Information for *Oreochromis esculentus*

Main Ref.	Lowe-McConnell, R.H., 1982		
Sex of fish	unsexed		
Age range (y)	2	-	3
tm (y)			
Age Ref.			
Length (cm)	20	-	
Lm (cm)	TL		
Length Ref.			
Locality	Lake Victoria		

Age and length at which 50% of the studied specimens were found to be mature

3. MATURITY Table



Length at first maturity *vs* asymptotic length (L_{inf})

4. SPAWNING Table

Search Page → List of species with maturity information

Species Summary Page

Spawning for *Oreochromis esculentus*

n = 5

J	F	M	A	M	J	J	A	S	O	N	D	Country	Locality
111	111	111	111	111	111	111	111	111	111	111	111	Uganda	Hannington Bay in the Jinja area
111	111	111	111	111	111	111	111	111	111	111	111	Kenya	Kavirondo Gulf
111	111	111	111						111	111	111	Tanzania	Mwanza Gulf, Lake Victoria
111	111	111	111	111	111	111	111	111	111	111	111	Uganda	Pilkington Bay in the Jinja area
111	111	111	111	111	111	111	111	111	111	111	111	Tanzania	Smith Sound, Lake Victoria

4. SPAWNING Table

Spawning of *Oreochromis esculentus*

Main Ref:	Trewavas, E., 1983											
Data Ref.:												
Country:	Kenya											
Spawning ground:	lacustrine											
Locality:	Kavirondo Gulf											
Season:	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
	111	111	111	111	111	111	111	111	111	111	111	111
Sex ratio:	% Ref.:											
Temperature:	- °C											
Gestation period:	month/s											
Length of offspring:	cm											
Batch spawners												
Daily spawning frequency	- Mean: Min Ref.: Max Ref.: Mean Ref.:											
Comments:												

The habitat type where spawning occurs, which may be lacustrine, riverine, estuarine, coastal, shelf or oceanic.

Pertains to the average percentage of spawning females in a spawning stock.

The monthly percentage of mature females is entered here. When '111' is used, this refers to months during which mature females were reported, but without indication of their relative abundance.

