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Burrow utilization by yellowedge grouper, *Epinephelus flavolimbatus*, in the northwestern Gulf of Mexico*

Robert S. Jones[1], Elmer J. Gutherz[2], Walter R. Nelson[3] & Gary C. Matlock[4]
[1] *The University of Texas at Austin, Marine Science Institute, Port Aransas, TX 78373, U.S.A.*
[2] *National Marine Fisheries Service, Mississippi Laboratory, Pascagoula, MS 39567, U.S.A.*
[3] *National Marine Fisheries Service, Marine Laboratory, Miami, FL 33149, U.S.A.*
[4] *Division of Fisheries, Texas Parks & Wildlife Department, Austin, TX 78744, U.S.A.*

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Synopsis

Submersible dives were made on a site in the Gulf of Mexico 160 km southeast of Galveston, Texas in September 1984. Both yellowedge, *Epinephelus flavolimbatus,* and snowy grouper, *E. niveatus*, were observed utilizing shelter around rock ridge habitats. The yellowedge grouper also sought shelter within three types of burrows cut into soft sediment. Many of these burrows were significant excavations consisting of large trenches 7–8 m long, 2–3 m wide, and 1–1.5 m deep. Burrows were found in depths from 265 to 290 m. Tilefish, *Lopholatilus chamaeleonticeps*, also occur at this site, usually inhabiting the characteristic vertical burrows already described for this species. In four daytime submersible transects covering a linear distance of over 13000 m, we observed a total of 66 yellowedge groupers. Twenty-five were in burrows, 39 among rocks, and two over open bottom. It is suggested that this species may have an advantage over congeners that utilize only rocky habitat for cover. It may also compete for shelter with tilefish at depths where the two species overlap.

Introduction

The yellowedge grouper, *Epinephelus flavolimbatus*, occurs from Cape Hatteras in the continental United States to South America, including records from the Bahamas, Gulf of Mexico, Cuba, and Central America (Nelson & Carpenter 1968, Smith 1971, Nelson et al. 1982, Chester et al. 1984). It is sympatric throughout much of its range with the snowy grouper, *E. niveatus* (Smith 1971), and the tilefish, *Lopholatilus chamaeleonticeps.*

The yellowedge dominate exploratory fishery catches in the Gulf of Mexico (Nelson & Carpenter 1968, Nelson et al. 1982) and are often caught concurrently with snowy grouper and tilefish. In contrast with most other grouper species, the yellowedge is not limited to rough terrain but is also caught over smooth bottom in the Gulf.

In a longline survey made by one of us (WRN) in May 1984, tilefish and yellowedge grouper were caught together at a site 160 km southeast of Galveston, Texas. Based on these data, we made an-

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other cruise to this site in September 1984 in order to compile additional longline data and to make submersible observations of the yellowedge grouper habitat. This paper describes our observations of the habitat and a unique use of diverse habitats by yellowedge grouper.

Materials and methods

Bathymetric survey. Prior to submersible operations, the NOAA fishery research ship OREGON II made bathymetric surveys in the general study area using data from a color-enhanced fathometer and plotting the results on Loran C charts. Several topographic highs were located within the defined study site and were surveyed with longlines and the submersible. Bottom types surveyed included smooth-sided mounds and ridges, some with profuse concentrations of rock on their summits, and others with only scattered rock outcrops and boulders.

Longline operations. The study area was fished with bottom longline gear deployed from the FRS OREGON II by a team of fishery biologists from the National Marine Fisheries Service and the Texas Parks and Wildlife Department. This gear consisted of 366 m long groundlines with 100 equally spaced hooks on 46 cm gangions. They were baited with squid and fished during daylight for two hours each. The methods and results of the fishery effort are reported in detail by Matlock et al. (1988).

Submersible operations. A Harbor Branch Foundation, Inc. research submersible, JOHNSON-SEA-LINK II, was used in this study. The vehicle was operated from the R/V JOHNSON. A series of four visually surveyed transects crossed the study area. The mean transect lengths were 3250 m and the total distance run was 13000 m. The observable transect width was 11 m (total area viewed = 143000 m^2). Total length (TL) of fishes observed were from estimates made by comparing objects of known size on the submersible's lower work platform with the fish and from analysis of video images.

