PROCEEDINGS OF THE CALIFORNIA ACADEMY OF SCIENCES

Series 4, Volume 60, No. 13, pp. 447–454, 6 figs., 1 table. September 25, 2009

Comments on the Extremes in Longevity in Fishes, with Special Reference to the Gobiidae

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The life span of fishes has been determined primarily by survival time in public aquaria and by counting the annular marks of otoliths. The fishes with the longest duration of life are deeper-water species, such as rockfishes of the genus *Sebastes*, some with validated ages in excess of 100 years. The goby *Eviota sigillata*, maximum length 21 mm, has the shortest published life span, 59 days. However, other smaller gobies, such as *Trimmaton nanus* (mature at 10–12.5 mm), the neotenic gobioid fishes of the family Schindleriidae (mature as small as 8.5 mm), and the miniature cyprinid fishes of the genus *Paedocypris*, (mature as small as 7.9 mm), might be expected to have even shorter life spans. Predation, parasites, disease, and catastrophic environmental events shorten the lives of fishes in nature. We report here the longevity of the following small gobiid fishes in aquaria in Hawai'i: *Kelloggella oligolepis*, 22 months; *Eviota nigriventris*, 23 months; *Trimma rubromaculatum* and *T. tevegae*, 12–20 months; *Priolepis nocturna*, 3 years and 3 months; *Asterropteryx semipunctata*, at least 11 years, and *Gobiodon okinawae*, at least 13 years. A table is provided of 15 species of fishes that have lived from 13 to 24 years in the Waikiki Aquarium, Honolulu.

The life span of fishes is believed to be related to their adult size, with small species having the shortest duration of life, as we might deduce from mammals by comparing the longevity of a shrew with that of an elephant. While this is true of fishes in general, there are many exceptions. The Dolphinfish (*Coryphaena hippurus*), which reaches a length of 2.1 m and a weight of 40 kg, has a life span of only four to five years. We will show that some gobiid fishes smaller than 10 cm in total length can live more than 10 years in aquaria, where they are free from predation, and with proper care, from disease.

Some early publications on natural history attributed ages as great as 150 years to the Carp (*Cyprinus carpio*) and 200 years to the Pike (*Esox lucius*). These records have been shown to be fables (Norman 1949). Flower (1925) quoted Buffon (1769) on the two ways to determine the age of a fish: by counting the annular marks in scales (the denser zones of the concentric rings that represent a period of slower growth) or by recording its life span in captivity. He then reported on the longevity of 42 species of fishes representing 11 families in the Gezira Aquarium in Cairo, which he directed from 1903 to 1923. In addition, he obtained data on survival time of 59 more species from 15 public aquaria that he visited, as well as longevity data from R.C. Osborn of the New York Aquarium. The longest life span he found was 36 years for the sturgeon known as the Sterlet (*Acipenser ruthensis*). The greatest reliable age he gave for the Pike was 14 years, and for the Carp,

24 years. He cited Günther (1880) for the shortest life span of a fish, the Transparent Goby (*Latrunculus pellucidus*, now *Aphia minuta*), which ranges throughout Europe and North Africa. It lives only one year and dies after spawning. Günther called it the first annual vertebrate. Flower (1925) also included the maximum age of three individuals of the Mangrove Goby (*Periophthalmus koelreuteri*) in the London Zoological Garden as 14.5 to nearly 19 months.

Myers (1952) wrote an article entitled "Annual Fishes" in the July issue of the *Aquarium Journal of the San Francisco Aquarium Society*. He listed species such as South American killifishes (*Cynolebias* spp.) that live less than one year.

In the published proceedings of a colloquium on ageing in animals, Nigrelli (1961) reported the longevity of 123 species of fishes from records of the New York Aquarium. The seven longest-lived were the Bowfin (*Amia calva*) 30 years, Longnose Gar (*Lepidosteus osseus*) 30 years, Striped Bass (*Roccus saxatilis*) 24 years, African Lungfish (*Protopterus annecteus*) 23 years, Shortnose Gar (*L. platosteus*) 20 years, Rock Bass (*Ambloplites rupestris*) 18 years, and the Dog Snapper (*Lutjanus jocu*) 14 years. He also listed the 23 species of fishes that lived 20 years or more in other public aquaria. Of these, 11 lived 25 years or more: *Acipenser ruthenus* 69 years, *Cyprinus carpio* 38 years, *Polypterus senegalus* 34 years, *Pimelodus stegelichi* 30 years, *Morone labrax* 30 years, *Epinephelus gigas* 29 years, *Marcusenius isidori* 28 years, *Pimelodus clarias*, 27 years, *Gymnothorax mordax* 26 years, *Doras* sp. 26 years, and *Ginglymostoma cirratum* 25 years. Noteworthy for a gobioid fish is the 20-year, 5-month longevity of *Eleotris marmoratus.*

In the same colloquium, Beverton and Holt (1961) reviewed the longevity of fishes in nature as related to growth, size, maturation, and other physiological factors.

