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Fast Maturity and Spawning within an Initial Reproductive Season of Japanese Filefish, *Rudarius ercodes* (Pisces: Monacanthidae)

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Abstract Maternal egg care is known in the Japanese filefish, *Rudarius ercodes*, during the spawning season from June to September in northern Kyushu, Japan. At the end of the spawning season, a small female was found caring for eggs on the rocky reef. Otolith increments revealed that the female was 65 days old and had hatched in the same spawning season. Considering the length of the spawning season and age at maturity, *R. ercodes* that hatched through July have a chance to reproduce in the initial spawning season in which they hatched. Such fast maturity is rare in temperate reef fishes, and is the first record from the order Tetraodontiformes.

Key words: reproductive behavior, egg-care, otolith increment, life history, Tetraodontiformes.

The spawning season of coral reef fishes is year-round in many species (*e.g.*, Thresher, 1984), although it is restricted within a few months in temperate reef fishes. At Tsuyazaki, in northern Kyushu of Japan, the spawning season of *Enneapterygius etheostomus* (Tripterygiidae) is from May to September (Hamada and Nakazono, 1989), *Halichoeres tenuispenis* (Labridae) and *Chromis notatus notatus* (Pomacentridae) from June to August (Nakazono, 1979; Nakazono *et al.*, 1979), *Paramonacanthus japonicus* (Monacanthidae) from July to September (Nakazono and Kawase, 1993) and *Pseudolabrus japonicus* (Labridae) in October (Nakazono, 1979). Thus, most reef fishes cannot mature within the initial spawning season in which they hatched (*e.g.*, Ikehara, 1976; Suzuki *et al.*, 1985).

The Japanese filefish *Rudarius ercodes* is a smaller species in Monacanthidae (Tetraodontiformes) which attains a total length of 70 mm (TL). The fish is commonly seen on rocky reefs and seaweed beds in shallow waters of Japan and southern Korea (Matsuura, 1984). The eggs of *R. ercodes* are deposited on the algae, and cared for by parental females until hatching a few days later (Nakamura, 1942; Kawase and Nakazono, 1995; Akagawa and Okiyama, 1995). The spawning season of *R. ercodes* is from June to September at Tsuyazaki (Kawase and Nakazono, 1995). At the end of the spawning season, I found a small female *R. ercodes* caring for eggs on the rocky reef of Tsuyazaki. In this paper, first the daily periodicity of the otolith increment formation of *R. ercodes* is described based on an aquarium experiment. Second, the age and birth date of the parental female are estimated by the otolith increments, and the fast maturity of *R. ercodes* within the initial spawning season is discussed.

Materials and Methods

In order to validate the periodicity of otolith increment formation, 11 individuals (6.5-31.6 mm TL) of *Rudarius ercodes* were captured by a hand net at rocky reefs of Koinoura, Tsuyazaki in northern Kyusyu, Japan (33°47′N, 130°29′E) on September 7 and 24, 1989. On the day following capture, the specimens were immersed in an aerated 150 ppm solution of Alizarin Complexone (Alizarin-3-methylamine-N, N-diacetic acid; ALC) in sea water for 24 hours without feeding. Subsequently, the fish were kept in a 30 l outdoor tank (water temperature: 24.2-27.3°C) for 4 days and fed once per day on shrimp. Then, they were again immersed in the ALC solution with the same method. Afterwards, they were returned to the outdoor tank for 3 days and finally fixed in 95% alcohol. A pair of both otoliths, sagittae and lapilli, were removed from each specimen and mounted in epoxy resin on microscope slides. The otoliths were ground in the sagittal plane with a 1500-grit abrasive paper until the increments near the edge became clear, after which they were viewed under an optic microscope under ultraviolet (UV) and tungsten light. Counts were made of the number of increments between the two fluorescent bands corresponding to the time of ALC treatments.

An underwater research study was carried out at the rocky reefs of Koinoura on September 8, 1990 (water temperature: 27° C). During the research, a small female of *R. ercodes* measuring 34.6 mm TL was found caring for eggs deposited on the algae. The parental female and eggs were collected together, and both were fixed and kept in 95% alcohol. Later a pair of saggitae were removed from the fish and mounted in epoxy resin on a microscope slide. Then the otoliths were ground to the core in the horizontal plane with a 1500-grit abrasive paper. The dark bands in the otoliths were counted from the center to edge under an optic microscope at 400-1000 X. The right sagitta was employed for the age estimation of the parental female because it showed clearer bands than the left one. The number of eggs deposited on the algae were counted with a binocular microscope.

