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Behavior of Juvenile Black Sea Bass, *Centropristis striata* (Linnaeus) on Oyster Reefs

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ABSTRACT **The substrate preferences of juvenile black sea bass *Centropristis striata* (Linnaeus) was tested in a circular tank (1.5 m diameter × 0.4 m deep) divided into two equal areas of oyster-related (oyster reef and whole oyster shell) and sand substrates. All trials were video taped for 20 min. Tapes were viewed on a monitor and locations of all fish recorded and timed with respect to substrate. Mean ± SE times on oyster shell were 18.1 ± 2.0 min (1-fish trial-1) and 17.5 ± 1.7 min (5-fish trial-1). Mean ± SE times on sand were 2.0 ± 1.0 min (1-fish trial-1) and 2.5 ± 1.7 min (5-fish trial-1). Black sea bass juveniles showed a significant preference for oyster reef and shell over sand substrate in single-fish trials (paired *t*-test, *P*/0.05) and also in five-fish trials (paired *t*-test, *P*/0.05). Mean ± SE times under oyster reefs were 16.6 ± 2.0 min in single-fish trials and 10.7 ± 2.3 min in five-fish trials. Mean numbers of movements among oyster reefs were 1.1 ± 1.0 in single-fish trials and 11.5 ± 3.1 in fivefish trials. Fish spent significantly less time under oyster reefs in five-fish trials, compared to single-fish trials (paired *t*-test, *P*/0.05) and they moved more frequently in five-fish trials than in single-fish trials (paired *t*-test, *P*/0.05). Significantly higher competition for a refuge in five-fish trials may induce less time under oyster reefs as well as frequent movement of black sea bass juveniles on shell substrate.**

Key words : Black sea bass, juveniles, substrate preference, oyster reef, oyster shell

INTRODUCTION

Estuaries are well known as vital breeding and nursery grounds for both fishes and decopod crustaceans (Weinstein *et al.*, 1980; Szedlmayer and Able, 1996; Costa *et al.*, 2002). The South Atlantic Fisheries Management Council (SAFMC) in the United States estimates that greater than 90% of the commercial and recreational landings in the South Atlantic are of species that depend on estuaries at some stage in their life cycles (SAFMC, 1998). Salt marsh cordgrass, *Spartina alterniflora* (Poaceae) and eastern oysters, *Crassostrea virginica* (Gmelin), cover a large proportion of the intertidal zone of estuaries along the southeast coast. They have long been recognized as important intertidal habitats for a number of fishes and invertebrate species (Coen *et al.*, 1999; Dionne *et al.*, 1999).

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Black sea bass, *Centropristis striata*, are distributed in the Northwest Atlantic from Maine to Florida in the USA. Sea bass are members of the family Serranidae, which includes groupers commonly found in tropical and sub-tropical waters (Musick and Mercer, 1977). Juvenile black sea bass occur in high-saline areas of estuaries where they find shelter in oyster reefs and surfclam shell (Kendall Jr., 1972; Cupka *et al.*, 1973). Arve (1960) and Lehnert (2000) also demonstrated that oyster shell plantings of bare subtidal areas increased trap catches of fish, especially black sea bass, *Centropristis striata*. Most subtidal estuarine bottoms in the Southeast USA are dominated by muddy or sandy sediments, except adjacent to well developed intertidal oyster reefs. In these areas, small clusters and oyster shell have been accumulated due to down-slope movement from intertidal reefs in addition to limited subtidal production. These subtidal bottoms do not have as much three-dimensional relief as the intertidal oyster reefs, but they are more complex than sandy or muddy bottoms that dominate most subtidal areas.

In some habitats, large differences in substrate complexity produce obvious effects. For example, studies of coral reef fishes have shown that habitat complexity significantly affected fish distribution, recruitment and survivorship (Williams and Sale, 1981; Shulman, 1984; Jones, 1991; McGehee, 1994). In the northwest Pacific, substrate type and complexity were significant factors in explaining the discrete distribution of rockfish, *Sebastes* spp. (Stein *et al.*, 1992; Murie *et al.*, 1994). In the Mediterranean off Spain, fishes in the families Blenniidae, Tripterygiidae, and Gobiidae all displayed a clear preference for a specific substrate type, and that preference was unrelated to substrate availability in the environment (Macpherson, 1994). The availability of adequate shelter may be of more importance than other environmental resources for fish that have a high substrate affinity, and the lack of adequate shelter may substantially affect metabolism and somatic growth rates in benthic fish (Philipp, 2000).

