

Mating Habits of the Surfperch, *Ditrema temmincki*

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Abstract Mating habits of the viviparous surfperch, *Ditrema temmincki*, were observed underwater with the help of SCUBA on the northern coast of Kyushu, Japan, during the period from 1977 to 1979. The mating season of the fish lasted from early September to early December. During the season, the fish moved into depths of 0.5~5.0 m, and large males over 1 year in age set up territories of 5~10 m in diameter. Females of nearly the same body length as males visited territories everyday. When females appeared in a territory, the male displayed by marked body color change and head-lowering posture. The territorial behavior and color change in small males under 1 year in age were not conspicuous in comparison with large males. After a repeated pre-copulatory behavior, copulation was accomplished between the sexes of nearly the same body length by contacting anal regions for a short time. Although courtship display of males and pre-copulatory behavior were seen frequently, copulation was seen only infrequently. The relationship between the mating season and occurrence of spermatozoa in ovaries is discussed.

The surfperches, Embiotocidae, show the most advanced viviparity among the teleost fishes and have attracted the attention of many ichthyologists (Eigenmann, 1892; Hubbs, 1921; Turner, 1938; Ishii, 1957; Igarashi, 1961; Mizue, 1961; and so forth). However, their works are mostly histological and cytological studies on reproductive organs, and investigations on their natural mating habits and copulation are limited to several works, such as Hubbs (1917), Rechnitzer and Limbaugh (1952), Weibe (1968), and Shaw and Allen (1977). In Japanese waters, *Ditrema temmincki* Bleeker, *D. viridis* Oshima and *Neoditrema ransonneti* Steindachner are known (Yamane, 1964). Among these three species, *D. temmincki* is found abundantly inhabiting rocky reefs along the northern coast of Kyushu. Although the fish constitutes one of the most numerous components of the reef fish fauna there, its mating habits are little known. In this report, we describe the results of underwater observations on mating habits and copulation of *D. temmincki*. We also report the results of histological examination on the occurrence of spermatozoa in ovaries.

Materials and methods

The present study was carried out at the rocky reefs of Tsuyazaki (130°29'E, 33°47'N), on the northern coast of Kyushu, Japan. During

the periods from July to January in 1977, 1978 and 1979, a total of approximately 130 hours of underwater observations were made on the mating habits of *Ditrema temmincki*. Territorial behavior and courtship display of males, appearance of females in males' territories and copulation were observed in detail. In order to understand the relationship between the mating season and occurrence of spermatozoa in the female reproductive organs, about 60 specimens were collected by spear during the mating season. Their gonads were weighed and fixed in 10% formalin or Bouin's solution. After embedding in paraffin, transverse sections of ovaries were cut at 5~7 μ m from the mid-region and stained using haematoxylin and eosin. The occurrence of spermatozoa in ovaries was examined under a microscope.

Results

Territorial behavior of males. Populations of *Ditrema temmincki* found at Tsuyazaki during the period from July to January were composed of two groups with easily distinguishable body lengths. One group consisted of fish over 1 year in age, ranging from 140 to 165 mm in standard length. The other one included fish born in the previous spring (under 1 year in age), and having a standard length of 70~120 mm.

During the period from early September to

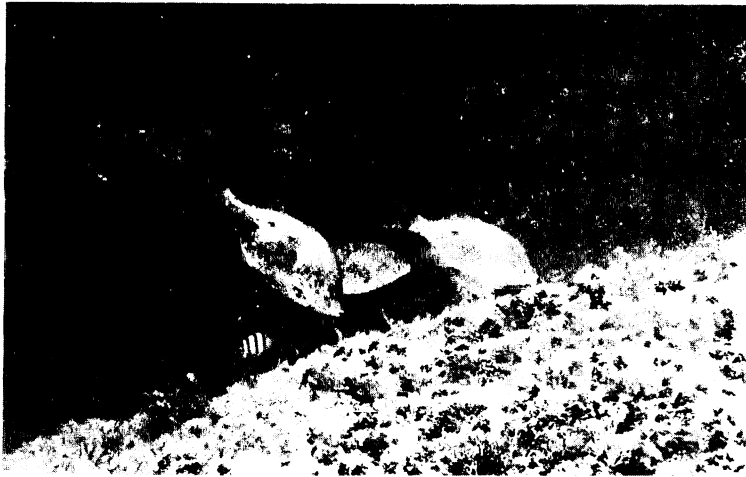


Fig. 1. Underwater photograph of a displaying male of *Ditrema temmincki* (>1 year in age). The male in dark body color with two white spots on the side is herding two females. One of the females is pecking at the bottom to feed.