The fish specimens, otoliths, and eggs of the individuals studied were registered and are being kept in the Coastal Branch of Natural History Museum and Institute, Chiba, Japan (CMNH-ZF-0012447-0012459).

Results and Discussion

1. Validation of daily otolith increment formation

Two fluorescent bands dyed by ALC were clearly observed in both the sagittae (Fig. 1A) and lapilli of all individuals. Four increments were observed between the two bands (Fig. 1B), which represent the days during which the fish were kept in a tank between the two immersions in ALC solution. The 4 increments were observed in 7 sagittae and 7 lapilli of 9 individuals, although the number of increments could not be counted in the remaining two individuals because they were narrow and/or unclear. This result suggests that otolith increments are formed daily in *Rudarius ercodes*.

The daily formation of otolith increments is very common and has been validated in many teleost fishes (*e.g.*, Victor, 1982; Wellington and Victor, 1989). In Monacanthidae, daily otolith increment formation has been demonstrated in larvae and juveniles of *Meuschenia scaber* and *Stephanolepis hispidus* (Kingsford and Milicich, 1987; Rogers *et al.*, 2001). The first increment is formed during the first day of life in *M. scaber* (Kingsford and Milicich, 1987), while the formation occurs a day before hatching in *Rercodes* (Kawase and Nakazono, 1994). Therefore, it seems reasonable to assume that the otolith increment counts closely approximate the true age in days of the monacanthids.

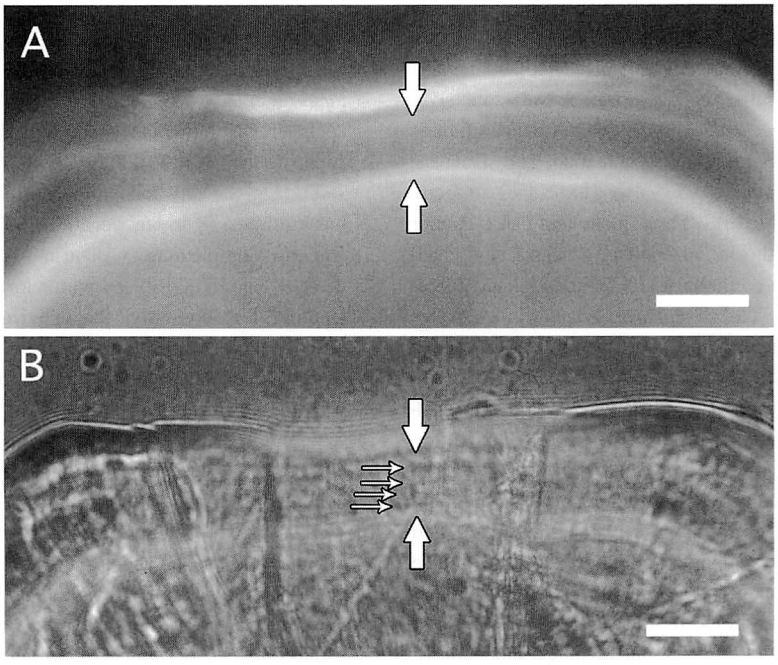

Fig. 1. Margin of the sagittal otolith of *Rudarius ercodes* (13.2 mm TL, CMNH-ZF-0012449) treated with ALC for daily increment formation experiment. (A) Two fluorescent bands (vertical arrows) clearly appeared under UV light. (B) Four increments (horizontal arrows) can be counted between the two fluorescent bands under tungsten light. Scales indicate 20 μm.