Although substrate affinity of black sea bass juvenile to oyster reef and shell in the field has been reported, estuarine oyster reef and subtidal shell rubble have mostly been overlooked as essential fish habitat. A key to help define critical nursery habitat would be demonstration of any behavior that shows a preference for one substrate over another that would reflect field distribution. In the present laboratory study, It was tested that black sea bass juveniles for substrate preference between oyster-related and sand substrate.

MATERIALS AND METHODS

Black sea bass juveniles produced at the Southland Fisheries Corp. (Hopkins, South Carolina, USA) were transferred to the University of Georgia Marine Institute. The fish were stocked in 600 L tanks with aerated running seawater prior to substrate trials.

Mean size of all fish tested (n=80) was 74.2 mm SL, ranging from 68 to 79 mm SL; and mean wet weight was 11.1 g, ranging from 9 to 14 g. Ammonia, nitrite, and nitrate levels in the seawater system were controlled with oyster shell biological and sand filters (NH_3=0 ppm, NO_2= 0 ppm, NO_3=20~40 ppm). Mean salinity ±SE was 28.9±1.1 ppt and was controlled by the addition of artificial sea salt or freshwater. Mean water temperature±SE was 21.8±2.1°C. All fish were fed to satiation daily with a pelleted trout diet (Rangen, Buhl, ID, USA). Substrate preference was tested in a circular tank (1.5 m diameter × 0.4 m deep). The test tank was divided into two equal areas of whole oyster reef and oyster shell or sand substrates. A black plastic blind was built above and around the tank to reduce external stimuli. Prior to each trial, the air diffuser and water inflow lines were removed from the tank to eliminate any artifacts that may have altered fish behavior. A preliminary study with five black sea bass juvenile showed little change in dissolved oxygen concentrations over a 9 h period.

All fish were fed to satiation 1 h before substrate trials. The fish were measured and weighed at the end of each trial and not used again. The water inflow and air diffuser lines were replaced for overnight recirculation. For the present study 20 min periods for each trial was applied for a recording. In the first set of trials a single fish per trial (n=30) was tested and subsequently five fish per trial (n=15) in the second set of trials. Each trial was continuously recorded on video with a Sony DCR-TRV11 video camcorder. The camcorder was mounted directly over the test tank and operated with a remote control to eliminate observer disturbance. Tapes were viewed on a Sony KV-27S25 color video monitor. Locations of all fish were recorded and timed with respect to substrate. Data were statistically analyzed by paired *t*-tests. Statistical analyses and data presentation were carried out using STATISTIX 8.0 for Windows (Analytical Software, Tallahassee, FL, USA). Significance was accepted at $P<0.05$.

RESULTS AND DISCUSSION

Black sea bass juveniles clearly showed a preference for oyster reef and shell over sand substrate in the present laboratory experiments (Figs. 1 and 2). Single-fish trials showed that black sea bass juveniles spent significantly more total time per trial on oyster reef and shell compared to sand substrate (paired *t*-test, P=0.0001, t=17.89). In addition, mean total percent time per trial was significantly greater over oyster reef and shell compared to sand substrate (paired *t*-test, P=0.0001, t=17.79, Fig. 1). In five-fish trials, total time per trial was significantly greater over shell compared to sand substrate (paired *t*-test, P=0.0001, t=17.16). In addition, mean total percent time per trial was significantly greater over oyster reef and shell compared to sand substrate (paired *t*-test, P=0.0001, t=17.17, Fig. 2). In the nursery grounds, black sea bass juveniles are mainly associated with hard bottom, such as oyster and surfclam shell habitats, and are seldom seen over sand substrate (Arve, 1960; Kendall Jr., 1977; Able *et al.*, 1995). Thus the present laboratory study confirms the importance of oyster reef and shell substrate, and suggests that it was actively selected by black sea bass juveniles.