early December, the surfperch came to shallow depths of 0.5~5.0 m along the shore line, and large males over 1 year in age set up territories. According to observations made in the mating season of 1978, nine large males were constantly recognized at one of the study reefs, 150 m long along the shore line and 5~10 m wide. These large males were holding territories of 5~10 m in diameter and each territory was found along the nearly straight shore line. At the border of neighboring territories, aggressive interactions of territory owners, such as frontal display and chasing the intruder, were frequently observed. Males also tried to drive away other fishes of roughly the same body length, such as *Oplegnathus fasciatus* (Temminck et Schlegel), *Goniistius zonatus* (Cuvier et Valenciennes) and *Pseudolabrus japonicus* (Houttuyn).

At the center of each territory, there was always a flat bottom of rock, gravel or sand patch, more or less narrower than the territory. This flat bottom was surrounded with rocks or *Sargassum* vegetation, 0.3~1.0 m in height, which served as a shelter for the mating fish. There, a male was observed to herd females of nearly the same body length as himself almost all through the day time. The number of females herded by a male differed from 0 to 8, mode at 2~3. Among nine males found at the study reef, the largest male usually herded the most females. Two slightly smaller males at both sides of the

largest male's territory were frequently observed having no female in their territories and trying to intrude into the largest male's territory. However, it was observed in a few cases that the largest male had no female and the smaller males on both sides had some females in their territories. From the facts that the total number of females found within the study reef during the mating season of 1978 was nearly constant at 9~14 (by 8 countings on different days) and that no female was observed outside of the study reef, it was suggested that the females found at the study reef were the same individuals.

Male courtship behavior. Male body color, when herding females, was darker than usual and two large white spots appeared on the side and a small one on the caudal peduncle. The basal region of the anal fin was also lighter than the rest of the body (Fig. 1).

When courting, the male lowered his head and swam slowly near the bottom (Fig. 2a). The male sometimes leaned his body to right and left alternatively and showed his side to a female. If a female tried to leave the territory, the male chased her and led her back, displaying in the head-lowering posture. While the male was chasing an escaping female, the remaining females stayed within the territory swimming motionlessly, directing their heads in the same direction. Such a courtship display by the male lasted almost all through the day time, but the number of

