

## SHORT COMMUNICATIONS

## Sexual Selection in the Crested Newt

A widely accepted function of courtship is to stimulate female receptivity. This seems evident in newt courtship since in the first phase (the approach), the female generally swims or walks away and only after repeated courtship attempts will she accept the male display that probably stimulates her visually, tactually and olfactorily (Halliday 1977). Halliday (1974) in the smooth newt (*Triturus vulgaris*), showed that females are more likely to pick up the spermatophores deposited in the later sequences of a courtship encounter, when more display has been performed. In *Notophthalmus viridescens*, a positive correlation between the number of male courtship acts (cheek rubs, forelimb rubs, tail vibrations) and spermatophores deposited or picked up has recently been found (Verrell 1982). This is in line with Arnold's hypothesis (1977) that the probability of spermatophore absorption increases as more time is spent in courtship. Persistence in courtship, implying a large amount of stimulation, should enhance the sexual motivation of the female and/or improve her orientation during the spermatophore-transfer stage of an encounter. Since male newts differ intraspecifically in size and secondary sexual characters, it seems likely that there will be variance in reproductive success. Halliday (1977) observed in the smooth newt that larger males produced more spermatophores. Since size is a function of age (Bell 1973) he argued that female selection of older, larger males might be adaptive: this theory predicts therefore that females will show preference for large males with big crests.

In our study we examined the sexual behaviour of the crested newt, a species particularly suitable for testing the above-mentioned hypotheses since it shows spectacular sexual dimorphism and because sexual behaviour is easily observed in captivity. We measured weight, tail height (a secondary sexual characteristic: Vellano et al. 1970), time spent in courtship and spermatophore production, and looked at the correlations between them. We used male and female crested newts collected in Arzano (Naples) at the beginning of the reproductive period. Males and females were kept separately in large aquaria for a period of acclimatization (about 1 month) where they were maintained at seasonally ambient temperature and photoperiod and were fed regularly on earthworms. During the observation period (January) 20 males were kept individually in 20 smaller tanks (30×20×20 cm) and were tested daily for sexual behaviour on 10 successive days. Tests lasted 90 min and took place between 1700 hours and 1900 hours. Each test started when females, chosen from a pool of mature individuals, were introduced randomly to the males, one in each tank.

We found that time spent in courtship is highly correlated with the number of spermatophores, both deposited and picked up, suggesting that male display rate is an important factor in the stimulation of female receptivity. There are also significant correlations between time spent in courtship and both tail height and body size, between spermatophore deposition and tail height, and between spermatophore pick-up and tail height, though not between spermatophore production and body size (Table I). A Kendall's coefficient of concordance shows a strong relationship between the four parameters considered ( $W=0.61$ ;  $N=20$ ;  $P\leq 0.001$ ). Our study therefore confirms Halliday's hypothesis about sexual selection in newts, since males with fully

Table I. Spearman's Rank Order Correlation Coefficients ( $r_s$ ) between Time Spent in Courtship, Spermatophores Deposited and Absorbed, Tail Height and Size

Parameter	SP	TH	Size
TC	†0.80**/0.70**	0.41*	0.48*
SP	—	0.49*/0.55**	0.17
TH	—	—	0.43*
Size	—	—	—

\* $P\leq 0.05$ ; \*\* $P\leq 0.01$ .

†The first figure refers to the correlation with spermatophores deposited/the second figure refers to the correlation with spermatophores picked up.

TC: time spent in courtship; SP: spermatophores deposited and absorbed; TH: tail height.

developed epigamic characteristics are more successful in mating. Nelson (1959) found a relationship between crest development and display propensity in this species, although this was surprisingly variable. From the physiological point of view it must be remembered that prolactin and testosterone, the hormones that control the development of epigamic characters, are also involved in the expression of courtship behaviour (Malacarne et al. 1982; Andreoletti et al. 1983). Courtship requires prolonged exertion so that it is mainly the endocrinologically-mature males that seem to achieve reproductive success. Further research could verify whether variance in reproductive success depends on a different ability of persistent males to increase female receptivity or if females exert a mate choice by accepting courtship and/or preferentially picking up the spermatophores of the sexually mature, more attractive males. Probably both mechanisms contribute to the variance in male reproductive success.