Other species have shown similar substrate associations from inner shelf habitats of the mid-Atlantic bight, USA. For example: ocean pout, *Macrozoarces americana* (Bloch and Schneider), longhorn sculpin, *Myoxocephalus octodecemspinosus* (Mitchill), and red hake, *Urophycis chuss* (Walbaum), all showed significant

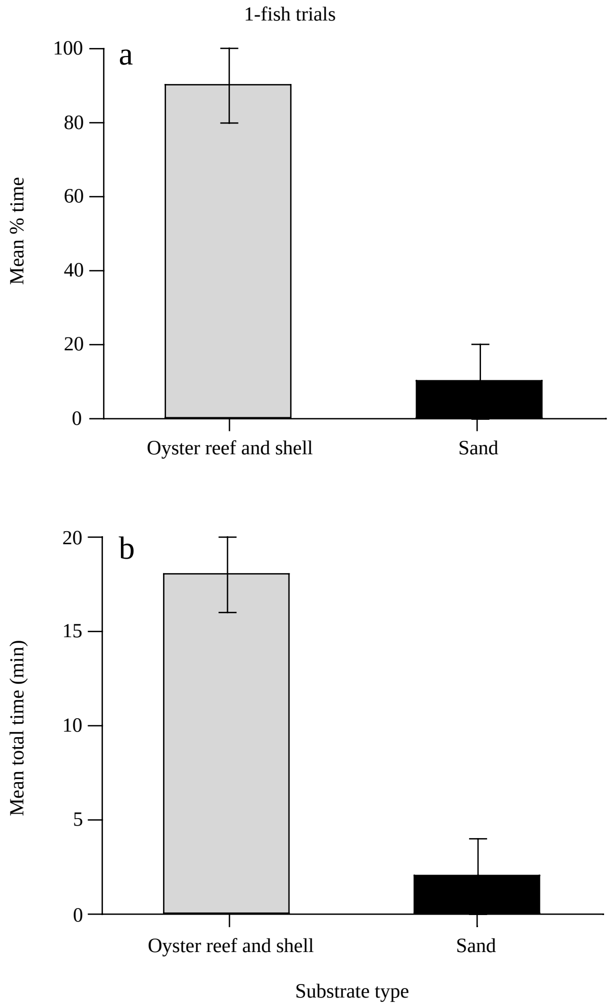

Fig. 1. Substrate preference in single-fish trials by juvenile black sea bass for oyster-related (oyster reef and whole oyster shell) or sand substrates: a-mean total percent time ± SE per trial, and b-mean total time ± SE per trial.

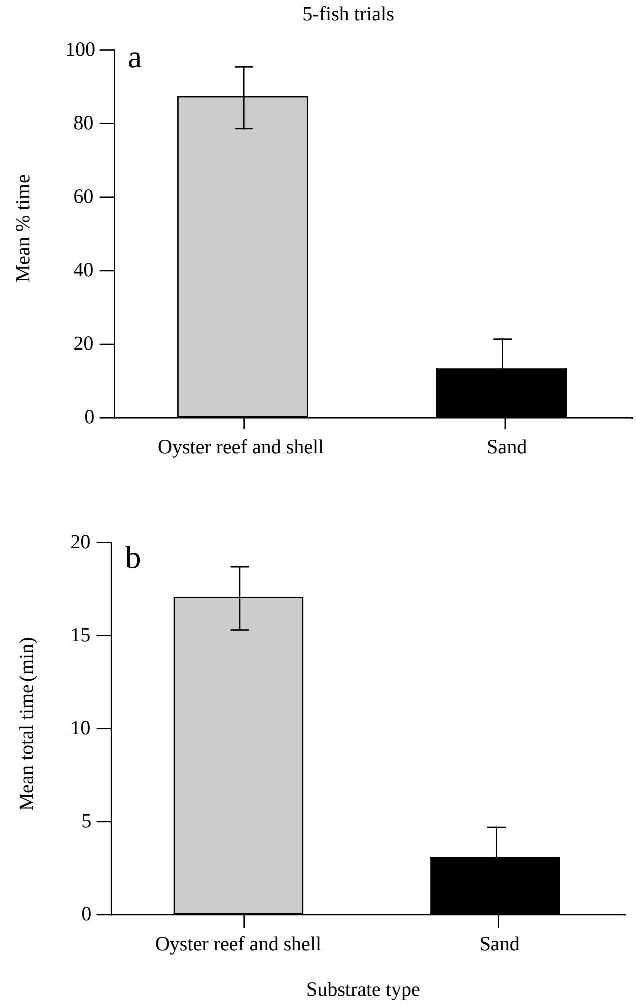

Fig. 2. Substrate preference in five-fish trials by juvenile black sea bass for oyster-related (oyster reef and whole oyster shell) or sand substrate: a-mean total percent time ± SE per trial, and b-mean total time ± SE per trial.