The study area. We selected our study area based on preliminary longline sets. Catches of both snowy and yellowedge grouper were made on the topographic highs with heavy concentrations of rock outcrops. In contrast, catches of both yellowedge grouper and tilefish were made on topographic highs with minimal rock exposure. Two reconnaissance dives confirmed the presence of yellowedge and snowy grouper in areas with higher rock concentration.

Remaining work on yellowedge grouper was then shifted to a specific site in the general study area where the catch consisted primarily of both yellowedge grouper and tilefish. This area was located at 27° 41.3' N Latitude and 94° 23.6' W Longitude. Depth ranged from 265 m along a central ridge to 311 m at the outer edge of the study area. The site was characterized by a largely smooth bottom, but with isolated boulders and a few scattered, low rock ridges concentrated in depths of less than 283 m.

Results

Burrow types

From our submersible transects we discovered both yellowedge grouper and tilefish occupying burrows in the mud/clay bottom. Although tilefish are known to burrow into the sea floor where the smooth, soft substratum consists of a cohesive mud/clay horizon (Able et al. 1982, Grossman et al. 1985, Twichell et al. 1985, Grimes et al. 1986), grouper species of the genus *Epinephelus* are more commonly associated with reef and other hard bottom habitat (Smith 1971, Grimes et al. 1982).

Yellowedge grouper occupied three types of burrows:

Vertical. This burrow type, possibly representing the earliest stage of construction, resembles and was often indistinguishable from those of small to medium sized tilefish (Fig. 1a) (Able et al. 1982, Grimes et al. 1986). These 'vertical' burrows were 25–30 cm across, of unknown depth, and were