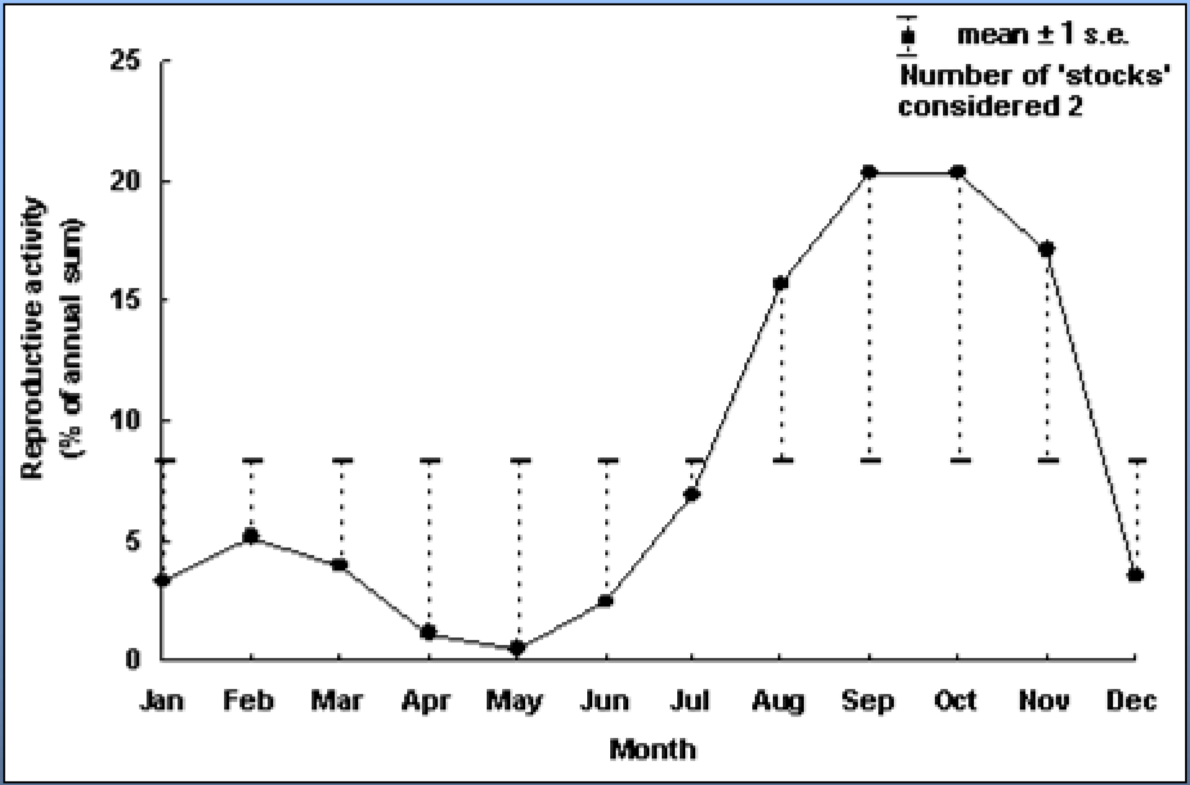
4. SPAWNING Table

Spawning of *Oreochromis esculentus*

Main Ref:	Trewavas, E., 1983											
Data Ref.:												
Country:	Kenya											
Spawning ground:	lacustrine											
Locality:	Kavirondo Gulf											
Season:	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
	111	111	111	111	111	111	111	111	111	111	111	111
Sex ratio:	% Ref.:											
Temperature:	- °C											
Gestation period:	month/s											
Length of offspring:	cm											
Batch spawners												
Daily spawning frequency	- Mean:											
	Min Ref.: Max Ref.: Mean Ref.:											
Comments:												

Applies to batch spawners only, and gives the frequency of spawning per day (e.g. 0.5 means half of the females spawn every day, i.e., an individual female spawns every second day).

4. SPAWNING Table



Seasonality of spawning in *Engraulis ringens* off North/Central Peru

Engraulis ringens (anchoveta)

4. Fecundity Table

Search Page → **List of species with fecundity information**

Species Summary Page

Fecundity for *Clarias gariepinus*

Sort by ◉ Country ○ Locality
[n = 6]

Country	Locality	Absolute Fecundity		Relative Fecundity			Fecundity/length relationship	
		min	max	Min	Mean	Max	a	b
	Lake Victoria	5,000	192,000					
Egypt	Lake Manzala	27,000	112,000					
Ethiopia	Lake Awassa	8,800	650,000				0.0891251	3.2
Nigeria	Cross River (Jan 2004-Dec 2006)	62,879	81,047					
Nigeria	hatchery	0	0	208		326		
Turkey	River Asi (1996-1998)	4,483	336,157					

4. Fecundity Table

Fecundity of *Clarias gariepinus*

Main Ref:	Dadebo, E., 2000			
Country:	Ethiopia			
Locality:	Lake Awassa			
Ecosystem:				
	Absolute Fecundity			
	min 8,800	(g)	(cm)	Ref: Dadebo, E., 2000
	max 650,000	(g)	(cm)	
Comments on Fecundity:				
Relative Fecundity				
	Min:	Ref.:		
	Mean:	Ref.:		
	Max:	Ref.:		
	Fecundity/length relationship (F = a * L ^b):			
	Size: 34 - (cm) TL			
	n: 67			
	a: 0.089	95% confidence limit:		
	b: 3.200	95% confidence limit:		
	r^2: 0.734			
Spawning Cycles:	(1/y)	Ref:		
Comments:	Breeding occurs during high rainfall and low temperature (Ref. 38048). Breeding migration might occur but more evidence is needed to confirm this (Ref. 38048).			
Entered by: *Torres, Armi G.* ***- 08.09.03*** ***Modified by:*** *Luna, Susan M.* ***- 17.09.03***	Back to Search			

Number of eggs in a female of a certain length/weight

Defined as the number of mature oocytes in a female divided by the total weight of that female.