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### Response by Potential Prey to Coral Reef Fish Predators

Agonistic behaviour is one of the most interesting and studied interactions among reef fishes. Intra- and inter-specific agonistic encounters between fishes often involve such actions as fin-spreading, tail-beating, mouth-gaping, pendulum movements, and other less equivocal movements (Miller 1978). Lateral displays are one form of behaviour used in intra- and interspecific agonistic encounters and in anti-predator situations between fishes. These displays appear to communicate status and/or threat, sometimes being entirely sufficient to dissuade further encroachment by potential enemies (Chiszar 1978).

This note adds to the growing literature on predator-prey interactions in fishes, specifically those involving prey actively moving to the immediate vicinity of potential predators for purposes of apparent mobbing. I report on lateral displaying and rubbing behaviour exhibited by butterflyfishes (Chaetodontidae), damselfishes (Pomacentridae) and surgeonfishes (Acanthuridae) and directed toward moray eels (Muraenidae) and lizardfishes (Synodontidae).

The nocturnal and diurnal predatory behaviour of moray eels and lizard fishes on other tropical reef fishes, including spinous forms such as butterflyfishes, has been reported by Winn & Bardach (1959), Hobson (1974, 1975) and Burgess (1978).

The interactions described here occurred over coral substrate at various locations in Hanauma Bay, Oahu, Hawaiian Islands on eight separate occasions between 1200 and 1530 hours, and involved nine species of displaying fishes (Table I). In general, after sighting the potential predator, the displaying fish(es) approached it from a distance of up to 3 m. The displays swam directly towards the potential predator and displayed laterally anywhere from 20 cm in front of it to making direct contact with the predator's head. The displaying fish was oriented approximately perpendicular to the predator's head, which was protruding from a crevice in most cases. The displayer often exhibited tail-beating behaviour, involving slow oscillations of the caudal fin. If contact with the predator's head occurred, it was gentle and made by the caudal fin. During displays, the dorsal fin of the displayer could be either fully or partially erect, or not erect. In cases of close proximity between the displayer and the predator, the former occasionally exhibited rolling or leaning, in which the fish rolled its body with its dorsal spines more or less directed towards the predator. It was not noted whether colour changes accompanied the interactions.

Displays lasted approximately 5–20 s, after which the displaying fish swam a short distance away from the predator and then returned to display one or more times, either in the same or the opposite orientation. In all cases described, the potential prey returned to display at least once more. In some cases the predator left the area following the display.

These displaying fishes may be exhibiting mobbing behaviour. Mobbing may involve one or more animals (Hartley 1950; Hinde 1970), is a reaction to a potential threat, and is not necessarily provoked by hostile actions (Hartley 1950). Mobbing may result in deterring or thwarting a predator's attack (Bertram 1978) and it generally makes nearby individuals of the prey species aware of the presence of the predator (Harvey & Greenwood 1978).

Displaying to potential predators has been briefly described for other reef fishes. Wickler (1961) likened the attacks to those of songbirds on owls. Eibl-Eibesfeldt (1962) observed a school of *Caesio cuning* harass a moray eel, causing it to move some 10 m away along the reef. Maksimov (1970) described 'mobbing' of sharks by tropical fishes as did Fricke (1973) for damselfishes towards barracuda (Sphyraenidae), triggerfish (Balistidae) and octopus. R. W. Abrams, M. D. Abrams and M. W. Schein (personal communication), MacElwain (1977) and possibly Collette & Talbot (1972) noted displaying of reef fishes to other potentially predatory reef fishes. Dubin (1982) hypothesized that similar behaviours exhibited by Atlantic reef fishes towards moray eels and snake eels (Ophichthidae) were stimulating the eels to move away. The behaviour may be functionally analogous to the mobbing response of small birds to predators. Curio et al. (1978) acknowledge that mobbing occurs in fishes, birds and mammals.

Mobbing may cause the predator to move off because of the lowered probability of prey capture in that area, given that most prey individuals are aware of the predator's presence either by spotting it or being alerted by the commotion of the others (Alcock 1979). In two of the eight observations reported here, the potential predator left the immediate area (Table I).

It appears unlikely that the displaying fishes are defending territories because: (a) of the species involved, only the damselfish *Abudefduf abdominalis* is territorial (Reese 1975; Neudecker & Lobel 1982; personal observations); and (b) in over 300 h of observation on *C. miliaris*, *C. ornatissimus*, *C. auriga*, *C. trifasciatus* and *C. unimaculatus*, I have never observed similar displays directed at other fishes.

The function of this behaviour, and whether it constitutes true mobbing, remains unresolved, but this note provides the most detailed account to date of this very interesting interaction among reef fishes.

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