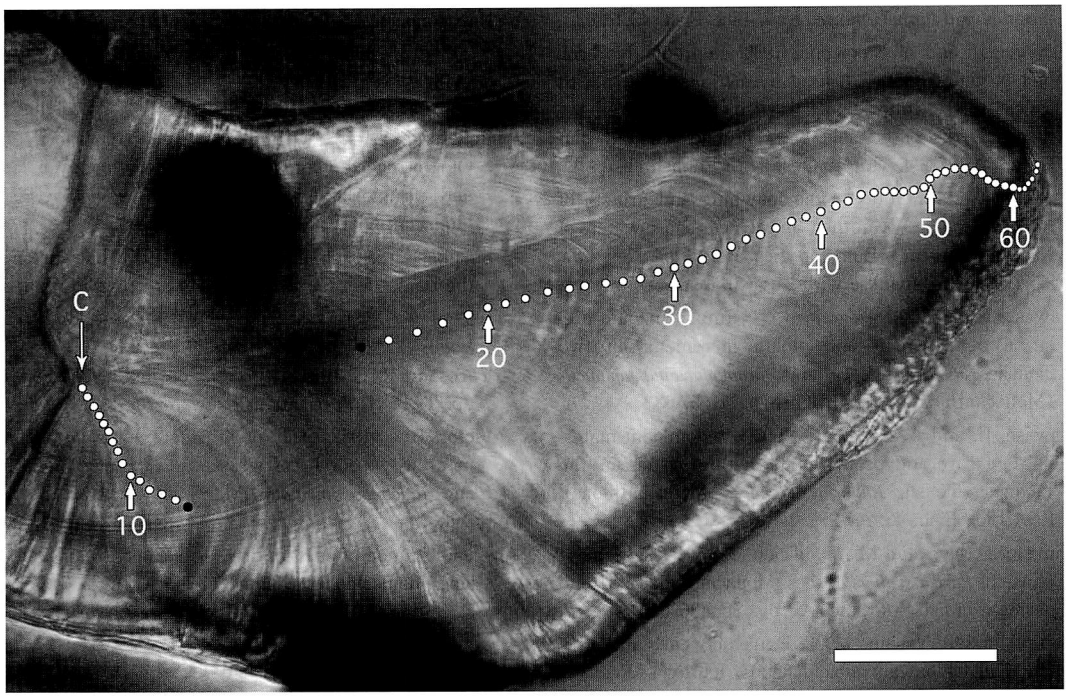

Fig. 2. Horizontal plane view of sagitta in the parental female *Rudarius ercodes* (34.6 mm TL, CMNH-ZF-0012458). White dots indicate the position of the daily increments; two black dots indicate the position of the 15th increment; arrows with numerals indicate the number of increments from the primordium; the arrow with a 'C' core. The scale indicates 50 μm.

2. Fast maturity of *Rudarius ercodes*

A female *Rudarius ercodes* measuring 34.6 mm TL was caring for eggs in the late spawning season of September, 1990. The eggs were deposited on the algae, and the clutch size was 2500. A sagitta of the parental female exhibited increments from the center to the edge, although not all parts of the ground plane showed a distinct pattern (Fig. 2). As a total of 66 increments were counted in the otolith, the age of the female was estimated to be 65 days because one increment is formed before hatching (Kawase and Nakazono, 1994). The birth date of the female was therefore 5 July, which was approximately one month from the beginning of the same spawning season. As the spawning season of *R. ercodes* is from June to September at Tsuyazaki (Kawase and Nakazono, 1995), this result shows that those fish hatched through July have a chance to mature and reproduce in the initial spawning season in which they hatched, while those hatched after that time seem to begin reproduction in the next spawning season. Such an early maturity is rare in temperate reef fishes, and is the first report from Tetraodontiformes.

Kon and Yoshino (2002) reported extremely early maturity in two tropical gobioid fishes, *Schindleria* sp. and *Paedogobius kimurai*. They demonstrated with otolith increments that the two gobioids mature at 23-60 days and 42-67 days all year round, respectively. They also discussed progenesis in the two gobioids, and assumed that the rapid alternation of generation (9 times per year in *Schindleria*) may contribute to an increase in speciation and diversity. However, *R. ercodes* is not a progenesis species. The spawning season is not continuous throughout the year, but is restricted to a period of about 4 months. Furthermore, *R. ercodes* can live more than one year (Kuronuma, 1941) and continue reproducing throughout their lifetime, and thus more than one generation coexists in a single spawning season.

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生まれた繁殖期内に産卵を開始するアミメハギ（カワハギ科魚類）

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アミメハギでは，産卵後に雌による卵保護が行われることが知られている．筆者は福岡県津屋崎町の岩礁で，繁殖期（6～9月）の終わりに卵保護をしている小型の雌を採集した．耳石日周輪によりその雌の日齢を査定したところ65日で，孵化日を逆算すると同じ繁殖期内のはじめに生まれていたことが明らかとなった．繁殖期の長さと成熟までに要する日数から考えると，7月までに生まれた個体はその年の同じ繁殖期内に産卵を開始できる可能性がある．温帯性の海産魚でこのように早く成熟する例は希で，フグ目魚類からは初めての報告である．