4. Fecundity Table

Fecundity of *Clarias gariepinus*

Main Ref:	Dadebo, E., 2000			
Country:	Ethiopia			
Locality:	Lake Awassa			
Ecosystem:				
Absolute Fecundity				
	min 8,800	(g)	(cm)	Ref: Dadebo, E., 2000
	max 650,000	(g)	(cm)	
Comments on Fecundity:				
Relative Fecundity				
	Min:	Ref.:		
	Mean:	Ref.:		
	Max:	Ref.:		
	Fecundity/length relationship (F = a * L ^b):			
	Size: 34 - (cm) TL			
	n: 67			
	a: 0.089	95% confidence limit:		
	b: 3.200	95% confidence limit:		
	r^2: 0.734			
Spawning Cycles:	(1/y)	Ref:		
Comments:	Breeding occurs during high rainfall and low temperature (Ref. 38048). Breeding migration might occur but more evidence is needed to confirm this (Ref. 38048).			
Entered by: *Torres, Armi G.* ***- 08.09.03*** ***Modified by:*** *Luna, Susan M.* ***- 17.09.03***	Back to Search			

Very useful but rarely given in literature.

5. EGGS Table

Search Page → **List of species with egg information**

Species Summary Page

Egg Characteristics of *Clarias gariepinus*

Main Ref.	Legendre, M. and G.G. Teugels, 1991
Place of Development	fixed on plant or stone
Shape of Egg	spherical
Attributes	smooth, sticky
Color of Eggs	
Color of Oil Globule	
Additional Characters	Eggs are scattered on some vegetation and adhere on the substrate (Ref. 43949).
Get Information on	Scirus

buoyant (pelagic) fixed on plant or stone in open nest in bubble nest attached to parental body in female (live-bearers) in another animal (i.e. bivalve)	on the bottom (demersal) in sand or gravel in covered nest (i.e. burrow or tunnel) in mouth (mouthbrooders) in brood pouch outside the water other	smooth with filaments with stalk other	sculptured with tendrils in jelly matrix

6. EGG DEVELOPMENT Table

Search Page → **List of species with egg development information**

Species Summary Page

List of Egg Development Time for
Clarias gariepinus

[n=3]

Sort by ○ Country ◉ Locality

Dev. time (days)	Temp. (°C)	Diam. (mm)	Salinity (ppt)	Locality	Country
1.10	25.00	2.00		Lake Victoria	(not available)
0.58	33.00	0.00		Not specified.	(not available)
1.38	25.00	0.00		Not specified.	(not available)

