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SEASONAL PATTERNS OF JUVENILE FISH ABUNDANCE IN SEAGRASS MEADOWS IN TEAGUE BAY BANK BARRIER REEF LAGOON, ST. CROIX, U.S. VIRGIN ISLANDS

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ABSTRACT: Considerable knowledge has been gained regarding fish use of nearshore habitats such as seagrass meadows or mangrove lagoons in the Caribbean (e.g., evaluation of nursery value, trophic linkages). However, few studies have been conducted on fish recruitment to seagrass habitat around the Caribbean. Juvenile reef fish in seagrass meadows at Teague Bay, St Croix, U.S. Virgin Islands were surveyed from October 1998 through September 1999 using a visual census technique. Grunts (Haemulidae) were the most abundant juveniles observed (60% of all fish), followed by wrasses (Labridae, 20%) and parrotfishes (Scaridae, 13%). French grunt, *Haemulon flavolineatum*, were the most numerous species (59.5% of all fish), followed by slippery dick, *Halichoeres bivittatus* (18.5%), and bucktooth parrotfish, *Sparisoma radians* (10.4%). Most numerically abundant fish species demonstrated peaks in recruitment during late summer and fall. Our results imply that the functioning of seagrass beds incorporates strong seasonal patterns of small-fish abundance that need to be accommodated in any study wishing to understand their importance to fisheries.

INTRODUCTION

Seasonal patterns of recruitment have been studied extensively in coral reef habitats at various locations, such as Great Barrier Reef, French Polynesia, Hawaii, and the Caribbean (Williams and Sale 1981, Eckert 1984, Walsh 1987, Doherty 1991, Dufour 1993, Casselle and Warner 1996, Planes 1997, Robertson and Kauffman 1998). However, there have been no studies on seasonal fish recruitment patterns within different coastal habitats such as seagrass beds, mangroves, and backreefs, despite the widely accepted view of these habitats as juvenile nursery grounds (Nagelkerken et al. 2000a, 2000b, Cocheret et al. 2002, Mumby et al. 2004). Ogden and Gladfelter (1983) claim these nearshore habitats act as nurseries for three main reasons: 1) they are located away from the heavy predation pressure characteristic of coral reefs, 2) they offer protection to small fishes due to the structural complexity of masses of leaves and roots, and 3) they provide a rich food supply based on plant detritus and associated microorganisms and small invertebrates. In addition, most studies of nearshore tropical fish habitat use (Nagelkerken et al. 2000a, 2000b, 2001, Cocheret et al. 2002, Halpern 2004, Mumby 2004, Chittaro et al. 2005) were conducted in short periods of time (1 to 4 months) without taking into consideration the seasonality of these species. Thus, it is critical to investigate seasonality of fish recruitment in seagrass beds in order to refine our knowledge of coastal fish habitat use.

Because critical seagrass habitats are generally close to shore, they are susceptible to anthropogenic disturbances such as storm-water and pollutant runoff and spills and mechanical damage by boats. With growing fears that stock restoration efforts are being compromised more by habitat loss from coastal development and by pollution than by overexploitation, conservation of habitats (such as seagrass meadows) is becoming an important part of fisheries management.

In order to support informed decisions for the sustainable management of marine fish and their habitats, there is a vital need for more documentation on the seasonality of habitat use by small juveniles. The goal of this study was to document temporal recruitment patterns in the fish assemblages in seagrass meadows in the U.S. Virgin Islands. This study was designed to answer the following questions: (1) Are there significant variations (order of magnitude) in recruitment patterns among the most abundant seagrass fish species? (2) Are there clear seasonal patterns in recruitment among seagrass-associated fish species?