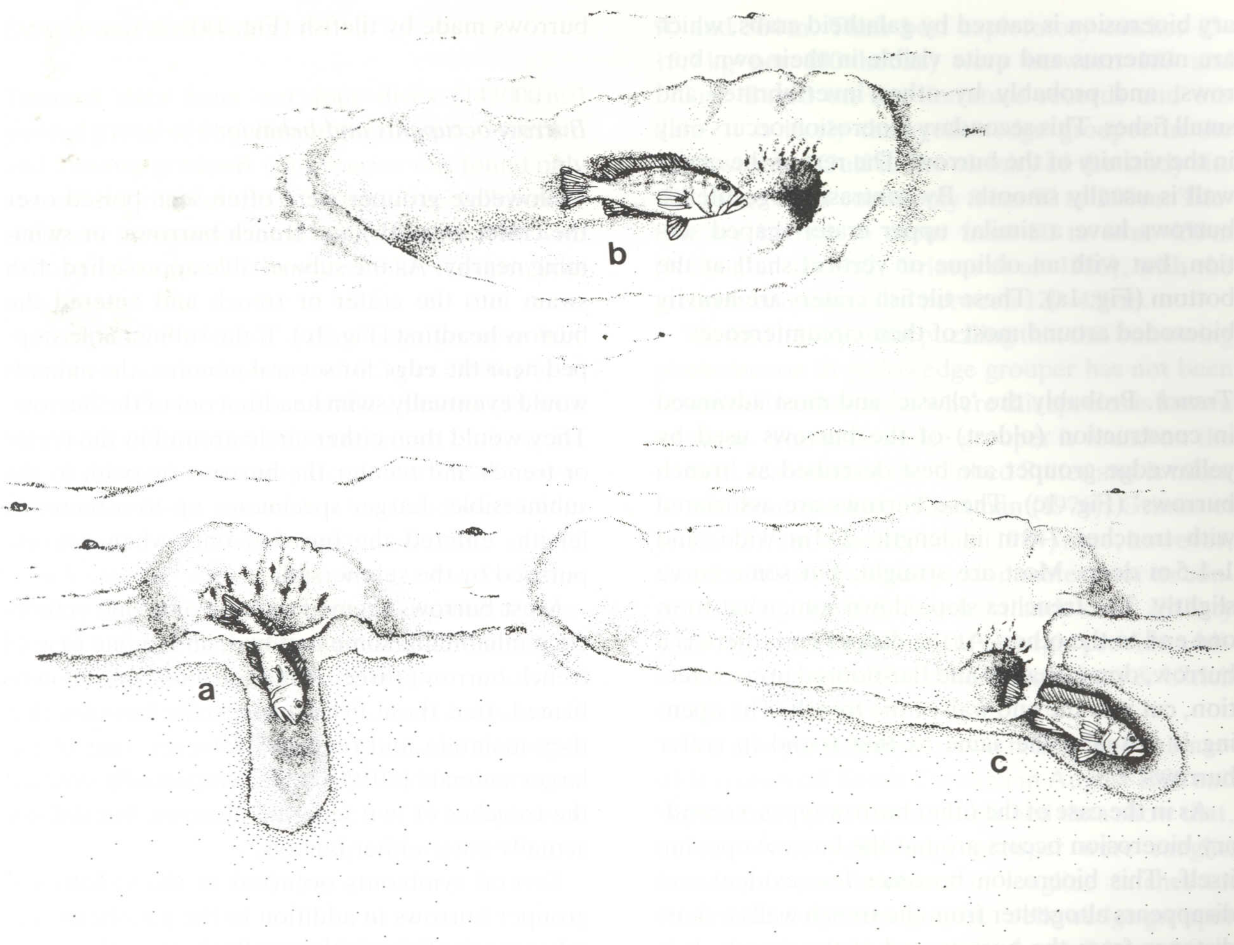

Fig. 1. a – A tilefish, *Lopholatilus chamaeleonticeps,* (100 cm TL) entering a typical vertical burrow. This burrow resembles those occupied by young yellowedge grouper (30–50 cm TL). b – A crater burrow of the yellowedge grouper, *Epinephelus flavolimbatus*, with an individual (100 cm TL) over the crater and poised to enter the burrow. c – A trench burrow occupied by a yellowedge grouper (100 cm TL). The scale is compressed for publication purposes, the trenches can be longer than depicted here.

flared slightly at the entrance. We observed three yellowedge grouper (30–50 cm TL) rapidly enter this type of burrow, headfirst and completely out of sight, when approached by the submersible. One was seen on a transect dive and two were seen on reconnaissance dives. A solution of formalin was pumped down one of the burrows and the fish burst explosively out of it, again headfirst, and retreated from sight. The largest yellowedge observed using a vertical burrow was a 40–50 cm TL individual.

Crater. The second burrow type, the 'crater burrow', may represent an intermediate stage of construction (Fig. 1b). It consists of a large crater 1–2 m in diameter and 1–1.5 m deep, with walls sloping to a rounded or flat bottom, and containing a single dome-shaped burrow cut horizontally into one point in the crater wall at or near the level of the floor. The burrows closely resemble the grottos or 'Pueblos' cut into clay outcrops of submarine canyon walls such as those described by Cooper & Uzmann (1977), Warme et al. (1977) and Grimes et al. (1986).

The face of this wall at the burrow entrance may be either heavily bioeroded or show evidence of having recently sheared off. In the latter case, clumps of mud/clay debris are found on the bottom of the crater at the opening to the burrow. Secondary bioerosion is caused by galatheid crabs, which are numerous and quite visible in their own burrows, and probably by other invertebrates and small fishes. This secondary bioerosion occurs only in the vicinity of the burrow. The rest of the crater wall is usually smooth. By contrast, large tilefish burrows have a similar upper crater-shaped section, but with an oblique or vertical shaft at the bottom (Fig. 1a). These tilefish craters are heavily bioeroded around most of their circumference.

Trench. Probably the 'classic' and most advanced in construction (oldest) of the burrows used by yellowedge grouper are best described as 'trench burrows' (Fig. 1c). These burrows are associated with trenches 7–8 m in length, 2–3 m wide, and 1–1.5 m deep. Most are straight, but some curve slightly. The trenches slope down somewhat from one end to the other. At the deeper end, there is a burrow, dome-shaped and flat-floored in cross section, cut into the end wall of the trench. The opening is virtually the same as that found in crater burrows.