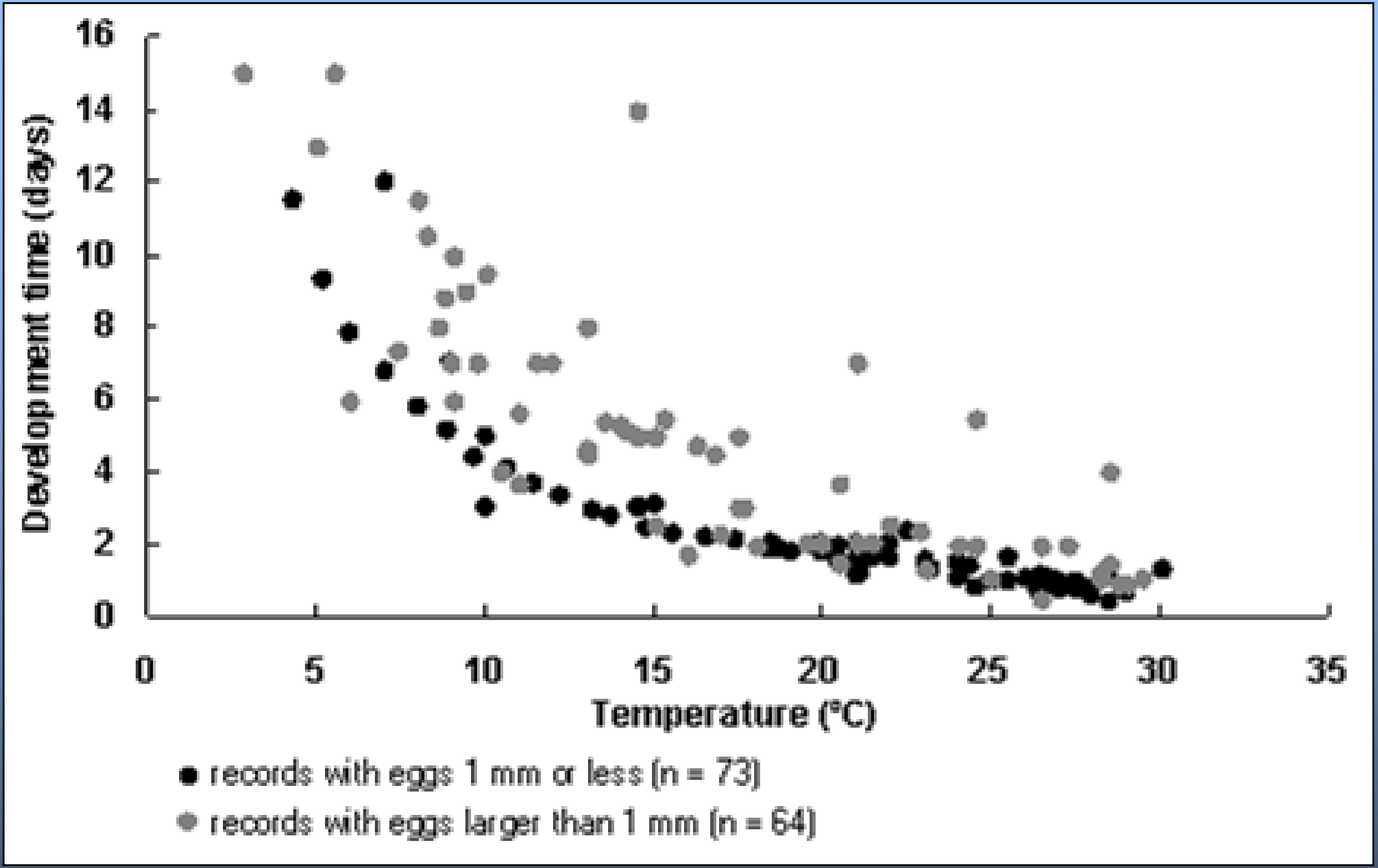
6. EGG DEVELOPMENT Table

Egg Development Time for *Clarias gariepinus*

Main Ref:	6868
Locality:	Lake Victoria
Country:	
Temperature:	25.00 ° C
Salinity:	ppt
Egg diameter:	2.00 mm
Egg development time:	1.10 days Ref. 6868
Data type:	based on field data
Remarks	Eggs about 2 mm or less; 22-28° C; 23-30 hrs hatching time

Duration from spawning/fertilization to hatching, in days; ideally this should refer to the time when 50% of the eggs have hatched, but often refers to a midrange.

6. EGG DEVELOPMENT Table



Relationship between the mean development time of fish eggs and the mean temperature of the water in which they develop.