Condé (1983) published on the current age of 77 species of coral-reef fishes of the families Chaetodontidae, Pomacanthidae, Pomacentridae, Labridae, Balistidae, and Tetraodontidae in the Nancy Aquarium as 6 to 15 years.

Frakes (1993) visited the Nancy Aquarium in 1986, and again in 1992. He determined that five of the original angelfishes, the butterflyfish *Chaetodon ephippium*, the anemonefish *Amphiprion perideraion*, and the wrasse *Choerodon fasciatus* had lived 20–21 years, and the triggerfish *Balistapus undulatus* 24 years. A Giant Grouper (*Epinephelus lanceolatus*) that measured 6 cm on arrival had grown to over a meter in length in 21 years. This species is reported to attain a total length of 270 cm.

Although data on longevity appear to be lacking for *Epinephelus lanceolatus*, there is age and growth information on another immense serranid fish, the Goliath Grouper (formerly Jewfish), *E. itajara*, of the tropical western Atlantic. It is reported to a length of 250 cm and a weight of 309 kg. Males are estimated to attain a maximum age of 26 years and females 37 years (Bullock et al. 1992; Sadovy and Eklund 1999).

While on the staff of the Waikiki Aquarium in Honolulu, the second author compiled records of the date of arrival of fishes, and current Waikiki Aquarium aquarist Norton Chan has determined those still alive that have been in the aquarium for more than 13 years (Table 1). Seven other species of fishes that may have survived 13 or more years in the aquarium cannot positively be identified from others of the same species that were acquired later.

One butterflyfish of the species *Chaetodon lunula*

TABLE 1. Survival Time in Years of Individuals of Species of Fishes at the Waikiki Aquarium, Honolulu

Years	Species
13	*Pygoplites diacanthus*
13	*Acanthurus pyroferus*
13	*Stegostoma varium*
14	*Chaetodon auriga*
14	*Centropyge potteri*
15	*Zebrasoma veliferum*
16	*Genicanthus personatus*
16	*Caranx ignobilis*
17	*Neocirrhites armatus*
17	*Centropyge flavissima*
18	*Carcharhinus melanopterus*
18	*Myrichthys magnificus*
19	*Gnathanodon speciosus*
23	*Chaetodon ulietensis*
24	*Siganus uspi*

arrived as an adult at the Waikiki Aquarium on September 5, 1986. It died sometime in 2008, so it had attained an age of at least 22 years.

The examination of scales to determine the age of fishes has been largely supplanted by "reading" the otoliths, generally the largest, the sagitta. For most fishes, a ring of calcium carbonate and fibroprotein is laid down daily in the otolith, providing a very accurate age of larvae, juveniles, and small species. As larger fish grow to maturity, the daily rings are no longer perceptible, but annular marks can be determined. They can be validated by relating them to an environmental change, particularly temperature, or from movement to water of different salinity (as by salmonids). Age determinations from otoliths have also been confirmed by rearing fish after giving an injection of oxytetracyline, which marks the ring laid down at that time, or by recovery of a tagged fish that was injected when tagged. The most serendipitous validation of the age of an otolith ring is the radioactive mark provided from the testing of thermonuclear explosions in the Pacific by the U.S. in the Marshall Islands in 1946, by the British in the Line Islands beginning in 1952, and by the French in the Tuamotu Archipelago beginning in 1966. It is referred to as the bomb radioactive chronometer. A recent radiometric aging method involving the known rate of radioactive decay across the otolith from its nucleus has been used to confirm age determination.

The deep-water rockfishes of the genus *Sebastes* of the North Pacific are currently among the oldest known fishes, with six species reported as having attained ages over 100, one at 205 years; however, only one is validated at an age over 100 years, the Yelloweye Rockfish *Sebastes ruberimmus*, 118 years. Although attaining large size, rockfishes are far from the largest of fishes. It is presumed that their longevity is related to their living in deep water, where low temperature, high pressure, low oxygen, and limited food supply may slow life processes (Cailliet et al. 2001). The species of rockfishes with the greatest age are those living in the deepest water, in general. Other long-lived, deeper water fishes with age validation are the Orange Roughy (*Hoplostethus atlanticus*), 125 years, and the Warty Oreo (*Allocyttus verrucosus*), 130 years. Of the sharks, the Spiny Dogfish (*Squalus acanthias*) is the oldest recorded, 50–75 years. The White Sturgeon (*Acipenser transmontanus*) was estimated to live 104 years, and the Tarpon (*Megalops atlanticus*) 55 years, with radiometric validation to 50 years (references from Caillet et al., 2001).

