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FEEDING HABITS AND SEXUAL DIMORPHISM OF THE VIOLET GOBY, *Gobioides broussoneti* LACEPEDE (PISCES: GOBIIDAE), IN THE ESTUARINE SYSTEM OF TECOLUTLA, VERACRUZ, MEXICO

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ABSTRACT *Gobioides broussoneti* were sampled in Silveña estuary, a branch of the Tecolutla estuary, Veracruz, Mexico, during 2 trips made between February 1998 and June 1999 to evaluate diet and sexual dimorphism. A total of 65 *G. broussoneti* ranging from 49–401 mm SL (0.7–124.2 g WW) were collected. There was a 1:1.2 sex ratio in favor of females. Seven food types were noted, with filamentous algae (25.4%) and detritus (21.3%) representing the principal food types. A 24 h feeding study revealed that this species feeds continuously throughout the day. The ovaries of all female *G. broussoneti* contained previtellogenic oocytes, characteristic of immature or regressed fish. In contrast, the lobular testis of the males contained late stages of spermatogenesis, suggesting that the fish examined were at the end of the reproductive season. Sexual dimorphism of *G. broussoneti* is distinguished by a small urogenital papilla, which is in the ventral region between the anal orifice and the anal fin origin. In the females it is short, blunt and has a yellow coloration; in males it is thin, pointed and has a smooth appearance. Only immature or regressed females were captured during this study indicating that *G. broussoneti* uses the Tecolutla estuary as a nursery and feeding ground. Questions about reproductive seasonality, ovarian development, and spawning of *G. broussoneti* need further investigation.

RESUMEN *Gobioides broussoneti* fue muestreado en el estuario Silveña, un brazo del estuario Tecolutla, Veracruz, México, durante 7 muestreos realizados entre febrero de 1998 y junio de 1999, para evaluar la dieta y el dimorfismo sexual. Fueron colectados un total de 65 *G. broussoneti* con tallas de 49–401 mm de longitud estándar y peso entre 0.7 y 124.2 g. Presentaron una proporción sexual de 1:1.2 a favor de las hembras. Siete tipos alimenticios fueron registrados; las algas filamentosas (25.4 %) y el detritus (21.3 %) representan los principales tipos alimenticios; un estudio alimenticio de 24 horas reveló que esta especie se alimenta continuamente a lo largo del día. Los ovarios de todas las hembras de *G. broussoneti* contienen ovocitos previtelogénicos, característicos de peces inmaduros o regresados. En contraste, el testículo lobular de los machos contenía estadios tardíos de la espermatogénesis, sugiriendo que el pez examinado se encontraba al final de la estación reproductiva. El dimorfismo sexual de *G. broussoneti* se distingue por una pequeña papila urogenital, que se encuentra en la región ventral, entre el orificio anal y el origen de la aleta anal. En las hembras esta es corta, achatada y de coloración amarilla; en machos es delgada, afilada y tiene una apariencia lisa. Estos resultados indican que *G. broussoneti* utiliza el estuario de Tecolutla como un lugar de crianza y alimentación, ya que en este estudio solo fueron capturadas hembras inmaduras o regresadas. Cuestionamientos acerca de estacionalidad reproductiva, desarrollo ovárico y desove de *G. broussoneti* requieren mayor investigación.

INTRODUCTION

Members of the Gobiidae are small benthic fishes inhabiting a wide range of habitats in temperate and tropical regions (Dawson 1969, Iglesias 1981, Nelson 1994) and are characteristically secretive and more abundant than generally noted (Hendon et al. 2000). Gobiids are one of the most abundant group of species in marsh-edge habitats in the Gulf of Mexico (Baltz et al. 1998, Hendon et al. 2000) and presumably play an important role in the ecology of coastal environments. They also contribute to the food web in many estuarine and marine environments (Maciolek 1981, Nelson et al. 1992).