As in the case of the other burrow types, secondary bioerosion occurs around the burrow opening itself. This bioerosion becomes less evident and disappears altogether from the trench walls a short distance from the burrow end of the trench. It is apparent that secondary bioerosion occurs only where there is a relatively fresh exposure of the mud/clay surface by the excavation activities of the primary inhabitant. As the distance from the burrow opening along the trench walls increases, secondary burrows become covered and smoothed over with soft sediment.

Repeated excavation of the burrow, followed by heavy secondary bioerosion of the end wall of the trench above the burrow opening and in the ceiling of the burrow itself, probably results in periodic cave-ins of the roof. This mechanism may lead to gradual lengthening of the trench as the inhabitant re-excavates the burrow, only to have the roof-eventually collapsed again by the secondary bioeroders working overhead. It is similar to the role of secondary bioerosion suggested by Able et al. (1982) to explain the progressive erosion and flaring of the openings (craters or funnels) of vertical burrows made by tilefish (Fig. 1a).

Burrow occupants and behavior

Yellowedge grouper were often seen poised over the crater (Fig. 1b) and trench burrows, or swimming nearby. As the submersible approached, fish swam into the crater or trench and entered the burrow headfirst (Fig. 1c). If the submersible stopped near the edge for several minutes, the animals would eventually swim headfirst out of the burrow. They would then either circle around in the crater or trench and reenter the burrow, or swim to the submersible. Larger specimens, up to a meter in length, entered the burrows only when actively pursued by the submersible.

Most burrows seemed to have only one yellowedge inhabitant, some had two, and in one case (a trench burrow) three. It is probable, but not confirmed, that these fish have specific burrows that they maintain and occupy. However, one of the larger animals (80–90 cm TL) repeatedly entered the trenches of two separate burrows, but did not actually enter either burrow.

Several symbionts occurred in the yellowedge grouper burrows in addition to the galatheids and other species living in the smaller holes in the crater and trench walls. Large numbers of an unidentified cleaner shrimp (*Solenocerus* sp.) were observed around the burrow openings and could be seen moving toward a grouper when one came near. This suggested cleaning behavior, but it was never actually observed. One species of hake (*Urophycis* sp.) was seen in several burrows. Moray eels (*Gymnothorax kolpos*) were driven out of two burrows with the formalin solution. Two particularly significant observations were: a tilefish entering one of the trenches and occupying the burrow along with a yellowedge grouper, and another tilefish using a vertical burrow with a yellowedge. In both cases, the fishes disappeared entirely within the horizontal or vertical burrow shaft.

Density and distribution

Transect data from our four dives (143000 m^2) yielded a total of 66 yellowedge groupers, 7 tilefish, and 5 snowy groupers (this species was found only around rock structures). Twenty-five yellowedge groupers were associated with burrows, 39 with rock structures, and two were seen over open bottom areas.

A total of 38 'active' yellowedge grouper burrows were seen (a density of 0.3 per 1000 m^2), of which 22 were vertical or crater burrows (14 with fish and 8 without) and 16 were trench burrows (11 with fish and 5 without); 16 other trench burrows were seen which appeared to be abandoned and in the process of filling in with sediment; and 65 trench-shaped depressions were observed that might have been trench burrows which were completely filled in with soft sediment. Grimes et al. (1986) report similar burrow filling for tilefish.

The temperature range in the part of the study site occupied by yellowedge and snowy grouper was 12–13° C during the study period. Tilefish were observed between 11.6 and 12.9° C. This species is normally found at water temperatures between 9 and 14° C (Grimes et al. 1986).

Discussion

Burrow distribution

It is evident from fishing data and submersible operations, that yellowedge grouper co-occur with tilefish on the summits of the topographic highs in the northwestern Gulf of Mexico. The yellowedge grouper outnumbered both the tilefish and snowy grouper on and just below the summits of the topographic highs. Off these summits, below 290 m and down to over 330 m, the tilefish was the only one of the three species captured on longlines or observed from the submersible.