7. LARVAE Table

Search Page → **List of species with maturity information**

Species Summary Page

Attach your web site to this page

Summary for *Clarias gariepinus* larvae
North African catfish

www.larvalbase.org

Clarias gariepinus (Burchell, 1822)

Family:	Clariidae (Airbreathing catfishes)
Order:	Siluriformes
Class:	Actinopterygii (ray-finned fishes)
English name:	North African catfish
Distribution:	Africa: almost Pan-Africa, absent from Maghreb, the upper and lower Guinea and the Cape province and probably also Nogal province. Asia: Jordan, Israel, Lebanon, Syria and southern Turkey. Widely introduced to other parts of Africa, Europe and Asia. Several countries report adverse ecological impact after introduction. Trade restricted in Germany (Anl.3 BArtSchV).
Adult biology:	Occurs mainly in quiet waters, lakes and pools but may also occur in fast flowing rivers and in rapids (Ref. 248). Widely tolerant of extreme environmental conditions. The presence of an accessory breathing organ enables this species to breath air when very active or under very dry conditions. Remains in the muddy substrates of ponds and occasionally gulp air through the mouth (Ref. 6465). Can leave the water at night using its strong pectoral fins and spines in search of land-based food or can move into the breeding areas through very shallow pathways (Ref. 6868). A bottom feeder which occasionally feeds at the surface (Ref. 248). Forages at night on a wide variety of prey (Ref. 6868). Feeds on insects, plankton, invertebrates and fish but also takes young birds, rotting flesh and plants (Ref. 6465). Migrates to rivers and temporary streams to spawn (Ref. 34291). Also caught with dragnets. During intra-specific aggressive interactions, this species was noted to generate electric organ discharges that were monophasic, head-positive and lasting from 5-260 ms (Ref. 10479). Known as sharptooth catfish in aquaculture, a highly recommended food fish in Africa (Ref. 52863). Marketed fresh and frozen; eaten broiled, fried and baked (Ref. 9987).
Diagnosis:	At 6 mm, mouth is terminal, pectoral fins appear, dorsal and anal finfolds become broader, flexion achieved. At 7 mm, exogenous feeding starts, a rudimentary stomach appears, gas bladder and liver visible, taste buds develop along the entire margin of the finfold and the pectoral fins. At 8 mm, heavy pigmentation over the head and entire body. Lepidotrichia appers on the lower lobe of the caudal fin. At 8.5 mm, rudiments of the pelvic fin appears, lepidotrichia are completely formed in the caudal fin. Barbels grew as broad lobes. At 9 mm, first rays of the dorsal fin appear. At 12 mm, body almost black, 14 rays appear in the anal fin, 30 fin rays in the dorsal fin. At 16 mm, body is strongly pigmented. Number of rays in fins: D 62-82, A 50-65, P 10-12. Pectoral fin is half of head length.. See also LARVAE table.
Climate Zone:	subtropical; 8 - 35°C; 52°N - 28°S
Main Ref:	Zaki, M.I. and A. Abdula. 1983. (Ref. 43949)
More information:	Allele frequencies | Broodstock | Collaborators | Common names | Countries | Egg dev. | Egg Nursery System | Eggs | FAO areas | Food consumption larvae | Fry Nursery System | Genetics | Introductions | Larvae | Larval Nursery System | Maturity | Predators | References | Reproduction | Spawning | Synonyms |
Internet sources:	CISTI | Google | GoogleImages | GOBASE | GenBank | PubMed | Scirus | Zoological Record | Check for Self-registered sites Note: use the Back button of your browser to return to LarvalBase.

7. LARVAE Table

LarvalBase | FishBase

Larvae Information Summary for *Clarias gariepinus*

Main Ref: 43949

Yolk-sac larvae

	max	min	mod	Ref.
Length at birth (mm)	4.8	4.4	4.6	43949
Preanal L. % TL				

Place of development	in close association with substrate		
Larval area	Lake Manzala, Egypt		
Yolk-sac	elongated	Ref:	
Yolk		Oil globules	
Rows on tail	dorsal + ventral row		
Other melanophores on tail	no other melanophores		
Melanophores on head + trunk	melanophores on head + trunk		