The violet goby, *Gobioides broussoneti*, is a larger member of the Gobiidae and is distributed from the western Atlantic of the United States to Rio de Janeiro, Brazil,

including the Gulf of Mexico, and the Caribbean coast along Colombia, Venezuela and French Guyana (Greenfield and Thomerson 1997, Murdy 1998, Hoese and Moore 1998). It typically occurs in marine and estuarine environments (Castro-Aguirre 1978, Hoese and Moore 1998) but has been found in fresh water (Hubbs et al. 1991). Little data are available on the ecology and life history of this species, with the exceptions of systematic (Pezold 1993, Murdy 1998), cytogenetic (Aguirre and Nader 1987), and aquarium care and maintenance studies (Brackish Water Aquaria FAQ 2003, Fishbase 2003). Given the lack of much biological or ecological data on this species (Darcy 1980, Fishbase 2003), the objective of this work is to document the feeding habits and sexual dimorphism of *G. broussoneti* in the estuarine system of Tecolutla, Veracruz, Mexico.

MATERIALS AND METHODS

Field sampling

Fish were sampled in Silveña estuary, a branch of the Tecolutla estuary, Veracruz, Mexico, with a beach seine (30 m long by 1.5 m high, 12.7 mm mesh) during 7 trips made between February 1998 and June 1999. All fish were placed in 20 L buckets, and transported to a provisional laboratory where they were sacrificed, weighed (g), measured for standard length (SL, mm), and preserved in 10% formalin. During the March 1999 trip, fish were sampled every 4 h over a 24 h period to estimate feeding periodicity.

Laboratory procedures

In the laboratory, fish were rinsed overnight in running tap water, and the entire digestive tract was removed from each individual and placed in petri dishes with distilled water to avoid desiccation. The food items were separated with the use of a Nikon model SMZ-1 stereomicroscope and a Nikon optic microscope. Food items were identified to the lowest taxonomic level possible, following Sanchez and Ponce (1996). The frequency of occurrence of each food type was estimated (Hyslop 1980), and the diet of the fish collected during the 24 h study was expressed on a qualitative scale (Prejs and Colomine 1981). This was done using a combination of food quantity and its distribution in the digestive tract (stomach vs. intestine) to estimate when the fish last fed, with 0 =

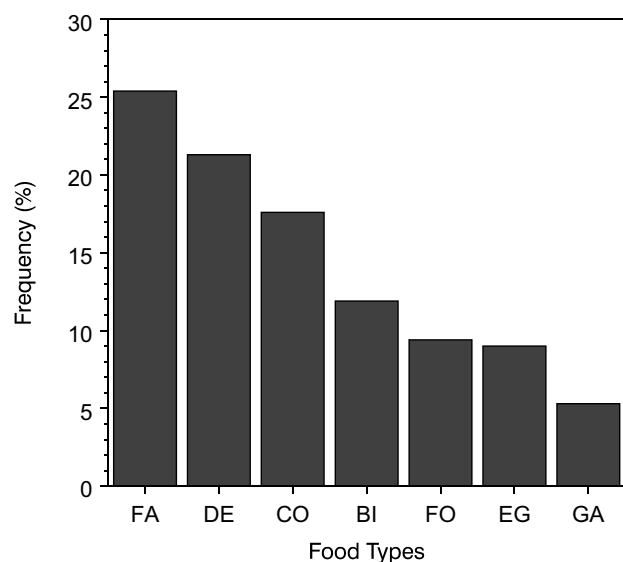


Figure 1. Frequency of occurrence of food types of *Gobioides broussoneti* ($n = 65$) from February 1998 to June 1999 in the estuarine system of Tecolutla, Veracruz. FA = filamentous algae, DE = detritus, CO = copepods, BI = bivalves, FO = foraminifera, EG = eggs, and GA = gastropods.

empty, 1 = minimal food, 2 = scarce food, 3 = medium food, 4 = full, not bulging, and 5 = full and bulging.