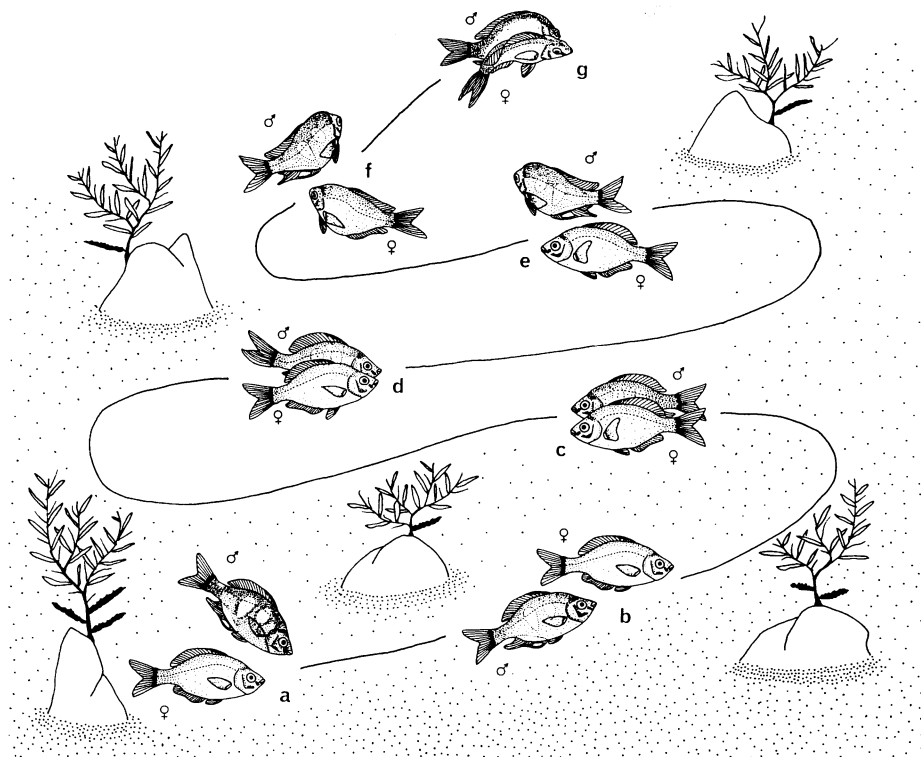


Fig. 2. Schematic illustration of mating behavior and male body color change in *D. temmincki*. Not drawn to scale. The swimming paths drawn in solid lines are reduced into 1/2~1/3 of their length. a: Courtship display of a male in dark body color. b~d: Following of the male. This process continues for a relatively long time and the pair repeatedly swim in a zig-zag course. e, f: Presentation of the male. g: Copulation. Note the black bar running from male's eye, through the side just below the dorsal fin and ending at the peduncle.

females tended to decrease at midday and again with the approach of sunset, near 17:30, when male body color reverted to the lighter normal pattern. The male seemed to consume most of his time in the courtship display, and was observed to feed on the bottom only when females were not seen in his territory. On the contrary, females were frequently seen feeding on the bottom, while the male was displaying (Fig. 1).

We observed 136 cases of courtship displays given by more than 20 different large males during the course of this study. In some cases, it was observed that the dark body color of males suddenly faded, when the male started to follow a female. This was the onset of pre-copulatory behavior, and it commenced irrespective of the time of the day. At the initial phase of pre-copulatory behavior, the male followed the fe-

male placing himself slightly below and behind the female (Fig. 2b). Soon the male caught up with the female and placed himself slightly above and parallel with the female (Fig. 2c). The pair swam side by side on a straight course for 40~60 cm, where the male moved to the opposite side of the female and the pair turned and swam in a different direction (Fig. 2c, d). In this way, the pair swam in a zig-zag course. When the male did not change to the opposite side of the female, the pair circled within a narrow range. In late stages of zig-zag swimming or circling, the male passed ahead of the female at one side and then again on the other side. As the male repeated such activities, he seemed to get more and more excited, and stopped in front of the female bending his body laterally, presenting out his anal region to the female (Fig. 2e, f).



Fig. 3. Underwater photograph showing the color change of a male *D. temmincki* (<1 year in age) at the final presentation. A female (arrow) which did not respond the male's final presentation is going away.

The male repeatedly presented his anal region to the female, and at the final presentation, a narrow black bar appeared running from his eye, through his side just below the dorsal fin, widening and ending at the caudal peduncle (Fig. 3). At this time, the side of the male gleamed silverly.

Although the following behavior of large males over 1 year in age was observed 21 times and lasted for more than 10 minutes in the longest case, copulation of these large fish was not seen. The unusual existence of a diver in the territory and the scarcity of fish over 1 year in age were considered to be the reasons for our failure to observe copulation. It is noteworthy that females seemed to be more nervous about divers than males, for our failure to observe copulation in these large fish was due to the fact that females did not respond to males in spite of vigorous following and presentation of males.

Copulation. It was possible to observe copulation only in fish smaller than 120 mm in standard length or under 1 year in age, for they seemed to be less nervous about the diver and the higher population density of the group in the same habitat seemed to facilitate our observation.

A total of 17~57 (by 8 countings on different days) small fish under 1 year in age was observed

inhabiting the same study reef as large fish in the mating season of 1978. About 30% of these small fish were males and they occurred solitarily, but females were usually in schools of 2~11 individuals. Some males showed territorial behavior for a few days, but mating territories were temporary among many small males. Females were observed to swim freely within the study reef. When females chanced to visit or pass near a male, the male lowered his head and displayed, changing body color much like in large males. However, change of the body color in small males was less prominent and it was sometimes hard to recognize. After displaying for a while, the male started to follow a female, swimming rapidly. The male's following behavior or zig-zag swimming of the pair usually lasted several minutes, then the male repeatedly presented his anal region to the female. At the final presentation of the male, a black bar suddenly appeared on his side as was seen in large males, then the female also bent her body laterally, putting out the anal region to the male, and the pair approached each other quivering the posterior halves of their dorsal and anal fins. Anal regions of the pair touched with their vertical axes angling about 100°, for about 0.5 second or less (Fig. 2g), then the pair separated quickly and the male, whose body color recovered to the ordinary following pattern, chased the