Yellowedge grouper records have been reported from depths as shallow as 33 m to as deep as 457 m (Smith 1971). However, Nelson & Carpenter (1968) and Nelson et al. (1982) found the highest concentrations in the Gulf of Mexico to be between 90 and 364 m. Their best exploratory catches (3–15.7 kg per 100 hooks) were between 183 and 273 m. Based on the literature records and our data, it is likely that yellowedge grouper in the northwestern Gulf in the vicinity of the study site will range most commonly from 90 to 290 m. Tilefish are known to occur from 80 to over 450 m (Nelson et al. 1982, Grimes et al. 1986), with the greatest concentration between 120–450 m.

We find it somewhat puzzling that this burrowing phenomenon in yellowedge grouper has not been observed in other areas where this species is known to occur. The yellowedge grouper is found on the eastern seaboard of the United States and is taken in headboat catches. Huntsman (1976), Grimes et al. (1982), and Chester et al. (1984) note, however, that the snowy grouper predominates over its congener along the U.S. South Atlantic shelf. Fishery data off South Carolina and Georgia provide additional evidence for this observation (Low & Ulrich 1982).

We also participated in two fishery and submersible cruises off South Carolina in August 1982 and September 1983. Our unpublished data show that, though some yellowedge grouper were caught, snowy grouper dominate in longline catches on rocky and rough topography. Yellowedge grouper were not observed from the submersible nor were they observed or captured over smooth bottom where tilefish occurred. Moreover, nothing resembling the crater or trench burrows was seen on these dives. Both the submersible observations and fishing efforts were conducted at depths of 184–220 m. Although these depths fall within the range of concentration for the Gulf fishery for this species, the submersible depths are shallower than those investigated in the Gulf.

Numerous submersible dives (over 50) were made on the east central Florida continental shelf and upper slope by the senior author from 30 to 300 m. These dives were made over rugged *Oculina* coral bottom and over smooth bottom which was occupied by both the tilefish, *L. chamaeleonticeps,* and the blueline tilefish, *Caulolatilus microps*. Although yellowedge grouper were never observed on these dives, the snowy grouper is a common species on the Florida *Oculina* reefs. Yellowedge grouper are occasionally taken by fishermen in this area, but are far outnumbered by the snowy grouper (R.G. Gilmore, Harbor Branch Oceanographic Institution, personal communication). Again, in spite of the frequency of submersible dives within the known depth and temperature ranges of this species and over mud/clay substratum, no crater or trench type burrows were seen.

Additional dives made by the senior author and others on the West Florida continental shelf in September 1985 found the yellowedge to outnumber the snowy grouper in rugged habitats. Observations were also made over smooth bottom where populations of tilefish occurred, but no yellowedge grouper were observed utilizing burrows in these areas.

Perhaps yellowedge grouper do utilize burrows in other areas and have just not been seen. However, at this time, the phenomenon appears unique to the northwestern Gulf of Mexico.

Burrow construction

The most obvious questions are, do the yellowedge grouper excavate and maintain these structures, or are they symbionts with tilefish or perhaps an unseen burrow occupant? We rarely observed this symbiotic phenomenon, although one tilefish was indeed seen during a transect dive in a trench burrow with a yellowedge and another interspecific pair was observed in a vertical burrow. Past experience has shown that tilefish are frequently seen around their burrows. Of the seven tilefish seen at this site on the transects, six were observed around vertical burrows of the type typically constructed by the species.

We have considered two hypothesis regarding yellowedge grouper burrow construction. First, the yellowedge grouper may begin burrow construction as young adults, either by excavating a vertical burrow or by taking over a small burrow made by another animal. As suggested by Able et al. (1982) for tilefish, the burrow would be gradually widened and deepened as the fish grew in size. As the burrow expands, the exposed mud/clay margins are colonized by smaller animals such as galatheid crabs. Their secondary bioerosion leads to a flaring of the burrow margin. At some point, the grouper would change the direction of excavation from vertical to horizontal. The cratering and finally trenching would follow.

