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**DIEL COLOR PHASE CHANGES IN THE CONEY, *EPINEPHELUS FULVUS* (TELEOSTEI, SERRANIDAE).**—Many piscivorous fishes (e.g., stonefish, lizardfish, and flatfish) have cryptic coloration that reduces their chances of being detected by potential prey (Hobson, 1975). The groupers (subfamily Epinephelinae) are common predators on Caribbean coral reefs that exhibit a wide variety of patterns and colorations to match their surroundings (Townsend, 1929; Smith, 1971). Variation in coloration can also be under the individual's behavioral control to enable rapid camouflaging. This ability occurs in many fishes and is so common that it has apparently been attributed to some fishes without observational proof (Cott, 1957). We report here observations of normal diel color phase changes in a species in which the changes were previously thought to occur only due to excitement.

**Study species.**—Coneys (*Epinephelus fulvus*) are small groupers common in the western Atlantic in shallow water (5–20 m deep) near coral patches (Smith, 1971). They are known to exhibit at least four color patterns (or phases) in nature, as illustrated in Townsend (1929, plate 9). One of the phases consists of a uniformly dark brown body with faint blue-black spots. Although some authors (e.g., Thompson and Munro, 1978) have reported that coneys from deep water are red, they actually appear brown underwater because under normal conditions there is very little red light below 10 m on coral reefs (Jerlov, 1976). In a second color phase, the dorsal part of the body is dark brown or black, and the ventral part of the body is creamy white. Between the black-and-white areas, there

is a clear demarcation that runs from the tip of the snout to the dorsal part of the caudal peduncle (Smith, 1971). In the third pattern (xanthic coloration), the body is a uniform bright yellow. The fourth "sleep" pattern consists of irregular bars and blotches and occurs when the individual is at rest at night (Smith, 1971).

Individual fish can vary between the all-brown and black-and-white phases (Smith, 1958), whereas xanthic coneys are apparently not capable of color change (Townsend, 1929). In coneys, the yellow color is probably the result of a single recessive gene (Smith, 1971) unlike xanthism in a congener *E. drummondhayi*, which is simply an ontogenetic phase (Ross, 1988). Here we discuss only the all-brown and black-and-white patterns, because no xanthic coneys were observed during this study.

**Methods.**—Using SCUBA, we observed coneys almost daily from 12–29 Aug. 1991 at Playa Bengé off the northwest coast of Bonaire, Netherlands Antilles (12°8'N, 68°25'W). The site (depth 8 m) consists of a soft sandbed approximately 50 m in diameter surrounded by coral reefs (van Duyl, 1985; map B3). Fish around the sandbed were habituated to the presence of divers because we had been using the site for behavioral studies of green razorfish, *Xyrichtys splendens* (Nemtsov, 1992). A diver swam slowly around the perimeter of the sandbed and recorded the coloration of each coney observed as all brown, black and white, or intermediate between these two. We noted the time at the beginning of each survey and used it to identify the survey. We conducted 36 (8–10 min) surveys between 0700 h and 1735 h. A mean ( $\pm$  SD) of  $20.3 \pm 4.7$  (range 13–34) coneys were recorded on each survey. During the study, the sun rose at 0640 h and set at 1850 h ( $\pm 5$  min).

**Results and discussion.**—Most coneys observed during the early morning and late afternoon hours exhibited black-and-white coloration, whereas most of those seen near midday were all brown (Fig. 1). There was a significant difference between the proportion of fish in either color phase for every survey (G-test,  $P < 0.05$ ) except for the surveys conducted at 0930 h and 1615 h (G-test,  $P > 0.8$  and  $P > 0.99$ , respectively). At these two times, there were approximately equal proportions of fish in the two phases. The proportion of fish with intermediate coloration was highest (Fig. 2) near these two times, namely, at 0915 h and 1540 h.

These observations show that the intermediate coloration is a transition between the all-brown and black-and-white phases. Thus, the

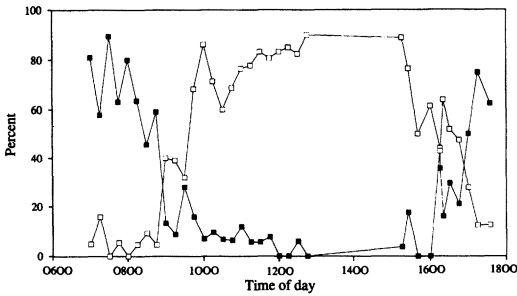


Fig. 1. Diel change in the proportion of coney in each of two color phases; black and white (filled squares), and all brown (open squares). The sum of the observations for the two color phases at each time of day do not total 100% because data for fish with an intermediate color pattern were excluded.