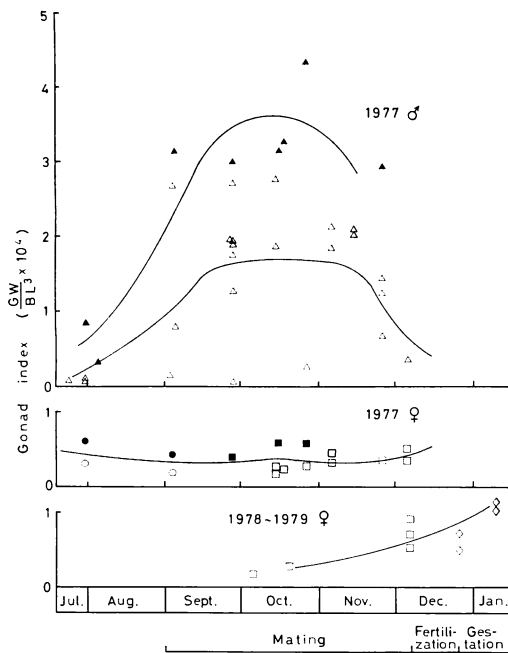


Fig. 4. Seasonal change of male and female gonad indices and occurrence of spermatozoa in ovary of *D. temmincki*. Solid symbol: Individual over 1 year in age. Open symbol: Individual under 1 year in age. Triangle: Testis. Circle, ovary without spermatozoa; square, ovary with spermatozoa; diamond, ovary with embryos.

female rapidly for a short time. The male soon took the head-lowering posture and the female went away.

Although we could note 76 cases of the followings in small males during the three-year study, the contact of anal regions was observed only three times, on the afternoon of Sept. 27, Oct. 2 and on the morning of Oct. 24 in 1978. In most cases, females swam away in earlier stages of the following or at the final presentation of males.

Occurrence of spermatozoa in ovaries. In order to know when spermatozoa appear in female reproductive organs, ovaries of 25 females were examined histologically. Also the change of male and female gonad indices during the period from July to January were obtained. Although the gonad indices of males over 1 year in age showed much higher values than males

under 1 year, as is seen in Fig. 4, both groups showed the highest values in October, as was previously shown by Mizue (1961). Ovaries of females caught in the early part of the mating season had no spermatozoa in the ovarian cavity, and the oocytes in young stages were found in the ovigerous fold (Figs. 4, 5A). Although mating behavior started in early September, the first appearance of spermatozoa in the ovarian cavity was seen in the later part of September, coinciding with our first observation of copulation in late September. Spermatozoa were found in masses in the ovarian cavity until the early part of December, and oocytes in various developmental stages were found within the ovigerous fold (Figs. 4, 5B). In late December, the masses of spermatozoa and oocytes disappeared and young embryos were recognized in the ovarian cavity, when the gonad indices of females started to increase (Figs. 4, 5C). From the facts mentioned above, it is strongly suggested that fertilization takes place only in December, when the sexual activity of the fish starts to wane. The spermatozoa passed into the female reproductive organ in late September may wait for the maturation of oocytes for more than two months.

Discussion

In the present paper, mating habits of the surfperch, *Ditrema temmincki*, were studied. The observed mating season lasted for about three months from early September to early December, when the surfperch came to the shallow rocky reefs just inshore, and there the sexes mated. The migration of embiotocid fishes toward a shallow area for mating is reported in *Cymatogaster aggregata* and *Hyperprosopon argenteum*, the only two species for which mating behavior has been studied so far (Hubbs, 1917; Weibe, 1968; Shaw and Allen, 1977, for the first species, Rechnitzer and Limbaugh, 1952, for the second).

In the present species, territorial behavior was outstanding among males over 1 year in age. Shaw and Allen (1977) also observed territorial behavior of male *C. aggregata* in an aquarium but it is not reported in *H. argenteum*. The mating behavior of *D. temmincki* was composed of the following sequence of activities: (1) courtship display of the male, (2) pair formation and