By preparing growth curves from sagittal otolith age determinations, Choat and Axe (1996) estimated the age of 10 species of surgeonfishes (Acanthuridae) in eastern Australia. The annular pattern in the otolith was confirmed for four of the species by recovery of individuals that had been injected with tetracycline. Choat and Robertson (2002) continued the study on surgeonfishes and a second herbivorous fish family, the parrotfishes (Scaridae). The longest life span of the 13 species of the genus *Acanthurus* was that of *A. lineatus*, 42 years; and of the genus *Naso*, *N. annulatus*, 45 years. For 19 species of scarid fishes, *Bolbometopon muricatum* had the longest estimated maximum age, 33 years, as might be predicted from its very large size for a parrotfish, 120 cm.

The other extreme in the age of fishes belongs to the family Gobiidae, as noted above for the Transparent Goby. Other gobies shown to have short life spans are *Silhouettea aegyptia* in the Red Sea, less than two years (Miller and Fouda 1986); *Eucyclogobius newberryi* from brackish water of California, one year (Swift et al. 1989); *Pomatoscistus minutus* and *P. microps* from the Tagus Estuary in Portugal, 26 and 32 months, respectively (Moreira et al. 1991); *Gobiosoma bosci* in the Gulf of Mexico, about 13 months (Conn and Bechler 1996); *Aphia minuta* in the Mediterranean Sea, 7 to 8 months (Iglesias et al. 1997); *Pomatoschistus marmoratus* in the Mediterranean Sea, 17 months (Mazzoldi and Rasotto 2001); and *Istigobius decoratus* in lagoons of the Great Barrier Reef, 22 months (Kritzer 2002).

Hernaman and Munday (2005a,b) studied the age and growth of the following five species of gobiid fishes from Orpheus Island, Queensland: *Asterropteryx semipunctata*, *Istigobius goldman-*

ni, *Amblygobius bynoensis*, *A. phalaena*, and *Valenciennea muralis*. From 134 to 162 adult individuals of each species were collected and sacrificed for age determination from reading the otoliths. The specimens of the five species ranged in total length from about 60 mm for *I. goldmanni* to 110 mm for *A. phalaena.* The longevity of *Asterropteryx semipunctatus* was the greatest, 16 months for males and 14 months for females, and that of *Istigobius goldmanni* the shortest, 13 months for males and 11 months for females. The females of *Amblygobius phalaena* and *Valenciennea muralis* attained slightly greater size and age than the males. The five species showed similar growth rates in relation to their maximum life span, with about two-thirds of their maximum size attained by half their maximum life span.

The shortest life span for a vertebrate was reported by Depczynski and Bellwood (2005) for the Indo-Pacific coral-reef goby *Eviota sigillata*, which attains a total length of 21 mm. They collected 319 individuals from the Great Barrier Reef for otolith examination. The settlement mark showed a duration of larval life as 23–27 days. The maximum duration of life, including that in the larval stage, was 59 days.

Other fishes that mature at very small size may usurp this record of shortest longevity when their maximum ages are ascertained. Females of the gobiid *Trimmatom nana* mature at 8–10 mm in standard length (SL, the length without the caudal fin, converted here to 10–12.5 mm total length), claimed as the smallest living vertebrate by Winterbottom and Emery (1981) at the time they described the species.

Watson and Walker (2004) described the neotenic gobioid fish *Schindleria brevipinguis* from Queensland, stating that it is sexually mature at 7–8 mm SL, and claiming it as the smallest known vertebrate. However, Kottelat et al. (2006) contested this, noting that Watson and Walker's smallest fully mature female measured 8.4 mm. The smallest mature female of their freshwater cyprinid fish *Paedocypris progenetica*, from a peat swamp in Sumatra, measured 7.9 mm in total length. The maximum length for the species is 10.3 mm. The life spans of this and other cyprinid miniature fishes remain to be documented.

The second author has determined that some small gobies are not as short-lived as expected, based on records of their stay at the Waikiki Aquarium in Honolulu, where the threats from predators, parasites, and catastrophic environmental events in the sea are obviated.

