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Author(s)	ONO, Yoshiaki; UEMATSU, Tatsumi
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Mating Ethogram in *Oryzias latipes*

By

Yoshiaki Ono and Tatsumi Uematsu

(Kagawa University)

(With 1 Text-figure)

There have been made various ethological researches on the mating behavior in fishes¹⁾⁻¹¹⁾. In the present paper the repertoire of the mating behavior patterns obtained by the ethological analysis in *Oryzias latipes* is reported.

Method

Full-grown Himedakas, the red variety of *Oryzias latipes*, were used mainly, but sometimes wild fishes of *Oryzias* were used as experimentals. The mating behavior patterns were studied in pairs of the different or the same sex and also in 3-individuals-groups.

At some distance from the frontal side of each observation aquarium (12×13×18 ccm) was put a sheet of millboard, containing a peep-hole of about 3 cm in diameter through which fish behavior could be observed. The other 3 sides of each aquarium were screened from other ones by both-sides frosted glass.

Observation was made in the dark room during the breeding season from March to September. An electric lamp (150 watt) was put on at the distance of 1.7 m above the aquaria. The experimentals were fed on abundant *Limnodrilus* and mixed baits. But before observation the remained baits were entirely removed from the aquarium with some exceptions. The mating behavior patterns were observed in the aquarium for 10 to 30 minutes and recorded with corresponding signs. Besides some special observations were performed to examine the behavior patterns in detail.

Mating ethogram

“Approaching” (S1; fig. 1a)—An individual recognizes a stimulating source such as other one or baits and approaches the stimulant with normal swimming. Approaching can be observed when the stimulating source stays or swims very slowly. The function of this behavior pattern is to shorten the distance to the stimulating source by normal swimming of the reacting individual. Approaching the ♀ may be regarded as a kind of mating behavior.

“Following” (S2; fig. 1b)—An individual follows the other swimming normally from behind. The swimming velocity of both the stimulating and the reacting individual is about the same. The distance between both individuals is almost constant and not longer than 5 cm. When the ♂ follows the ♀ the following may be especially regarded as a pattern of mating behavior.

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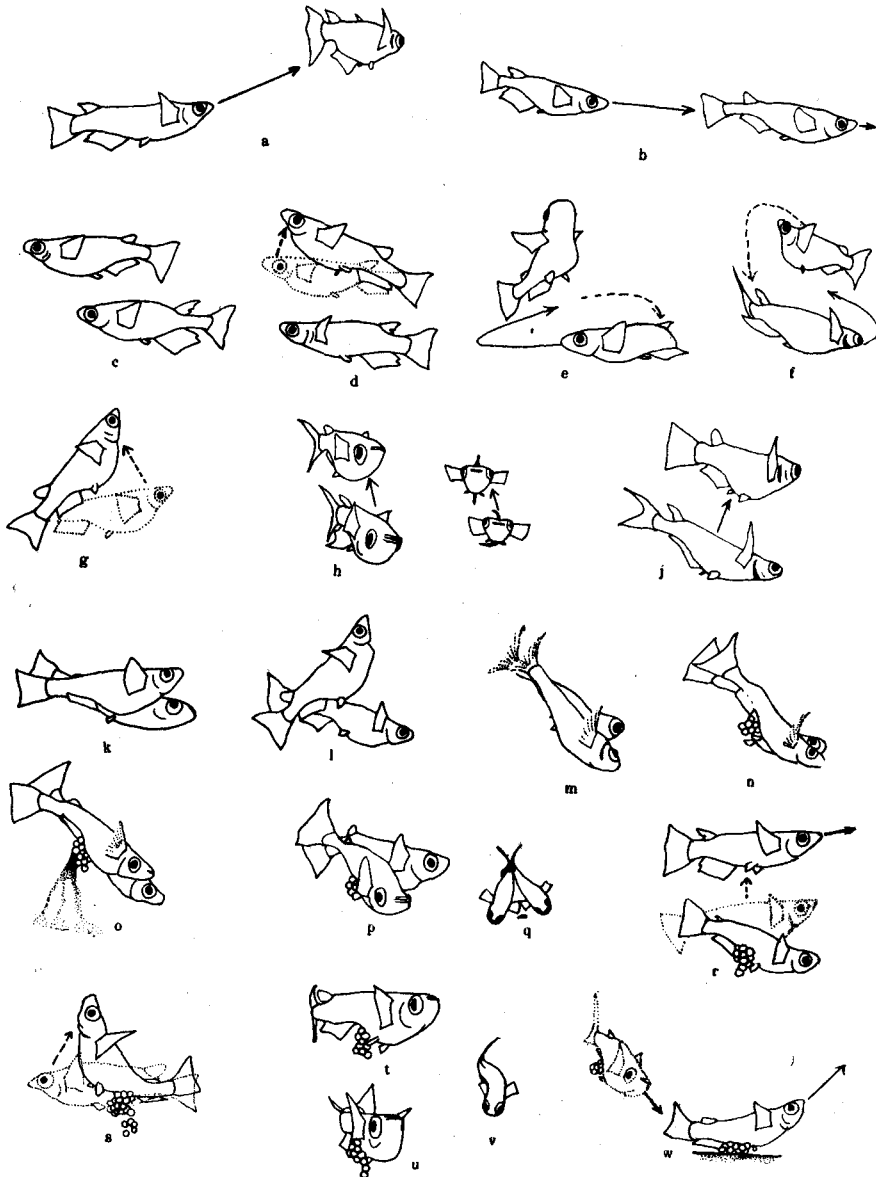