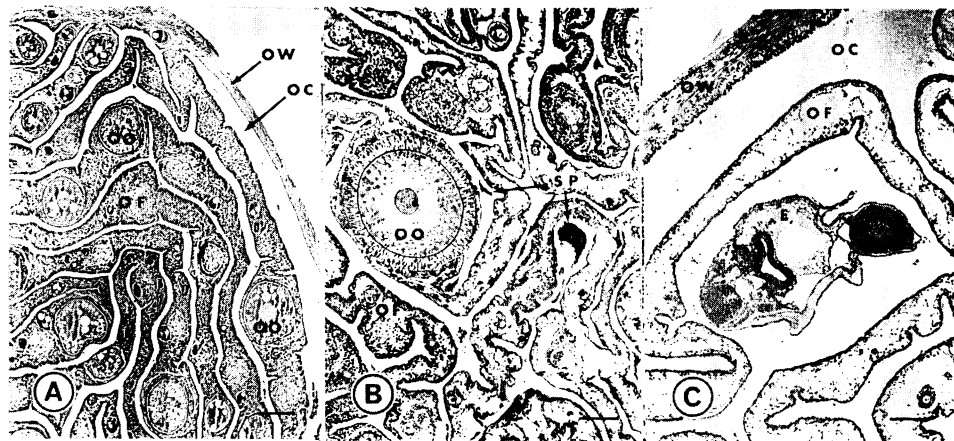


Fig. 5. Photomicrograph of ovary of *D. temmincki* in three different stages. A: Ovary in the early part of the mating season. Oocytes are in young stages and spermatozoa are not seen. Sept. 3, 1977. 94 mm SL. B: Ovary at the end of mating season. Oocytes are maturing but still in ovigerous fold. Masses of spermatozoa are seen in the ovarian cavity. Dec. 6, 1978. 92 mm SL. C: Ovary with young embryos in its ovarian cavity. Spermatozoa and oocytes are already disappearing. Jan. 9, 1979. 112 mm SL. OW, ovarian wall; OC, ovarian cavity; OF, ovigerous fold; OO, oocyte; SP, spermatozoa; E, embryo; Each black bar shows 100 μ m.

following of the male, (3) presentation of the male and (4) copulation by the pair. Details of these mating behavior are described in the present paper.

The copulation involved a close contact of anal regions by both sexes for a very short time and was observed only very infrequent. Weibe (1968) also reported that copulation of *C. aggregata* lasted only a fraction of a second in comparison with long "courtship dance." Shaw and Allen (1977) also observed that a captured *C. aggregata* male juxtaposed his anal fin to the female fin for several seconds. These results show that spermatozoa of embiotocid fishes are transferred to female reproductive organs within a relatively short time.

Copulation among the subject species was observed only very infrequently. The present authors suspected a negative influence from the existence of a diver in the male's territory and made many observations from distant places, but the frequency of copulation did not increase. It is probable that the frequency of copulation is actually much lower than that of pre-copulatory behavior.

It is well known that the secondary sexual characters develop in the anal fins of male em-

biotocid fishes. In the present species, the XV~XIX rays of anal fin extend and a bulbous papilla develops on both sides of the anterior part of anal fin. Weibe (1968) observed that seminal fluid traveled in a groove of scales and epithelial lining at the base of anal fin rays to the tubular projection of bulbous papilla when external pressure was applied to mature testes. In the present species, we could not ascertain the role of the anal fin and bulbous papilla at the time of copulation. However, the seminal fluid was observed to be released into the water from the gonopore at the posterior end of the genital papilla, when the abdominal part of the fish was pressed in the water shortly after spear- ing. Further study is needed to know the role of the secondary sexual characters which appear in the male anal fin of the present species.

Histological study of ovaries of *D. temmincki* revealed that our underwater observations of mating behavior and occurrence of spermatozoa in the ovarian cavity of females are seen concurrently. It is reported that the spermatozoa of *C. aggregata* await the maturation of oocytes as long as six months in the female reproductive organ (Eigenmann, 1892). In *D. temmincki*, it is also found that spermatozoa, passed into

the ovary early in the mating season, are stored in the ovarian cavity until the maturation of oocytes two and a half months later.

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ウミタナゴの交尾生態

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福岡市近郊の津屋崎の岩礁地帯で、ウミタナゴの交尾生態を潜水観察した。津屋崎におけるウミタナゴの交尾期は9月初旬から12月初旬の約3カ月で、この間1才以上の大型雄は、水深0.5~5.0 mの岩礁で、直径5~10 mのなわぼりを作る。なわぼりに雌が現われると、雄は体色が黒ずむとともに、体側と尾柄に白色斑が現われ、長時間にわたり求愛を行った後、雌を追尾する。1才以下の小型雄では、なわぼり行動は不明瞭であるが、大型雄と同様の求愛と追尾が見られる。交尾は雄が追尾の後、雌の前方で体を曲げて雌を誘い、雌雄が相寄って短時間生殖口周辺を密着させて行われる。前交尾行動は交尾期間中毎回観察されたが、交尾の頻度は低く、1977~1979年の調査期間を通じて3回しか観察できなかった。さらに、本研究では卵巣の組織標本作製し、卵巣内に精子の出現する時期と交尾期との関係について検討した。

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