aggregations with ocean quahog shells, *Artica islandica* (Linne) (Auster *et al.*, 1995); and red snapper, *Lutjanus campechanus* (Poey), were much more abundant over oyster shells, *Crassostrea virginica* (Gmelin), compared to adjacent sand habitat (Szedlmayer and Howe, 1997). Connell and Jones (1991) suggested that habitat complexity may influence the growth and survival of juvenile fish through increased prey density and prey diversity. Compared to sand substrate, oyster shell provides habitat for a more diverse array of barnacles, sponges, hydrozoans, bryozoans, and tunicates (Wells, 1961) as well as resident motile fauna such as grasped and panopeid crabs (Meyer, 1988). In addition, the interstitial spaces within the oyster reef matrix may provide a refuge from predation for juvenile fishes. The typical behavior observed for gobies, blennies, clingfish, and small juvenile toadfish in the presence of either a predatory fish or a sudden move by a diver is to dart into the shell matrix rather than to flee along the substrate surface or rise in the water column (Coen *et al.*, 1999). Accordingly oyster reef and shell preference may benefit black sea bass juveniles due to increased food availability and predator protection.

Five-fish trials showed that black sea bass juveniles spent significantly less total time per trial under oyster reefs compared to single-fish trials (paired *t*-test, P= 0.0001, t=6.90). In addition, mean total percent time per trial under oyster reefs was significantly lower in five-fish trials compared to single-fish trials (paired *t*-test, P=0.0001, t=7.71, Fig. 3a and b). Interestingly, five-fish trials shows a significantly higher mean number of movements among oyster reefs per minute than single-fish trials (paired *t*-test, P=0.0001, t=15.54, Fig. 3c). Hecht and Appelbaum (1988) observed that *Clarias*

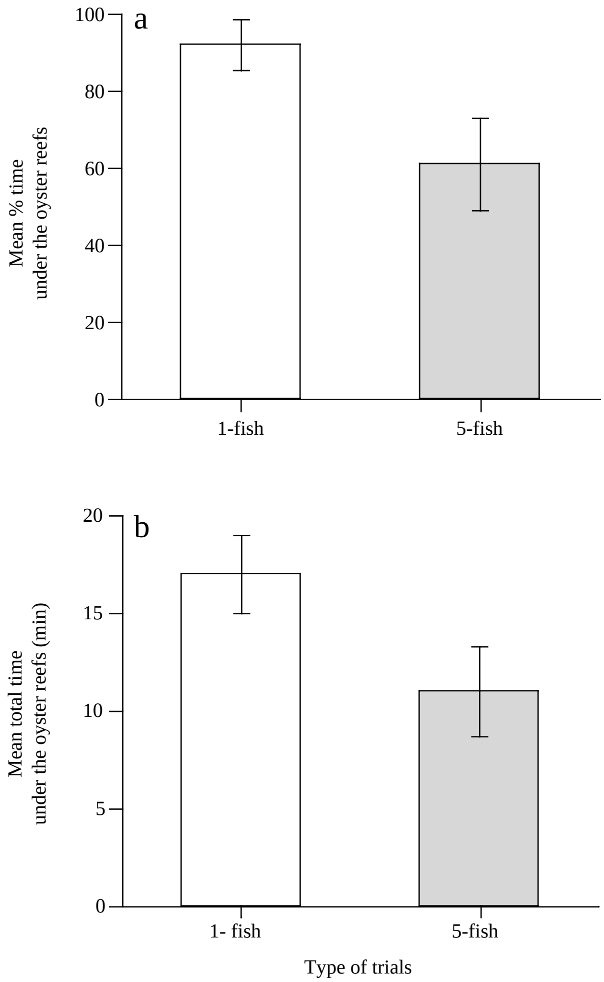

Fig. 3. Differences in mean total percent time under the oyster reefs ±SE per trial (a) and mean total time under the oyster reefs±SE per trial (b) between 1-fish and 5-fish trials of black sea bass juveniles.