Fig. 1. Mating ethogram. a) approaching. b) following. c) courting orientation. d) head-up I. e and f) courting round dance. g) head-up II. h-j) floating-up. k and l) crossing. m) copulation. n) spawning. o) ejaculation and fertilization. p-r) separating. s) head-up III. t-v) sigmoid. w) rubbing-on.

"Courting orientation" (M1; fig. 1c)— In breeding season the mature ♂ orients and stays parallelly in the same direction as the mature ♀, the former's head being almost always within 2 cm under the abdomen of the latter. In general, courting orientation is released when the ♀ is staying or swimming slowly. This behavior pattern may be regarded as either a kind of the approaching mentioned above in a broad sense or a variety of the following in rare cases when both individuals swim slowly, keeping the position of courting orientation. In special cases the ♂ tries to toss up the belly of the ♀ staying at the bottom with its mouth and to orient under it. This behavior pattern may be called "pecking-up".

"Head-up I" (M2; fig. 1d)— The ♀ raises its head slightly and as a result its body axis is inclined within 30°. This gesture follows the courting orientation.

"Courting round dance" (M3; fig. 1e,f)— In general, the ♂ swims rapidly around the ♀ as soon as the head-up I is performed. In the typical cases the ♂ draws a horizontal circle, clockwise or counter-clockwise, under the frontal part of the ♀ body and again keeps the original courting orientation. This dance is often repeated several times successively. But in special cases, owing to some causes, there are breaking off the display, or a transversal circular movement around the ♀ body axis, or a large horizontal circle around the whole ♀ body, or a small turning under the ♀. Such cases were regarded as incomplete courting dances.

"Head-up II" (M4; fig. 1g)— After either the courting dance or the floating-up mentioned later the ♀ raises its head about 60° in most cases, within the possible inclination 45–90°. When it follows after the floating-up the ♀ turns away to the opposite direction from the ♂ without breaking off the head-up posture.

"Floating-up" (M5; fig. 1h-j)— Having performed the courting dance, the ♂ floats quietly from its position of orientation up to the left or right side of the ♀ body, pointing its head downward slightly. Throughout this stage of the mating behavior both the dorsal and anal fins bend to the ♀ side.

"Crossing" (M6; fig. 1k,l)— The ♂ which approached the body side of the ♀ through the floating-up is inclined increasingly as a result of raising its tail and bends its body slightly so as to embrace the tail of the ♀ with both the dorsal and anal fins. The ♀ stays in a horizontal position. The vertical angle between both body axes is about 15°–30°. Though sometimes the crossing seems to follow immediately the head-up II without the stage of floating-up, it may soon be broken off for the crossed angle is so large that the ♀ turns its head away from the ♂.

"Copulation" (M7; fig. 1m)— This mating behavior pattern is the primary sexual behavior, i.e., the stage from crossing to spawning and ejaculation. Both sexes begin to sink down gently to the bottom, keeping the crossing posture. The fins of both sexes quiver finely but rapidly. Besides the whole body also quivers. When both the ♂ and the ♀ are inclined at about 60°, lowering their heads or

raising their tails, 15-30 seconds after crossing, trembling and quivering come to the climax. In the meantime they contact side by side almost completely. Therefore the crossing angle between both individuals becomes zero.

