

grading into a dull orange dorsally. A twelve-fold increase in attacks of garibaldi on señoritas was reported from nonbreeding to breeding season (Clarke, 1970). During nonbreeding season, señoritas were allowed to enter territories of adult male garibaldis, graze on territory peripheries, and "clean" the garibaldis (a seemingly mutualistic exchange). However, during the breeding season, these cleaners were chased away vigorously (SFC, pers. obs.). Egg protection may explain the heightened aggression toward the señorita, but the magnitude of change may be enhanced by the señorita's coloration, or possibly by its shape.

Clarke (1971) observed that much of the aggression exhibited by garibaldi was directed toward other species that did not recognize or respect their territorial boundaries. However, during the breeding season, the most intense attacks were directed at other intruding adult garibaldis (Clarke, 1971). It is not surprising that only a small percentage of nonbreeding season attacks were intraspecific (Clarke, 1971). In the absence of severe resource limitation, damaging or straining intraspecific encounters year round would be detrimental to a population on a long-term basis.

Lorenz (1962) postulated that bright "poster colors" in marine fishes are species-specific sign stimuli that release intraspecific aggression and result in intraspecific territoriality. However, Lorenz's (1962) suggestion that the primary function of poster colors is an advertisement of territory ownership may have been an overstatement. Since then, it has become apparent that bright "poster coloration" may serve a variety of functions (Ehrlich, 1975; Ehrlich et al., 1977). However, from the results of this study, we can see that in territorial species, poster coloration can and does release intraspecific aggression, particularly at critical periods of time such as the breeding season.

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DIET AND GROWTH OF A BROOD OF *BAGRUS MERIDIONALIS* GÜNTHER (SILURIFORMES: BAGRIDAE) IN LAKE MALAWI, AFRICA.—Trophic specializations among

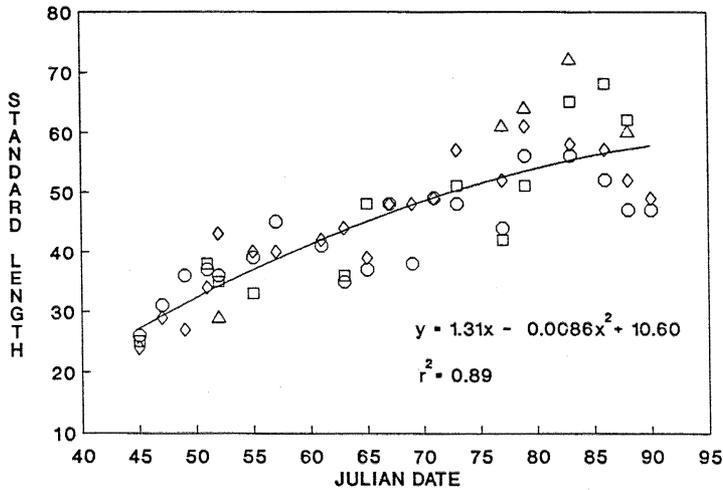


Fig. 1. Growth curve for *Bagrus meridionalis* during the first 2 mo of life.

fishes are generally facultative; diets may vary among season, habitat, or life stages (Goulding, 1980). Specializations reported in tropical fishes include paedophagy (Greenwood, 1959; McKaye and Kocher, 1983; Stauffer and McKaye, 1986), lepidophagy (Fryer and Iles, 1972; Ribbink, 1984), and facultative cleaning (Stauffer, 1991). Feeding on trophic eggs (e.g., unfertilized, degenerate eggs; Lincoln et al., 1984) occurs in some insects, particularly the social Hymenoptera, in which larvae feed on nonviable eggs in the colony (Wilson, 1971). The black salamander (*Salamandra atra*; Fachbach, 1969) and various prosobranch molluscs (Fioroni, 1966, 1977) are also known to use eggs as food. Weygoldt (1980) described the feeding by poison-arrow frog larvae (*Dendrobates pumilio*) on "nutritive" eggs which females had deposited in bromeliad leaf axils containing the larvae. Wassersug et al. (1981) suggested this same phenomenon may occur in Thailand rhacophorid frogs, whose guts were found to contain small-sized eggs.

Several forms of feeding on trophic eggs have been reported in fishes. Oophagy in porbeagle sharks (*Lamna* spp.) has been well documented (Lohberger, 1910; Shann, 1923; Stribling et al., 1980). Among ovoviparous sharks, in general, the first young to hatch in each oviduct preys on its embryonic siblings and consumes unfertilized eggs, which the mother continues to supply (Moyle and Cech, 1988). An analogous form of internal feeding has been suggested for the coelacanth, *Latimeria chalumnae* Smith (Wourms,

1981; Balon, 1984). External consumption of trophic eggs in fishes was first reported in the bagrid catfish, *Bagrus meridionalis*, by McKaye (1986), who also hypothesized that the male feeds the young benthic invertebrates gathered outside of the nest. The objective of this study was to investigate feeding of *B. meridionalis* young.

