



Fig. 1. Rate of chasing between female 322 and female 076 in 1977. Female 322 was the mother of the victims: female 076 was the killer. Parturition and infanticide occurred during week 6.

burrow. The entire sequence took less than 3 min. As soon as 076 had returned to her own territory, I investigated the area around 322's burrow and found four dead infants, each apparently killed by a single bite to the head. The details of this killing are similar to those described by Sherman (1981) for adult female *S. beldingi* that committed infanticide.

The mother of the victims (322), who had been out of sight during the infanticide, reappeared approximately 5 min later. She investigated the bodies briefly, then went into her burrow. She re-emerged shortly thereafter, spent the next 25–30 min lying next to the bodies on the burrow mound, and then began foraging. Female 322 continued to occupy her territory for the rest of the season, but reared no young. Female 076 weaned four juveniles that survived the summer of 1977.

On 7 June 1977, I observed a second incident which could be interpreted as infanticide. An unmarked adult dropped the body of an infant as I approached. The hairless body was still warm and had been bitten repeatedly on the head. As in the previous case, this incident occurred at a satellite site. I presume that the victim was the offspring of the recently parturient female who occupied the site together with her yearling daughter. Two juveniles survived the attack and subsequently emerged from the natal burrow.

Despite regular observations of 10 colonial females during the vulnerable period between parturition and juvenile emergence, I neither observed nor inferred infanticide in the colonial situation. Neither did I find any significant change in the frequency of chases or other aggressive interactions between colonial females. Festa-Bianchet & Boag (1982), however, working with a high-density colony of *S. columbianus*, reported an increase in aggressive interactions between females during lactation. Although they found no evidence that infanticide was occurring, they felt that the temporal pattern of female territoriality suggested a function such as protection of young from conspecifics. McLean (1978) suggested a similar function for the plugging of nest holes by female *S. columbianus* following parturition. The very limited

observations of infanticide described in the present paper are insufficient to assess the importance of infanticide as a reproductive strategy in *S. columbianus*. However, they are consistent with suggestions that vigilant behaviour by mothers may function to thwart infanticide.

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A Tractable Model System in which Social Deprivation Early in Life Leads to Behaviour-mediated Functional Sterility: The Mosquitofish, *Gambusia affinis*

Harlow & Harlow (e.g. 1962), Rosenzweig et al. (e.g. 1972) and others have emphasized the role that early social deprivation can have in generating abnormalities or deficiencies in the adult behaviour of rhesus monkeys (*Macaca mulatta*) and laboratory rats (*Rattus norvegicus*). McCann (1980) reviewed the literature on the impact of isolation on fish behaviour, and noted that there appears to be a critical period during and just after sexual maturation during which male guppies (*Poecilia reticulata*) learn to prefer females of the type with which they spend that period. Coss (1979) and Coss & Globus (1979) produced evidence suggesting that depriving jewel fish (*Hemichromis bimaculatus*) of varied environmental stimulation during the earliest phases of brain development leads to abnormalities in important adult behaviour. In line with this view, I here report a case which suggests that isolation extending from shortly after birth through to maturity can result in behaviourally-mediated functional sterility in a

species of the same family as the guppy: the mosquitofish, *Gambusia affinis*. This is smaller, easier to culture, and in several respects more experimentally tractable than either monkeys or rats.

The evidence is as follows. (1) When raised from birth with conspecifics in 15-litre aquaria, mosquitofish successfully copulate and give birth to numerous healthy offspring (Stearns & Sage 1980). (2) When isolated on the 10th day of life from their siblings, reared to morphological maturity individually in 1.5-litre containers, and then exposed to normal adult males for one week, fewer than 20 of 350 females gave birth. (3) Dissection of 20 isolated males demonstrated that all had numerous mature spermatophores indistinguishable in quantity and quality (numbers of mature spermatophores with active sperm per testis) from the spermatophores of wild-caught males. (4) When pairs of males and virgin females (each reared in isolation from the 10th day of life) were placed in each of 20 15-litre aquaria for 2 weeks, on the hypothesis that they needed a larger arena and more time to learn to copulate, none of the females were impregnated. (5) Artificial insemination was then performed on 112 females, including the 20 just mentioned. Of 112 females inseminated, 111 survived the operation and 98 gave birth ($\chi^2 = 70.10$, $P < 0.001$, for the comparison of pregnancy rates between the isolate females housed for 2 weeks with isolate males and the isolate females that were artificially inseminated). Techniques for rearing mosquitofish and performing artificial insemination are given in Stearns (In press).

That artificial insemination was successful means that both males and females were physiologically fertile, but at least one and possibly both sexes were behaviourally incompetent to perform copulation. The only condition that differed in the rearing of these fish, compared with the fish reared earlier that were capable of copulating and giving birth without intervention, was that these fish were reared in isolation from 10 days of age. This evidence strongly suggests that *Gambusia* require cohabitation with conspecifics between the age of 10 days and maturation (which occurs at the age of 35 to 90 days, depending on rearing conditions) to achieve behavioural competence in reproduction. This result may hold for other members

of the family Poeciliidae, including the guppy, which is even easier to culture in the laboratory. I recommend this fish family to the attention of people interested in the impact of social deprivation on adult behaviour. In many respects they are a more tractable model system than those previously investigated.

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