Materials and Methods

The three embayments sampled in this study (Cottongarden Bay, Teague Bay, and Yellowcliff Bay) are part the Teague Bay bank-barrier reef system that extends from Pull Point to Lamb Point on the Northeast coast of St. Croix (Figure 1). This lagoon is described in Mateo and Tobias (2001). All seagrass meadows were found at similar depths (0.5 m to 3 m), and the vegetation within beds was dominated by turtlegrass *Thalassia testudinum* and manatee grass *Syringodium filiforme* with percent seagrass coverage at about 80%. From October 1998 through September 1999, fish recruits (recently settled post-larvae and juveniles) were counted along 50 m x 2 m strip transects (Fowler et al. 1992). For each bay, a 20 m x 20 m grid pattern was laid over a nautical chart. Grid intersecting points were labeled with consecutive numbers and were the bases for selecting transect starting points for each embayment. Ten randomly selected starting points were surveyed per month for all three embayments, based

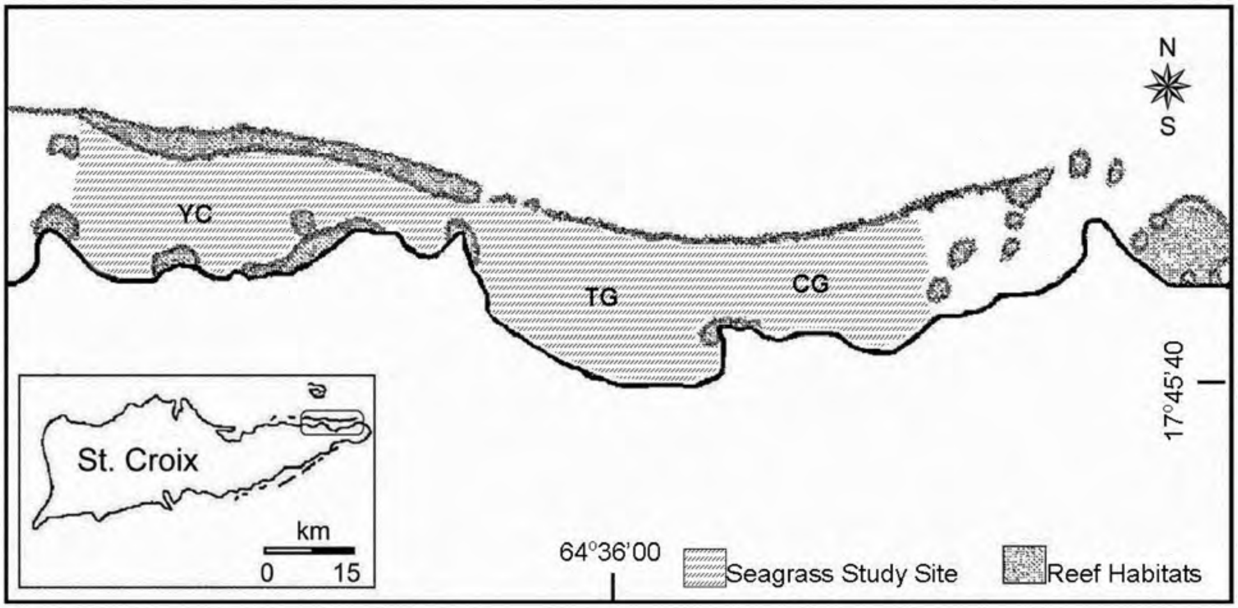

Figure 1.
Location of seagrass meadows study site at Yellowcliff Bay (YC), Teague Bay (TG), and Cottongarden Bay (CG) at the Northeast coast of St. Croix, USVI.

on a preliminary fish census that used cumulative species/transect counts Rogers et al. (1994). At each of the starting points, a single 50-m transect line (marked at 1 cm intervals) was laid out on a randomly selected compass bearing for each transect. On each transect, 100 m^2 were visually surveyed for fish by two divers swimming parallel but on opposite sides of the transect in a 1 m x 50 m belt transect.