Materials and methods.—A single brood of catfish was observed under a boulder at a depth of 4 m near Songwe Hill (34°56'E, 14°00'S) in the southern portion of Lake Malaŵi, Africa. Two to four catfish young were collected from the brood every other day from 14 Feb. 1989 through 1 April 1989 by SCUBA divers with 10 cm × 10 cm (3 mm mesh) hand-held dip nets. All collections except two were made before 1000 h. A total of 57 young were collected and fixed in formalin. Specimens were weighed to the nearest 0.001 g; standard length (SL) and head length (HL) were measured to the nearest 0.01 mm using dial calipers. Stomachs were removed and prey items counted, measured, and identified.

Feeding behavior of *B. meridionalis* fry was recorded in situ at seven nests near Thumbi West Island in Cape Maclear National Park (34°54'E, 13°59'S; Fig. 1) at depths of 20–40 m. This location was chosen for the recordings because it harbored large concentrations of breeding catfish. Two RCA video cameras (Model CMR 300) equipped with wide angle lenses, timing boards, and strobe lights were used. SCUBA

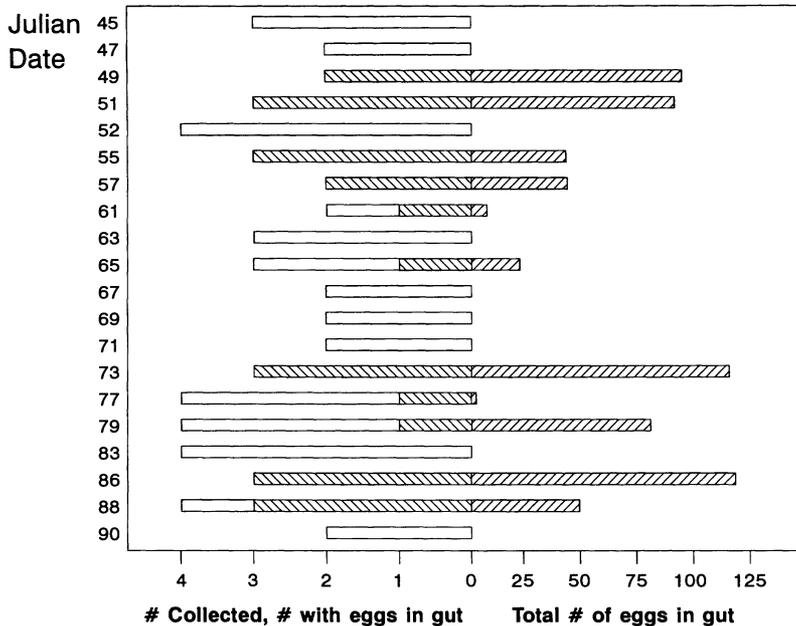


Fig. 2. Occurrence of trophic eggs found in stomach of bagrid fry. Bars indicate days on which trophic eggs were found.

divers positioned the video cameras on the periphery of the bowl-shaped nests approximately 1.5 m from the center. A series of 2-h recordings were made in the morning, afternoon, and night. Nocturnal behaviors were captured on videotape using a timing board preset to film either a continuous 50-min sequence (the length of time the strobe light's power supply held its charge) or a 1-min sequence every 17 min throughout the night. The video cassettes are cataloged into the Pennsylvania State University Fish Museum (PSU 2330).

Results and discussion.—The following growth curve for the bagrid fry was calculated using stepwise regression (Fig. 1): $y = 1.31x - 0.0086x^2 + 10.60$, where $y = \text{SL (mm)}$ and $x = \text{age (days)}$; $R^2 = 0.89$. The y-intercept is probably an overestimation of the size of the young when they emerge from the egg, because we did not start collecting data until the fry were approximately 14 days old. Of the 57 fry collected, 41 (72%) had food in their stomachs (Fig. 2). Of the stomachs containing food, 23 had trophic eggs, 22 had chironomid larvae, 21 had cladocerans, nine had corixids, seven had ephemerids, four had fish scales and bivalve molluscs, and one had a potamonautid crab. Trophic eggs were first observed in stomach

samples when the bagrid fry were approximately 30 mm SL (about 18 days old). Trophic eggs were found consistently in stomachs of fry throughout the sampling period (Fig. 2). Stomach contents were weighed to the nearest 0.1 mg, and trophic eggs comprised 91% of the total biomass found in the stomachs (Fig. 3).