"Spawning" (M8; fig. 1n), "ejaculation" (M9; fig. 1o), and "fertilization" (M10; fig. 1o) As soon as the vibration of both individuals reaches the climax the belly of the ♂ beats violently like a strong convulsion twice or three times. By the abdominal beating a clump of eggs is pressed out of the genital pore of the ♀ and swells out. The ♂ ejaculates at the same time of the abdominal beating of the ♀. In two examples there were observed both the abdominal beating and the spawning without reaching the bottom of the aquarium, and milky sperm to flow down like a streak of smoke.

"Separating" (M11; fig. 1p-r)—After spawning and ejaculation the trembling of both sexes becomes slower and slower. The inclined bodies recover horizontal orientation gradually. Keeping the contact of genital pores, both individuals bend their heads and tails like bows so as to repel each other. Soon the ♂ separates gently from the ♀ and floats up without breaking off its posture as if the former were pulled up by a thread. The distance of separation is about 5 cm. The ♀ stays still at that point for a while. It takes 30-90 seconds from crossing to separating.

"Head-up III" (C1; fig. 1s)—The ♀ begins to swim several seconds after the separation of the ♂, and suddenly raises its head. At that instant, therefore, the body represents a V-shape. Then strong impulsion seems to be given to the eggs and as a result a part of the clump separates from the body and sinks down to the bottom.

"Sigmoid" (C2; fig. 1t-v)—The ♀ hanging a clump of eggs can frequently be observed to bend its body in a S-curve. This behavior pattern is not so distinguishable as the head-up III. Generally both patterns are released irregularly in the same fish, but the sigmoid shows higher frequency than the head-up III. Some fishes show only either the sigmoid or the head-up III.

"Rubbing-on" (C3; fig. 1w)—When the ♀ hanging a clump of eggs approaches the bottom or such objects as willow roots, gauze and baits, it rubs its abdomen on them so as to attach its eggs to them and separates away violently.

Discussion

Both approaching and following are considered as the basis for all the social behaviors in fish. These patterns are called the schooling behavior and are different from either the mating behavior or the care of offspring. The mating behavior includes a series of behavior patterns such as courting orientation, head-up I, courting round dance, head-up II, floating-up, crossing, copulation, spawning, ejaculation, fertilization and separating. Head-up III, sigmoid and rubbing-on are all courses of the care of offspring.

The sensorial mechanism of the schooling behavior in *Oryzias* was analysed

experimentally by Ono (1955)⁷⁾.

Courting orientation, courting round dance and floating-up were frequently performed by the ♂ of which sexual drive had become very strong, towards the immature ♀ or even the ♂ or furthermore the various models of the fishlike or cylindrical or conical shape. Though it is almost sure that the head-up I releases the courting round dance, it is not clear which element contained in the former is the sign stimulus. According to our recent model experiments (not published), the movement of the stimulating body at this stage was proved to be the most important stimulus.

Now some of the functions of the courting round dance can be pointed out as follows: 1) The sexual drive of both individuals may be promoted. 2) The position of the ♀ can be fixed. 3) The ♂ can get the favorable position for floating-up.

Head-up II can be released, on one hand, when the sex drive of the ♀ was promoted extremely. Therefore, it is released even to the ♂ which does not show any sexual behavior. On the other hand it is also performed when the ♀ seems not to accept the crossing behavior of the ♂. At any rate, no individual which reached the crossing through the head-up II proceeds to the stage of copulation.

The papillar processes of the fin rays of the ♂ perhaps rather serve to rub the anal fin of the ♀ by quivering than to hook the ♀. Namely they may play the important part to offer the sign stimuli for releasing both the spawning and the fertilizing.

All the behavior patterns of the care of offspring are considered as the means to separate the eggs from the ♀ body.

The mating behavior in *Oryzias* is regarded as the chain reactions consisting of a series of behavior patterns. Namely there can be recognized both the certain sign stimulus and the behavior to be released by it in each stage. Moreover, the released behavior contains the sign stimulus to release the behavior of the next stage. Both the quantitative research on the sequence of development of the behavior patterns and the model experiments are being made to prove this opinion.

These behavior patterns relate with each other in various degrees, representing both the organic relation and the independence pointed out by Ono (1955)⁷⁾.

All these patterns of the mating behavior described above were observed in the laboratory. We hope to get a chance for field observation.

Summary

In the present study the repertoire of the mating behavior patterns observed in the laboratory was reported. Both the approaching and the following form the schooling behavior. In the mating behavior such patterns as the courting orientation, head-up I, courting round dance, head-up II, floating-up, crossing, copulation, ejaculation, spawning, fertilization and separating can be recognized.

The behavior of the care of offspring consists of head-up III, sigmoid and rubbing-on.

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