The second hypothesis suggests that yellowedge grouper occupy vertical burrows previously constructed by tilefish. Having taken over, the yellowedge might change burrow direction from vertical to horizontal, eventually evolving crater and then trench burrow systems. This could start with either a young grouper occupying a juvenile tilefish's burrow or by a larger individual appropriating an adult tilefish's burrow, already at or near the crater stage. There is evidence to indicate either or both could occur. The presence of two tilefish in yellowedge-occupied vertical and trench burrows is some indication that joint occupation is possible. But, we postulate that it is more common for tilefish to be evicted by the grouper or to have been previously eliminated by natural or fishing mortality.

How, or in fact, do the yellowedge grouper excavate and/or maintain vertical burrows, crater burrows, and trench burrows? Unfortunately, we never observed excavation or maintenance behavior by this species. Only submersible-deployed time lapse camera systems are likely to answer these kinds of questions. The one conclusive observation is that burrow associates such as galatheid crabs play a major role in shaping burrows.

Burrow construction has not been reported in the literature for other grouper species. However, gag grouper, *Mycteroperca microlepis*, have been observed 'fanning' and creating depressions in the sea floor off Charleston, South Carolina in depths of 18 m. These depressions were reported to be 1.0 to 1.5 m across and 30–40 cm deep. Similar depressions have been occupied by jewfish, *Epinephelus itajara*, in 6.0 m off Crystal River, Florida. However, no actual burrows were associated with the depressions occupied by the two species. Both observations were made by Mark Collins (South Carolina Wildlife and Marine Resources Research Institute, personal communication).

'Abandoned burrows'

Although we can only speculate, the apparently abandoned burrows and trench-shaped depressions may be the result of removal of the primary occupant by either natural or fishing mortality. Prytherch (1983) reports a considerable commercial longline fishing effort for yellowedge and tilefish in the Gulf. Twenty-one longline tracks (grooves in the sediment) were seen in the area, not all attributable to our fishing efforts. One of the largest yellowedge specimens (80–90 cm TL) seen had an 'old' hook and trailing gangion in its jaw. Grimes et al. (1986) found that tilefish burrows around Hudson Canyon could be expected to fill in with sediment in less than one year, after removal of the tilefish.

Resource partitioning

At least two possible levels of resource partitioning are suggested here and both are in the realm of habitat space utilization or shelter, if indeed either is a limited resource. First, there is possible competition for limited rocky or hard bottom habitat between the two closely related grouper species, the yellowedge grouper and its congener, the snowy grouper. Both are sympatric, but the yellowedge dominates in the Gulf and the snowy grouper dominates in the Atlantic. We would argue that the ability of the yellowedge grouper to occupy both rock habitat or burrows in soft sediment (the latter obviously in greater abundance on the continental shelf and upper slope) would give it an advantage. The fact that the occupation of burrows by yellowedge grouper on the South Atlantic shelf of the U.S. does not occur, or has not been observed as yet, is an enigma. If the yellowedge grouper do not derive this advantage in the Atlantic, perhaps because of some combination of depth, temperature, sediment type, proximity to rock outcrops for larval settlement, or other phenomena, it might explain why they do not outnumber the snowy grouper there as they do in the Gulf.

The other potential competition for space occurs between the yellowedge grouper and tilefish. There is obviously an overlap between these two species in terms of vertical zonation (yellowedge 90–290 m and tilefish 120–450 m). This provides a minimum band of overlap of 170 m in vertical zonation where the two species interact and possibly compete for space, food or other resources. It is possibly significant that, in this particular study area, the yellowedge grouper is restricted by depth and perhaps temperature to the summits of the topographic highs. They essentially occupy submerged islets and are surrounded by a 'sea' of tilefish.

In summary, we believe that the acceptance of a greater diversity of habitat by the yellowedge grouper, provides it with an advantage over both the snowy grouper and the tilefish where the species overlap in their distribution in the northwestern Gulf of Mexico.

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