We first observed feeding on trophic eggs in situ when fry were approximately 12 mm SL. Fry swam up to the female's vent and hovered directly beneath her, although we did not observe eggs being released. During the day, fry less than 50 mm SL remained clustered in the bottom of the nest when not congregating in the vicinity of the female's vent. At night, they dispersed throughout the bottom of the nest to forage. Periodically, while on the bottom of the nest, the male shook, quivered, and scooped sediment into his mouth. The young congregated behind him, presumably to feed on any exposed macroinvertebrates in the sand. The male was also observed to forage outside the nest, and, upon his return, the brood converged around his gills as he opened and closed his opercle. It is doubtful that the number of invertebrates found in the stomachs of the young catfish throughout the study would have originated solely in the substrate upon which the nest was constructed. Thus, it is likely that some

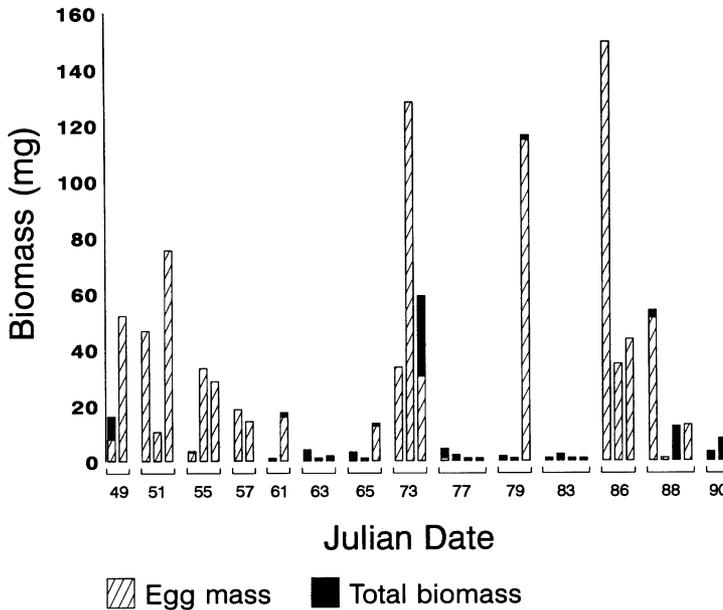


Fig. 3. Biomass of stomach contents of individual bagrid fry.

food is obtained from the gills of the returning male; however, based on data presented in Figure 3, invertebrates appear to represent a small amount of the total biomass consumed.

The number of eggs in the ovaries of five ripe *B. meridionalis* females examined ranged from 50,000–75,000, suggesting that these fish are capable of producing very large broods. Over the past 10 yr, however, we have observed over 50 broods, none of which contained more than 2000 young. Many of these broods were observed within two to three days of fertilization, and several were observed within one day of fertilization. Underwater video recordings of young gathering at the female's vents suggested that fry feed on trophic eggs. The existence of this feeding strategy was confirmed by stomach analyses; 40% of the catfish young sampled had eggs in their stomachs. Based on preliminary observations, we hypothesized that males also feed the young, either by (1) disturbing the substrate in the nests and/or (2) by bringing mouthfuls of sand and invertebrates from outside the nest and depositing them into the nest. However, based on data herein, invertebrates represent less than 10% of the total biomass consumed.

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HISTOLOGICAL EVIDENCE FROM CONTACT ORGANS FOR THE RESPECTIVE MONOPHYLY OF THE GENERA *GADUS* AND *BOREOGADUS* (GADIDAE).—According to Dunn's (1989) cladogram of *Merluccius* and 11 of the 12 genera of the monophyletic subfamily Gadinae sensu Svetovidov (1948) and Markle (1982), *Gadus*, together with *Theragra*, *Boreogadus*, and *Micromesistius*, belongs to a clade which is characterized by two synapomorphies. The analysis, based on 42, mostly osteological, characters, revealed no synapomorphies for *Gadus*. However, two synapomorphies were given for the *Theragra-Boreogadus-Micromesistius* subclade, and this lineage was used as the sister group to *Gadus*.

Vladykov et al. (1985) reported the presence and provided photographs of "breeding tubercles" on the scales of *Gadus*. *Boreogadus* is the only other gadine in which roughening structures have been reported (Svetovidov, 1948; Walters, 1955; Andriyashev et al., 1980). The presence of such nuptial tubercles in members of *Gadus* and *Boreogadus* was hypothesized by Renaud (1989b) to be the result of convergence. He also suggested that these tubercles could be used as evidence for the monophyly of each of these genera. The purpose of this histological study is to determine whether the tubercles in *Gadus* and *Boreogadus* are homologous.

Methods.—Institutional abbreviations are as listed in Leviton et al. (1985). Note that the National Museum of Natural Sciences (NMC) has changed its name to Canadian Museum of Nature.

Two adult specimens of *Boreogadus saida* and seven of *Gadus*, representing all three species recognized by Renaud (1989b); one specimen of *G. macrocephalus*, four of *G. morhua*, and two of *G. ogac*, were studied. These specimens had been fixed in 10% formalin and later preserved in 45–50% isopropanol or 70% ethanol. A tuber-