To document sexual dimorphism, a macroscopic description of the female and male reproductive apparatus was made. The gonads and urogenital papilla were removed from the fish, dehydrated, and embedded in paraffin following standard histological techniques. Tissue was sectioned at 5–7 μ m and stained with hematoxylin and eosin.

RESULTS AND DISCUSSION

A total of 65 *G. broussoneti* (36 females, 29 males) were collected, ranging from 49–401 mm SL and 0.7–124.2 g wet weight. The sex ratio was 1:1.2 in favor of females. *Gobioides broussoneti* was collected only over muddy bottoms in highly turbid areas adjacent to seagrass beds.

Feeding habits

Of the total of 65 digestive tracts examined, only 4 (6.1%) were empty. Seven food types were determined with filamentous algae (25.4%) and detritus (21.3%) representing the principal food types. These food types were followed in occurrence by copepods (17.6%), bivalves (11.9%), foraminiferans (9.4%), eggs (9.0%) and gastropods (5.3%) (Figure 1).

Gobioides broussoneti can be classified as a primary consumer (Yañez-Arancibia and Nugent 1977) as the diet generally consisted of detritus and filamentous algae. This is supported by the presence of a long, folded alimentary canal, a defining characteristic of herbivorous species (Horn 1989). The presence of copepods, bivalves, foraminiferans, eggs and micro-mollusks in the diet, although showing a relatively high frequency of occurrence, appears to be incidental. The violet goby feeds on colonies of benthic algae and can incidentally ingest large quantities of detritus and related organisms from this feeding habit (Brackish Water Aquaria FAQ 2003). The diets of many goby species also indicate that detritus and algae are common food types (Kinch 1979, Darcy 1980, 1981, Maciolek 1981).

Sixteen violet gobies were collected during the 24 h study, ranging in size from 121–227 mm SL and 7.8 to 45.3 g. Eleven contained food in the stomach and intestine, whereas 5 had a small quantity of food in the stomach but had a full intestine (Table 1), with no variation in food type based on size. Although diel variation in stomach fullness is common in fishes (Grossman et al. 1980, Wootton 1990), the majority (69%) of *G. broussoneti* sampled had full stomachs and/or intestines, regardless of the time of day (Table 1).

TABLE 1

Food distribution in the digestive tracts of *Gobioides broussoneti* over a 24 h cycle. S = stomach, I = intestine. Numbers in parentheses refer to qualitative scale. 0 = empty to 5 = maximally full.

Collection time	Number of fish	Food distribution in digestive tract
1530	6	S and I (4) (3 fish) S (1), I (4) (3 fish)
1930	0	—
2330	2	S and I (4) (2 fish)
0330	3	S and I (4) (2 fish) S(1), I (4) (1 fish)
0730	1	S and I (4)
1130	4	S and I (4) (3 fish) S (1), I (4) (1 fish)
1530	0	—

Sexual dimorphism

The ovaries of all female *G. broussoneti* examined for this study contained previtellogenic oocytes, characteristic of immature or regressed fish. In contrast, the lobular testis of the males contained several stages of spermatogenesis, including spermatids and spermatozoa. The lumen of the lobules was partially empty of spermatozoa, and there was little evidence of active spermatogenesis, suggesting that the fish examined were at the end of the reproductive season (Brown-Peterson et al. 2002). These results indicate that *G. broussoneti* uses the Tecolutla estuary as a nursery and feeding ground, as only immature or regressed females were captured during this study. Violet gobies have been reported to reach up to 553 mm TL and 311 g (Fowler 1947, Fishbase 2003), much larger than most females captured during this study. This suggests that *G. broussoneti* spawns in the open ocean and should be considered a tem-

poral species from Tecolutla estuary. The capture of males in late stages of the reproductive cycle, with minimal spermatogenesis, confirms that the fish may move into the estuary to feed once spawning is completed offshore.