At hatching, there are 22 segments on the trunk, 27 in the tail. Gut is straight. At 5 mm, the vascular system develops, rudiments of the gill arches appeared. Ramified ducts of Cuvier appear on the lateral surfaces of the yolk sac. At 5.1 mm, the myotome numbers increased to 41, segmental vessels are visible in the trunk and the tail. The pronephros, located above the gut has developed. Ttwo pairs of dilated lobular barbels (0.13-0.05 mm) are visible. Eyes, 0.1 mm in diameter, are small. Semicircular canals began to form in the auditory vesicles. At 5.2 mm, the head is straight, mouth is inferior, third pair of barbels forms. Melanophores are visible dorsally and along the lateral line. Eye melanin present. At 5.7 mm, yolk sac decreases, operculum present covering the gills with well developed gill filaments. Melanophores on the entire head present, also in two bands along the dorsum, along the gut, and the lower ends of the caudal myotomes. Each of the 4 paired barbels is located on the maxillary, anterior mandibula, posterior mandibula, and nasal area. At 6 mm, strong pigmentation present on the anal finfold and on the yolk sac. Length of barbels increases.

Post larvae

Striking feature	none		
Striking shape lateral	normal (not striking)	dorsal	
Striking feature	none		
Shape of gut	elongated		
Gas bladder early	visible	late	
Spinal armature early	no spines	late	no spines
Pigmentation early			
Rows on tail	dorsal row		
Other melanophores on tail	no other melanophores		
Melanophores on head + trunk	melanophores on head + trunk		
Rows on tail	no rows		
Other melanophores on tail	tail completely covered with melanophores		
Melanophores on head + trunk	melanophores on head + trunk		
Peritoneum	with row of melanophores		
Pectorals	normal with rows of melanophores		
Pelvics	normal (i.e. small or absent) with melanophores		

At 6 mm, mouth is terminal, pectoral fins appear, dorsal and anal finfolds become broader, flexion achieved. At 7 mm, exogenous feeding starts, a rudimentary stomach appears, gas bladder and liver visible, taste buds develop along the entire margin of the finfold and the pectoral fins. At 8 mm, heavy pigmentation over the head and entire body. Lepidotrichia appers on the lower lobe of the caudal fin. At 8.5 mm, rudiments of the pelvic fin appears, lepidotrichia are completely formed in the caudal fin. Barbels grew as broad lobes. At 9 mm, first rays of the dorsal fin appear. At 12 mm, body almost black, 14 rays appear in the anal fin, 30 fin rays in the dorsal fin. At 16 mm, body is strongly pigmented. Number of rays in fins: D 62-82, A 50-65, P 10-12. Pectoral fin is half of head length.

	L 1st feeding	Ref.	Months of presence of larvae			
max			○ Jan	○ Feb	○ Mar	○ Apr
min	7	43949	○ May	○ Jun	○ Jul	○ Aug
mod			○ Sep	○ Oct	○ Nov	○ Dec