At each transect site, a fish census and a benthic survey were done. Each diver recorded fish species and estimated the size classes (<5 cm, 5-10 cm, and > 10 cm total length [TL]) of individuals for each species. For most species, juveniles ≤ 5 cm were recorded as recruits. For smaller species, such as wrasses, grunts, and damselfishes, juveniles ≤ 3 cm were considered recruits. Only juvenile recruits were considered for analysis in the remainder of this study. Identification of grunt recruits was verified by both divers during each dive using an underwater guide of early life history of grunts taken from Lindeman (1997). To minimize the potential bias of counting the same individual twice along the belt transect, divers conferred with each other using hand signals to make sure fish were counted only once (Eberhardt 1978), and divers were trained to maintain constant swimming speed along the transect and to not count fish that entered the census area after the visual census had started (Samoylis and Carlos 2000).

Statistical Analysis

Prior to conducting data analyses, fish density estimates from both divers were checked for independence with a Pearson product-moment correlation coefficient (r) (Zar 1984). If uncorrelated, the paired transects could be considered independent samples. We considered r < 0.50 to indicate independence. Correlation between paired divers was low (r = 0.41, p = 0.243, n = 360), and we interpreted the data generated from the two divers as separate and independent census data sets. Data were standardized by month by pooling belt transects from all three embayments by habitat type. This allowed for equal sample size (n = 24) for the one year study.

The assumption of homogeneity of variance was tested prior to each analysis using the Levene Median test (Zar 1984) for data on number of fish per transect and density of the most abundant species. If this assumption was violated, we log (x+1)-transformed data to satisfy assumptions of homogeneity of the variances (non-transformed data were used in graphs for clarity). Monthly variation in density of the most abundant species recorded on transects were examined with a two-way ANOVA (Sokal and Rohlf 1981). If the overall F-value was significant, Tukey's pair-wise multiple comparison procedure was used to compare mean values.

Results

A total of 8,243 juveniles of 23 species were counted during the study (Table 1). Grunts (Haemulidae) were the most abundant family comprising 60.1% of all juveniles observed. Wrasses (Labridae) were the second most abundant family with 19.4% of the total, followed by parrotfishes (Scaridae, 13.3%). Eight other families comprised the remaining 7.2% of juveniles observed. Of 23 species observed, the French grunt, *Haemulon flavolineatum*, was overwhelmingly dominant, accounting for 59.5% of all recruits, followed by slippery dick, *Halichoeres bivittatus* (18.5%), and bucktooth parrotfish, *Sparisoma radians* (10.4%) (Table 1).

Significant differences in fish recruit density were found among species ($F_{7,11}$= 23.175, p < 0.001) and month ($F_{7,11}$= 20.737, p < 0.001) for all taxa. Significant interactions among species and month ($F_{7,11}$= 1.791, p < 0.003) were also found in this study. Recruit densities of H. *flavolineatum*, *H. bivittatus*, and *S. radians* were significantly higher than those for the remaining species (Tukey test, p < 0.001). There were also significant differences in small fish abundance of *H. flavolineatum*, *H. bivittatus, S. radians, Ocyurus chrysurus, Scarus iseri*, and *Acanthurus chirurgus* among months (Tukey test, p < 0.001).

Major recruitment peaks for *H. flavolineatum* were observed in November 1998 and July 1999 (Figure 2a). Because sampling was only conducted for 12 months, it is uncertain whether these peaks indicate annual or semi-annual pulses. The second most abundant species (*H. bivittatus*) exhibited abundance peaks in October 1998 and September 1999 and lower recruitment during other months (Figure 2b), indicating a prolonged recruitment period with a peak during autumn. Bucktooth parrotfish, *S. radians*, clearly exhibited bimodal recruitment, with peaks in October 1998, May 1999, and September 1999 (Figure 2c). Doctorfish, *A. chirurgus*, exhibited continuous recruitment from April to November and no recruitment from December to March (Figure 2d). Yellowtail snapper, *O. chrysurus*, recruits exhibited an annual peak in August and September of 1999 (Figure 2e). A similar pattern was observed for beaugregory, *Stegastes leucostictus*, with continuous recruitment from April to January and no recruits seen from February to March (Figure 2f). Blackear wrasse, *Halichoeres poeyi*, (Figure 2g) followed the same recruitment pattern as *H. bivittaus*. The striped parrotfish, *S. iseri*, showed a large peak in October 1998 (Figure 2h).