The tiny fishes of the large Indo-Pacific genus *Trimma* can be expected to have a short duration of life, judging from the 3-months longevity of *T. nasum*, as reported by Winterbottom and Southcott (2008). However, two species of the genus, *T. rubromaculatum* (Fig. 1) and *T. tevegae* (Fig. 2) lived from 12 to 20 months in the Waikiki Aquarium. One individual of the dwarfgoby *Eviota nigriventris* (Fig. 3) survived 23 ½ months, and two individuals of another Indo-Pacific coral-reef goby, *Priolepis nocturna* (Fig. 4), maximum length 45 mm, are still alive at the Aquarium at the age of 3 years, 3 months.

In June 1995, the Waikiki Aquarium purchased two adult individuals of the goby *Gobiodon okinawae* (Fig. 5) from a local tropical marine fish importer. They were placed in a 1300 L, open-system, marine aquarium containing several species of live coral and other tropical marine fishes. This goby, with a maximum total length of 38 mm, is a simultaneous hermaphrodite, and the two fish soon formed a breeding pair. They removed tissue from a small section of acroporid coral and laid eggs on the cleared patch; spawning continued for several years. One fish succumbed to a fungal infection in August, 2004. The other survived to 2008, hence had attained an age of at least 13 years (its age on arrival at the Aquarium was not known).

On being informed of this unexpected goby longevity, Philip L. Munday (pers. comm.) wrote: "I am not totally surprised. I had a few tagged adult *Gobiodon histrio* in the field for over 3 years. Assuming they were at least 1 year old when tagged, that would give them a longevity of at least