gariepinus (Burchell) exhibited particularly stronger territoriality when shelter is provided than when it is absent. In addition, competition for shelter is a common occurrence among coral reef fishes (Shulman, 1985; Hixon and Beets, 1989, 1993). Gwak (2003) observed that increased competition for a refuge in black sea bass juveniles induced significantly higher attacking frequencies in the sheltered aquaria with oyster reef. Accordingly this could be one of the reasons for a higher mean number of movements among oyster reefs and lower mean total time under the oyster reefs in five-fish trials of the present study. Based on the results of this experiment, it seems likely that shelter such as oyster reef and/or shell serves as an essential place for survival and growth of black sea bass juvenile and the place where they should encounter cannibal.

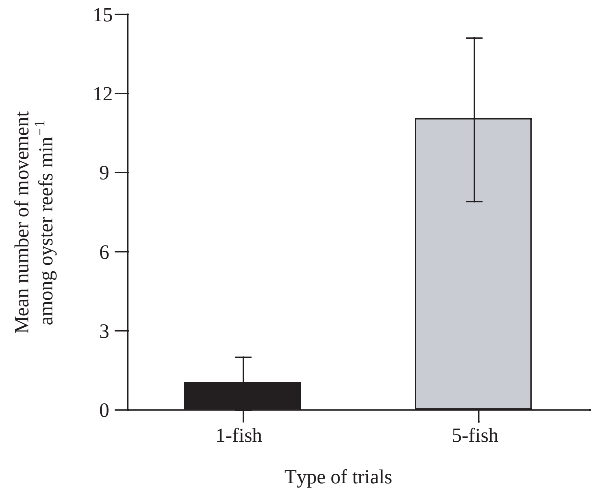

Fig. 4. Differences in mean number of movement among oyster reefs per minute±SE between 1-fish and 5-fish trials of black sea bass juveniles.

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Oyster reef에서 black sea bass, *Centropristis striata* 치어의 행동

곽우석

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요 약 : black sea bass 치어(이하 치어라 칭함)의 기질 선택성을 수조 내부의 바닥을 굴 껍질 관련 기질과 모래 기질을 덮어 이등분 한 원형수조(1.5 m 직경×0.4 m 깊이)에서 조사하였다. 실험어는 1개체를 수조에 넣는 단독수용과 5개체를 넣는 그룹으로 하였다. 모든 치어의 기질 선택행동 실험은 20분간 비디오에 녹화하여 모니터 상에서 관찰하였고 수조 내에서 치어의 위치와 각 기질에서 체류한 시간을 기록하였다. 굴 껍질 관련 기질에서 치어가 보낸 평균시간은 1개체 수용구에서 18.1±2.0분과 5개체 수용구에서 17.5±1.7분으로 나타났다. 한편, 모래기질 위에서는 1개체 수용구에서 2.0±1.0분과 5개체 수용구에서 2.5±1.7분으로 나타났다. 1개체와 5개체의 치어로 수행한 실험 모두에서 모래 기질보다는 굴 껍질 관련 기질에 대해 유의한 선택성을 나타냈다(paired *t*-test, $P<0.05$). 굴 껍질 관련 기질 아래 체제시간은 1개체 수용구에서 16.6±2.0분과 5개체 수용구에서 10.7±2.3분으로 나타났다. 굴 껍질 관련 기질 사이를 이동한 횟수는 1개체 수용구에서 1.1±1.0회와 5개체 수용구에서 11.5±3.1회로 나타났다. 치어는 1개체 수용구보다는 5개체 수용구에서 굴 껍질 관련 기질 아래 머무는 시간이 유의하게 적고, 또한 움직임이 많은 것으로 나타났다(paired *t*-test, $P<0.05$). 은신처 확보를 위한 치열한 경쟁으로 인해 5개체 수용구의 치어가 굴 껍질 관련 기질 아래 머무는 시간이 적고 움직임이 많은 것으로 추측된다.

찾아보기 낱말 : black sea bass, 치어, 기질 선택성, oyster reef, oyster shell