The sexes of *G. broussoneti*, as in the majority of the gobiids, are easily distinguished by the form of the urogenital papilla, which is in the ventral region between the anal orifice and the anal fin origin. In the females it is short, blunt, and yellow; in males it is thin, pointed, and has a smooth appearance. In both sexes, the urogenital papilla is covered only by epithelium and not by scales. In a transverse histological section, the female papilla has a thin layer of flat stratified epithelium, a network of capillaries, and a thick layer of muscular fiber. At the center are 2 different orifices. The larger opening is the oviduct, which is elongated and has evaginations of cylindrical epithelium. The urinary duct is smaller and has a lobular-shaped aperture of simple cubic epithelium (Figure 2A). In males, a transverse histological section of the papilla shows a layer of flat simple epithelium and a layer of connective tissue surrounding a capillary net. There are 2 openings at the center of the section. The large genital duct has an irregular, flower-like opening formed by a layer of cylindrical epithelium, whereas the small urinary duct has an oval aperture which is comprised of simple cubic epithelium (Figure 2B).

The histology of the urogenital papilla in both sexes revealed thick layers of muscular fibers, which suggest a contractile power by the females for ovulation and ovopositioning (Tavolga 1954, Miller 1984). In the males, the papilla functions as an erected organ to fulfill diverse functions such as courtship, secretion of chemical substance in the spawning area, and to help direct the sperm flow (Hoffman 1963, Bianco et al. 1987).

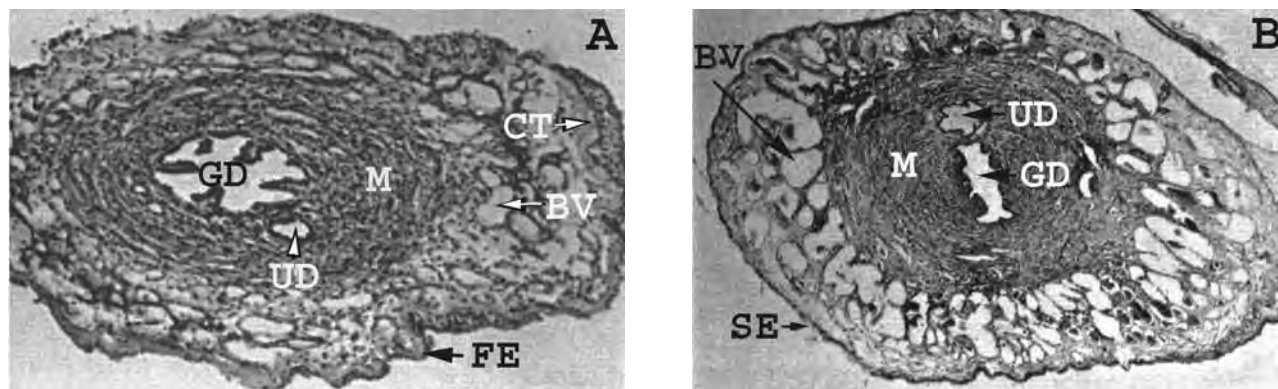


Figure 2. Transverse sections of the urogenital papilla of *Gobioides broussoneti*. A) Female. Present are a layer of flat stratified epithelium (SE), blood vessels (BV), musculature (M), urinary duct (UD) and genital duct (GD), 80x, H-E. B) Male. Simple flat epithelium (FE), connective tissue (CT), blood vessels (BV), musculature (M), genital duct (GD) and urinary duct (UD), 80x, H-E.

In conclusion, we have determined that *G. brossoneti* is a temporal resident in the estuarine system of Tecolutla, Veracruz, apparently using the estuary as a feeding and nursery ground. This fish is a primary consumer and feeds principally on algae at all times of the day, with no distinctive feeding period. Finally, the sex of *G. brossoneti* individuals can be determined by the urogenital papilla. Questions that remain to be answered include those concerning reproductive seasonality, ovarian development, and spawning of *G. brossoneti* within the Tecolutla estuarine system and adjacent offshore waters.

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