TABLE 1. *Abundance of fish recruits on seagrass meadows in Teague Bay, St. Croix, U.S. Virgin Islands, October 1998 to September 1999 using visual census. Total area surveyed was 36,000 m².*

Family and Species	Total Recruits	Percent of Total
Synodontidae		
Synodus foetens	1	0.01
Lutjanidae		
Ocyurus chrysurus	214	2.60
Lutjanus synagris	11	0.13
Lutjanus mahogoni	7	0.09
Haemulidae		
Haemulon flavolineatum	4,901	59.51
Haemulon plumierii	56	0.68
Mullidae		
Pseudupeneus maculatus	29	0.35
Chaetodontidae		
Chaetodon capistratus	30	0.36
Pomacentridae		
Stegastes leucostictus	123	1.49
Stegastes partitus	6	0.07
Labridae		
Halichoeres bivittatus	1,524	18.51
Halichoeres poeyi	72	0.87
Xyricthys martinicensis	7	0.09
Doratonotus megalepsis	4	0.05
Scaridae		
Sparisoma radians	860	10.44
Scarus iseri	155	1.88
	62	0.75
Acanthuridae		
Acanthurus chirurgus	122	1.48
Acanthurus bahianus	22	0.27
Monacanthidae		
Monacanthus ciliatus	9	0.11
Tetradontidae		
Canthigaster rostrata	11	0.13
Sphoeroides spengleri	7	0.09
Sphoeroides testudineum	2	0.02
TOTAL	**8,235**	**100.00**

Discussion

Although conclusions cannot be drawn from only one year of data, some of the common seagrass fishes in St. Croix appeared to show seasonal variation in recruitment pulses. Within our eight most abundant species we found that *H. flavolineatum*, *H. bivittatus*, *S. radians*, *O. chrysurus*, *S. iseri*, and *H. poeyi* had major recruitment pulses from late summer to late fall. In the Caribbean region, studies focusing on entire reef fish assemblages (not just those in seagrass) have documented seasonal recruitment, primarily during spring through fall. In Barbados, Tupper and Hunte (1994) found that assemblage-wide recruitment was high between May and November and low between December and April. Luckhurst and Luckhurst (1977) reported semi-annual recruitment pulses, primarily in the spring and fall, for sixteen species within seven families in the Netherlands Antilles. Beets (1997) found abundance peaks of fish recruits on artificial reefs in St. Thomas USVI in April and June. Finally, late spring-summer peaks in recruitment were documented for four of the five most abundant families (Gobiidae, Labridae, Haemulidae, Pomacentridae) in a fringing reef in St. John USVI (Miller et al. 2001).

The recruitment patterns exhibited by *H. bivittatus, H. poeyi, A. chirurgus*, and *S. iseri* contrasted with those found in other studies in the Caribbean. Luckhurst and Luckhurst (1977) reported year-round labrid recruitment with spring pulses in the Netherlands Antilles, whereas in our study *H. bivittatus* abundance peaks occurred during September and October. Adams and Ebersole (2002) reported recruitment peaks in June and February for acanthurid species on lagoonal patch reefs in St. Croix, while in