Water parameters Metric characters

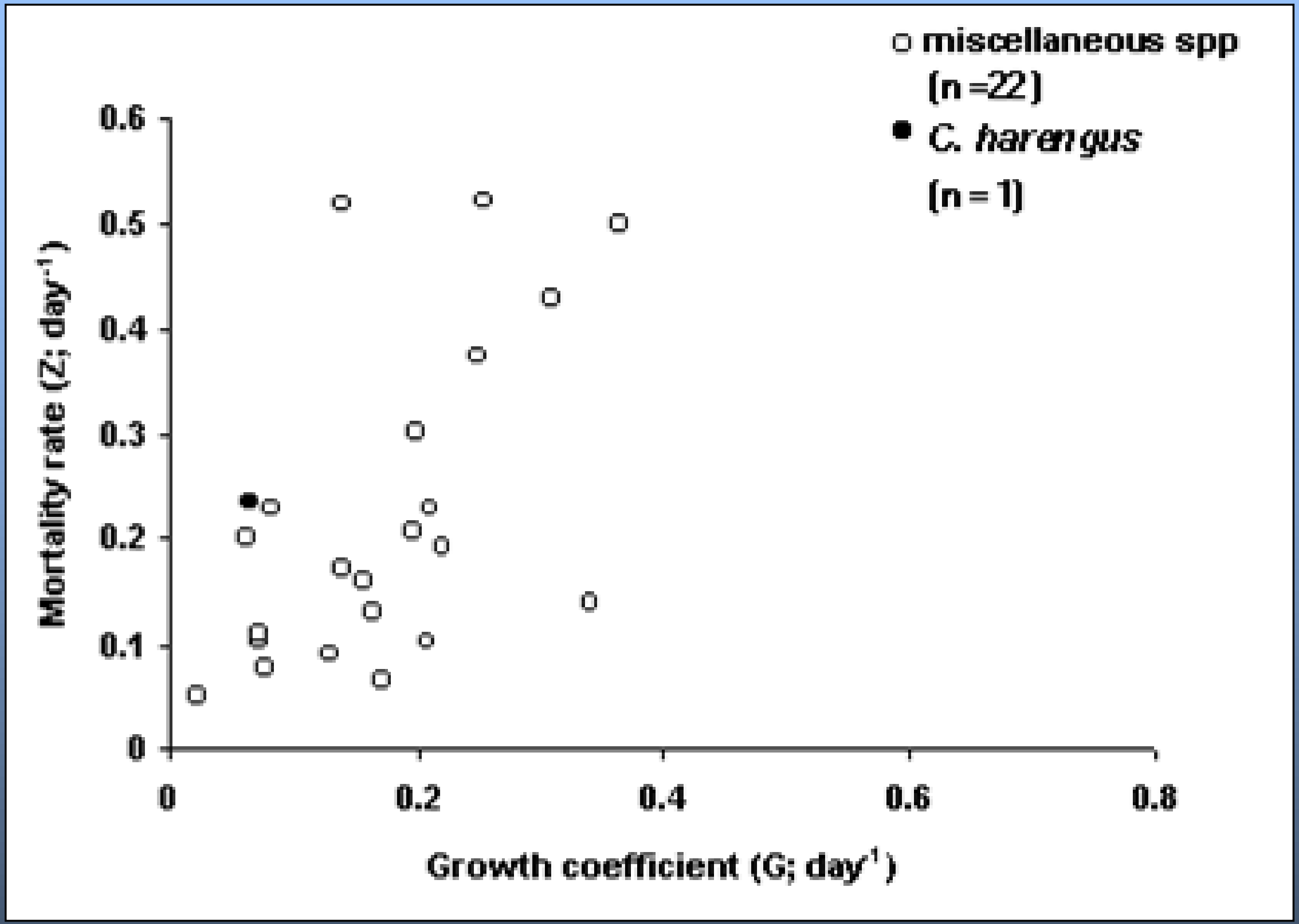
8. LARVAL DYNAMICS Table

Developed by Edward D. Houde and Colleen E. Zastrow (1993) (Ecosystem- and taxon-specific dynamic energetics properties of fish larvae assemblages. Bull. Mar. Sci. 53(2):290-335), covering only about 100 species

Larval Dynamics and Energetics for *Clupea harengus*

Main Ref:	3586
Ecosystem:	Shelf
Temperature: (° C):	11.5
Larval stage duration: (d):	160
Dry weight at hatching: (µg):	90
Dry weigth at metamorphosis (µg):	25000
Growth coefficient: (G; 1/d):	0.065
Mortality rate: (M; 1/d):	0.235
Oxygen consumption: (QO2; µl/mg/h):	2.65
Food ingestion: (I; 1/d):	0.181
Comment:	
References used:	4175, 4132, 4138, 4060, 4094, 4151, 4251, 4158, 4242, 4216, 4252, 4274

8. LARVAL DYNAMICS Table



Relationship between mortality and growth in larvae. Light dots: all data points in FishBase. Black dot: record for herring larvae.

Juvenile *Lepisosteus platyrhinchus* © www.stetson.edu