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Effect of preoptic lesions on male reproductive behavior in the himé salmon, land-locked *Oncorhynchus nerka*

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Reproductive behavior in fishes has been extensively analyzed by ethological methods[1,10]. It seems useful to extend the analysis by using physiological methods. Such attempts have been made in several species of fish[2,5–8]. This communication describes the reproductive behavior of the himé salmon, land-locked *Oncorhynchus nerka*, and the effect of brain lesions on the behavior.

The reproductive behavior of himé salmon was found to be composed of a combination of courting by the male and nest building by the female, leading to deposition of the fertilized eggs in the nest. The sequence of reproductive behavior was very similar to that in other species of salmon and trout previously reported[3,4,9]. At least 3 behavior patterns could be recognized in the male sexual behavior: following, quivering and orgasm, while at least 4 patterns were recognizable in the female: probing, digging (or cutting), orgasm, and covering. Orgasms were usually accompanied by ejaculation of sperm or emission of eggs. Aggressive behavior (chasing, head butting, and biting) was sometimes observed between the partners. The pair showed territorial defence to an introduced rival male or female. The intraterritorial fight also had at least 3 behavior patterns: chasing, head butting, and biting. Threatening (lateral display) by the territorial male towards the rival male was also observed sometimes.

When a matured pair (29.5–32.5 cm in length) were placed in an experimental tank (size, 182 × 90 × 45 cm; flow rate, 240*l*/min), they accomplished the spawning sequence within 22 to 233 min. One and the same pair repeated the spawning sequence at least 5 times in 5 to 10 days observation: it was performed once a day at an interval of 1 to 3 days. For measurement of the sexual and aggressive tendencies in the pair, the frequencies of quivering (male), digging, covering (female), and butting or biting (between partners) were counted, respectively, in one spawning sequence. The frequencies of butting or biting between rivals were also counted to assess the tendency towards territorial fighting. A rival male was introduced for 5 to 36 min, after the female had frequently shown deep crouching in the nest, a presage of orgasm.

Fig. 1A gives an example of the behavior patterns of the intact pair. The frequencies of quivering of the male towards the female partner (Q, Aa), of butting or biting of the male against a male rival (B1, Ab), and of digging by the female (D, Ad) remained high during the 4 spawning sequences. This suggests a strong tendency in the intact pair to behave sexually, and in the male to defend territorially during the course of the observations. On the other hand, butting or biting of the male against the female partner and *vice versa* (B2 and B3, Ac and Ae, respectively) remained low. Fig. 1B illustrates the effect of a brain lesion in the male partner of another pair on the behavior patterns. The electrolytic lesion was confined to within the medial part of the preoptic area. Rostrocaudally, the lesion extended from a level just caudal to the anterior com-