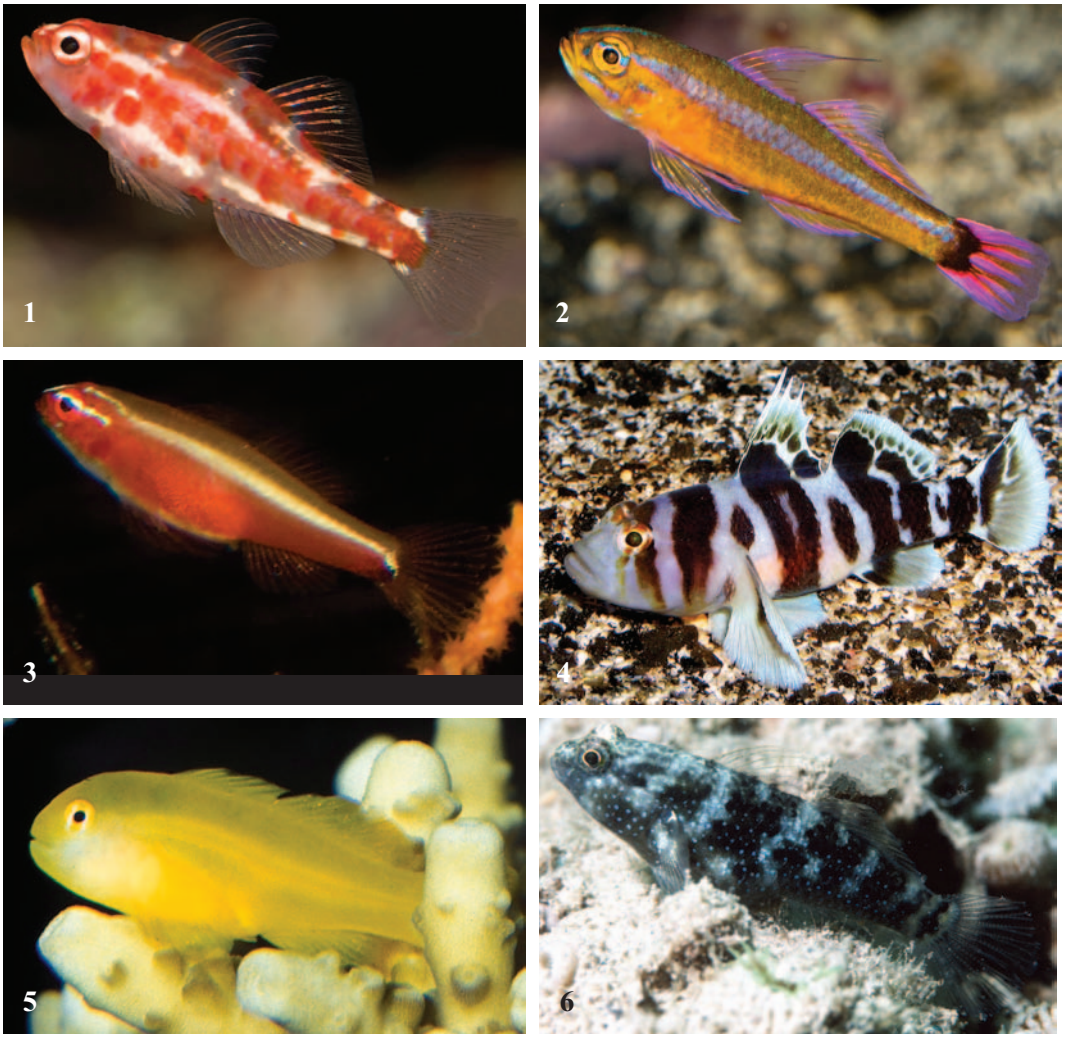

FIGURE 1. *Trimma rubromaculatum*, Waikiki Aquarium (J. Charles Delbeek). FIGURE 2. *Trimma tevegae*, Waikiki Aquarium (J. Charles Delbeek). FIGURE 3. *Eviota nigriventris*, Waikiki Aquarium (J. Charles Delbeek). FIGURE 4. *Priolepis nocturna*, Waikiki Aquarium (J. Charles Delbeek). FIGURE 5. *Gobiodon okinawae*, Waikiki Aquarium (J. Charles Delbeek). FIGURE 6. *Asterropteryx semipunctata*, O'ahu, Hawaiian Islands (John E. Randall).

4 years." The species of *Gobiodon* have a skin toxin, which probably makes them relatively unpalatable. In addition, they live among the branches of live coral, where they are protected from most predators.

The population of the wide-ranging Indo-Pacific goby *Paragobiodon echinocephalus*, an obligate commensal of the branching coral *Stylophora pistillata*, was studied by Kuwamura et al. (1994) on a reef flat in Okinawa over a period of three years. The mortality of the fish was correlated with that of the corals, the latter adversely affected by cold temperature in winter, by typhoon-generated waves in July to October, mortality from the starfishes *Acanthaster planci* and *Culcita novaeguineae*, and overgrowth by other corals, soft corals, and algae.

The Hawaiian *Kellogella oligolepis* is an example of a goby for which environmental change

is the greatest threat. It lives in the highest tide pools along exposed shores, some as splash pools. The pools are often no deeper than 10 cm. Although this species must have an extraordinary range of temperature and salinity tolerance, there are obviously extremes that it cannot survive. A total of 119 specimens in twelve lots of this species in the Bishop Museum, Honolulu, measures 10–23 mm total length. Two individuals of this goby, a male and a female, each 12.5 mm in length when collected from a tidepool, were maintained in an aquarium for 22 months. The male grew to 31 mm, and the female to 28 mm (data from Bishop Museum fish collection number 26370).

The rate of predation on most small gobies is very high, resulting in their short life expectancy (Munday and Jones 1998). Depczynski and Bellwood (2005) reported the average daily mortality rate of *Eviota sigillata* to be 7.8%. Depczynski and Bellwood (2006) found the even lower daily mortality rate of 4.3–5.6% for two other tiny gobies, *Eviota melasma* and *E. queenslandica*, and Winterbottom and Southcott (2008) reported the daily mortality rate of the diminutive *Trimma nasa* as 4.7%.

An example of the increased longevity of a goby, when the perils of life in the wild are removed, was provided by Lisa A. Privitera (pers. comm.). She studied the reproductive behavior and ecology of *Asterropteryx semipunctata* (Fig. 6) in the Hawaiian Islands (Privitera 2002). Her largest fish at the time of collection measured 46.5 mm total length for females, and 56 mm for males, therefore comparing closely to 45 and 56 mm for the same species of fish studied by Hernaman and Munday in Queensland. As mentioned, the age of the oldest of their 162 fish was 16 months. Privitera's fish were collected in 1987 and placed in an aquarium at the Hawaii Institute of Marine Biology of the University of Hawaii. The tank was needed for another student in 1998, so her fish were at least 11 years old when released. The largest male was estimated to have grown to nearly 80 mm in total length.

The long survival of *Asterropteryx semipunctata* in the aquarium and its reaching a greater length than any reported for wild-caught fish lends support to the explanation of the relatively short life of this species in the sea due to mortality from predation and other causes. However, the gobies that came to the Waikiki Aquarium from the aquarium fish trade were adults and did not show any obvious increase in size while in the aquarium. We therefore wonder if the short life spans attributed to some of the gobies in the literature from the examination of otoliths may have been underestimated.

Acknowledgments

We thank David R. Bellwood, Sergey Bogorodski, Norton Chan, Matthew T. Craig, Lawrence Currie, Philip L. Munday, Bruce C. Mundy, Lisa A. Privitera, Benjamin C. Victor, and Richard Winterbottom for their assistance in this study. We are also grateful to John E. McCosker for his critical review of the manuscript and Michele L. Aldrich for her careful reading of page proof.

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