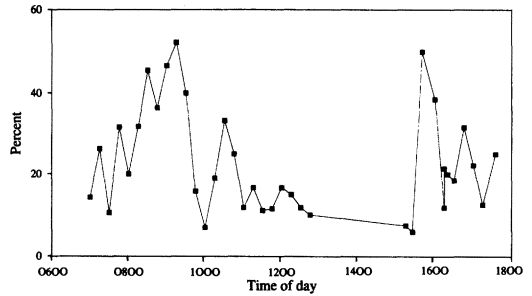


Fig. 2. Diel change in the proportion of coney with coloration intermediate between all brown and black and white.

peaks of the bimodal distribution in Figure 2 represent the times of the crossover from one color phase to the other which would be expected to occur twice each day. Only in the two surveys that were nearest these transition times was there no significant difference in percentage occurrence between the two color phases.

Smith (1958, 1971) called the black-and-white pattern an excitement phase because "fish assume the excitement pattern at the first approach of danger and, also, at the first scent of food" (Smith, 1971). We did not observe color changes due to excitement or introduction to food. During earlier experiments in which we provided food (Purina trout chow) to the razorfish, coney often approached to feed, but the coney occurred in both the all-brown and black-and-white phases. Similarly, when we saw coney swimming quickly across the sandbed to chase prey, we did not observe any color phase changes.

Nagelkerken (1981) noted that black and white was the usual pattern for coney in the Netherlands Antilles and that it put the coney "in harmony with the surroundings" which consisted of small coral patches on a white sandy bottom. Although our site matched this description, in our observations black and white was the most common phase only at certain times of day (Fig. 1).

If the black-and-white phase aided the fish by obliterative shading or countershading, it should have been most prevalent when there was bright light from above (Thayer's principle; Cott, 1957). Yet, contrary to this principle, coney at Playa Bengé exhibited the black-and-white pattern mostly during times of reduced lighting (Fig. 1). The black-and-white pattern may still have facilitated concealment in this habitat with a bright white sandbed, because the coney were

usually seen close to coral heads or under large branching corals, and not swimming out over the open sand.

We conclude that the black-and-white color pattern in coney is not exclusively an excitement phase nor is it used at all times for countershading. Although diel color phase change in coney may aid in intraspecific communication or thermoregulation, it seems more likely that in agreement with Thayer's principle, it aids in obliterative shading over the course of the day. The black-and-white pattern of the coney is likely to be most important for countershading during crepuscular periods, because this is when these fish usually feed (Randall, 1967).

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LOCOMOTION AND FEEDING RESPONSES TO MECHANICAL STIMULI IN *HISTIODRACO VELIFER* (ARTEDIDRACONIDAE).—Most shelf-dwelling antarctic fishes belong to the perciform suborder Notothenioidae and have radiated to occupy a variety of trophic and habitat niches (Andriashev, 1986; Eastman, 1991). One family, the Artedidraconidae, is distinguished by a median mandibular barbel which may function either as an organ of taste (as in catfishes) or as a lure (as in certain stomiatooids). We present behavioral and morphological evidence that in *Histiodraco ve-*



Fig. 1. Aquarium photo of *Histiodraco velifer*. Note that the mental barbel extends at an angle up from the bottom.

*lifer* the mental barbel functions as a lure. In addition, observations on its locomotion suggest that *H. velifer* behavior is convergent with that of frogfishes (Antennariidae). This work was highly opportunistic because the fish is very uncommon at McMurdo Sound.

An 87-mm SL *H. velifer* (Fig. 1) was collected by scuba in 25 m depth in Explorer's Cove, New Harbor (77°33'S, 163°40'E), McMurdo Sound, Antarctica. The fish occupied a small cavity in a mud bottom with scattered low (<0.5 m) rocky benches and was housed in a 1.6-m diameter, 0.9-m deep, circular fiberglass tank. Most observations were made in a 62-cm square × 10-cm deep plexiglas aquarium. Water temperature was between -1.5 C and 0 C. Most behavioral observations were made and videotaped under far-red (photographer's darkroom) light and infrared video (Dage-MTI model 65 with IR light source) in a flat black sealed room. The barbel was preserved in Karnovsky's fixative (buffered gluteraldehyde and paraformaldehyde) for sectioning and later SEM and histological examination.

The collector (MS) first noticed the barbel moving up and down at the lip of the cavity. The barbel shape and motion were similar to those of the common elongate amphipod *Antarcturus*. When approached, the fish attempted to crawl away via "rowing" of the pelvic fins against the substrate (see below) and made no attempt to swim. A second specimen of *H. velifer* (not collected) exhibited similar behavior (J. Weston, pers. comm.).

In the laboratory, *H. velifer* crawled on the bottom and over rocks by use of pelvic fin rowing. To move forward, the fins were simultaneously retracted, pushing against the bottom. After the body moved forward, fins were extended anteriorly for another stroke. Each