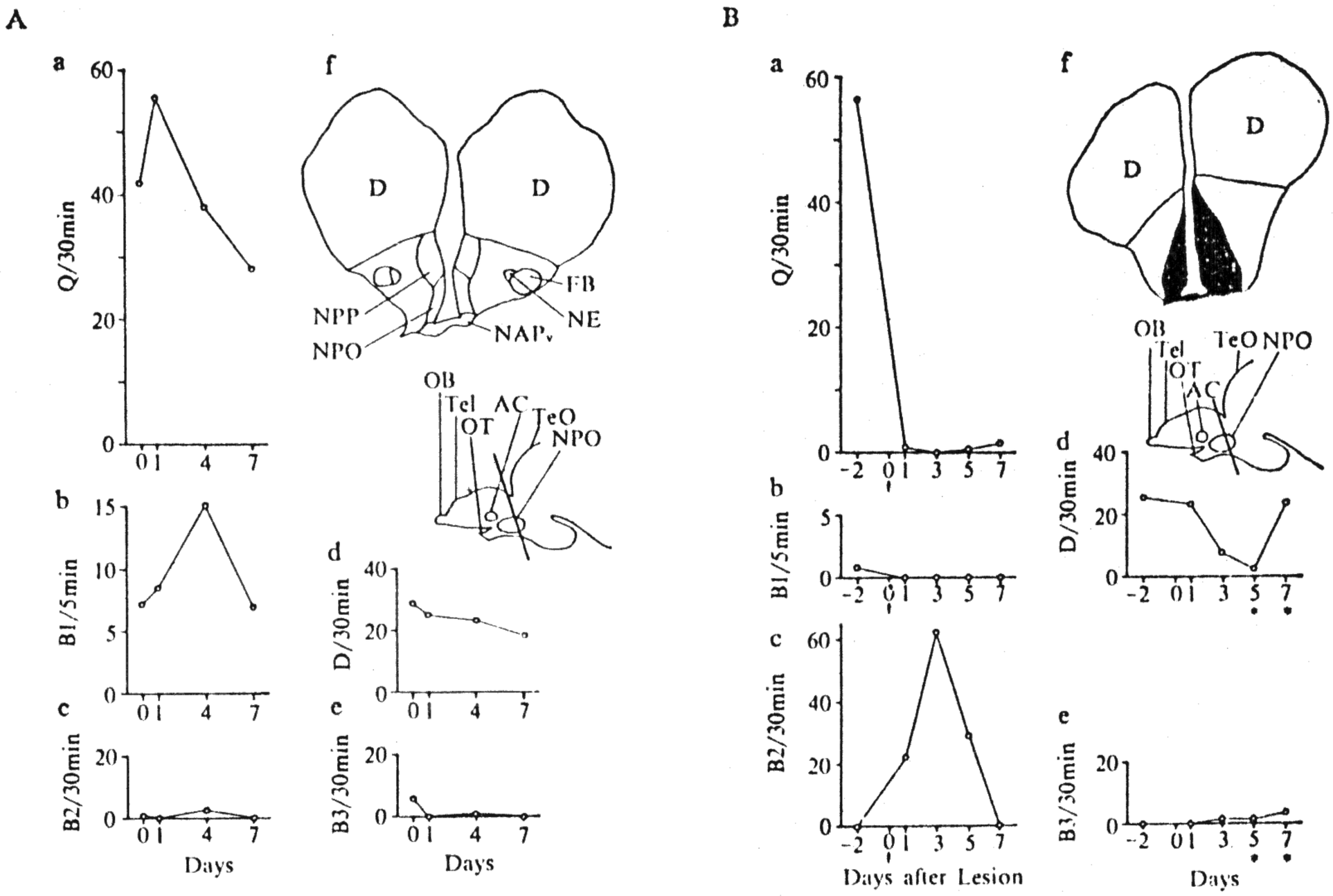

Fig. 1. Time course of the frequencies of behavior patterns in pairs with an intact (A) and a lesioned (B) male, respectively, during spawning sequences. Observations were made on days 0, 1, 4 and 7 (A) or days -2, 1, 3, 5 and 7 (B), respectively. In B, the day of electrolytic lesion is designated as day 0 (arrow). The asterisks in Bd, e indicate that intact females were newly used at days 5 and 7 as partners, since the females so far used had become wasted and/or decreased in sexual tendency. Af and Bf show frontal sections of the brain at the level indicated by the oblique lines in the lower inset drawings (outlines of a parasagittal section of the brain). The blackened area (Bf) shows the location of the electrolytic lesion. D, Area dorsalis telencephali; FB, forebrain bundles; NE, nucleus entopeduncularis; NPP, nucleus preopticus periventricularis; NPO, nucleus preopticus; NAPv, nucleus anterioris periventricularis; OB, olfactory bulb;Tel, telencephalon; OT, optic tract; AC, anterior commissure; TeO, tectum opticum.

missure to a level just rostral to the optic tectum. It included almost all of the NPP and most of the NPO and NAPv, and extended slightly into the cell sparse zone lateral to these nuclei (Fig. 1Bf). The frequencies of Q and B1 decreased dramatically after the lesion (Fig. 1Ba, b), whereas B2 increased at days 1, 3 and 5. The decrease in D at days 3 and 5 was due to an increased aggressiveness of the male partner. Two other males with severe damage in the NPO and NPP also showed a marked decrease in Q and B1, and sometimes responded frightfully to an attack of the female partner. In one of them, increased aggressiveness against the female partner and digging-or-covering-like behavior were occasionally observed. In all these 3 lesioned males, following (another pattern of the courtship behavior) was almost completely abolished. On the other hand, 3 other males whose NPP and/or area dorsalis of the telencephalon (D) were damaged, but

NPO, NAPv and lateral part of the preoptic area remained intact, performed normal reproductive behavior. All the 6 males lesioned showed normal orgasm, responding to the female's orgasm. They swam normally in the experimental tank, and no signs of motor deficit could be detected by simple behavioral tests (tests for motor ability to orient to a water stream, to follow schools of himé salmon or rainbow trout, and to escape from the fright stimulus of a shadow). These results strongly suggest that lesions in the medial preoptic area selectively decrease both quivering towards a female partner and intraterritorial fighting towards a male rival. This agrees well with previous reports in the bluegill[2] and killifish[6] which indicated that the preoptic area was involved in courtship behavior.

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