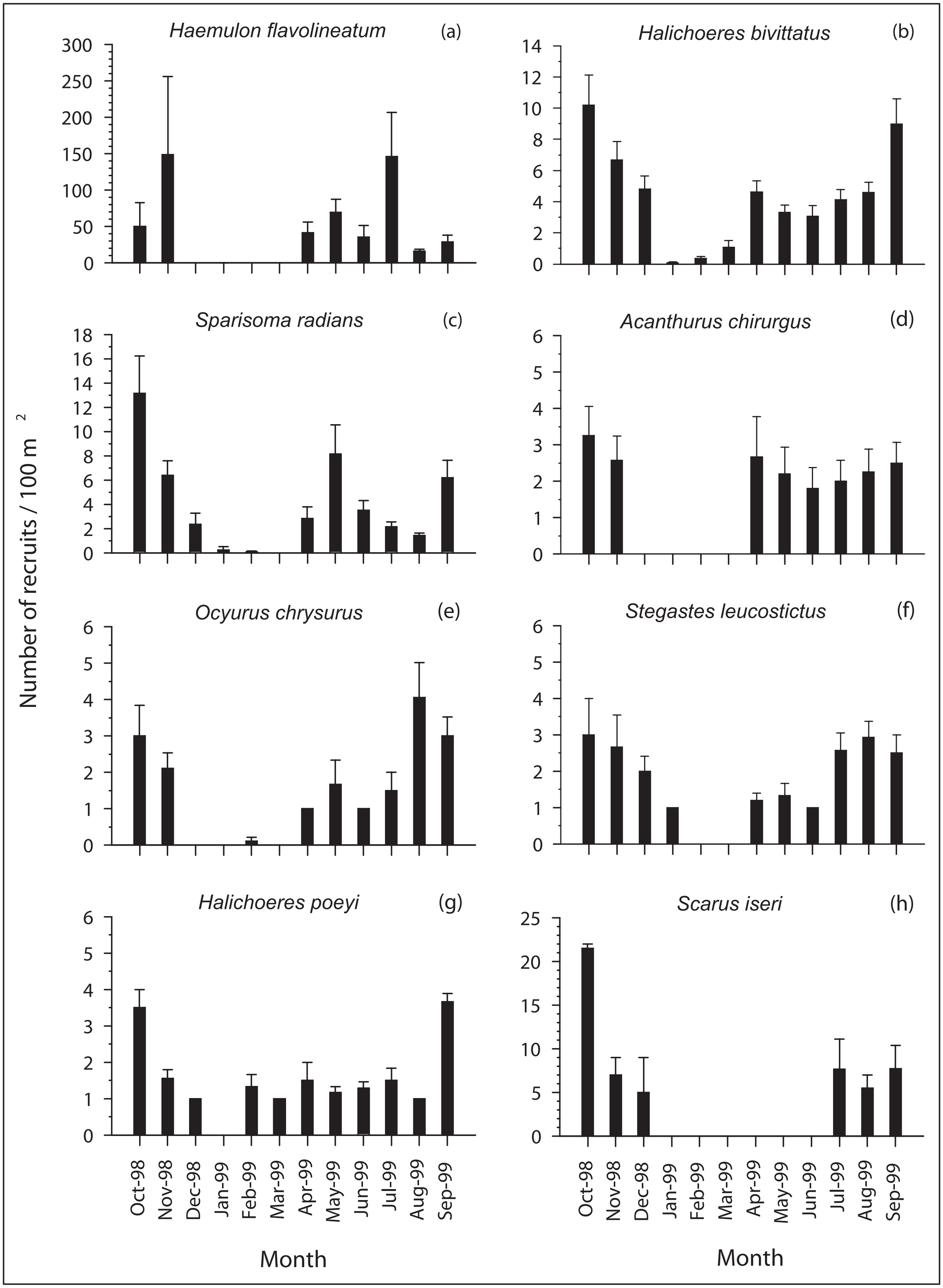

Figure 2.
Mean monthly abundance (± standard error) of dominant recruit species observed using visual census on seagrass meadows in Teague Bay from October 1998 to September 1999. n=10 transects per month (area of each transect = 100m²).

our study we found comparable densities of *A. chirurgus* recruits from spring through fall. For *S. iseri*, Miller et al. (2001) found recruitment peaks in summer, while we found more *S. iseri* recruiting from late summer to late fall, with a major recruitment peak during the month of October.

Signifficant geographical variation in seasonality of juvenile abundance seems likely to occur throughout the Caribbean (Victor 1991, Robertson and Kauffman 1998). Distinct intraspecific geographical variation in spawning seasonal ity has been reported within the Caribbean, with a tendency towards less seasonality in the more tropical parts of that region in some species and spawning peaks at different times of the year at different locations in others (Victor 1991, Robertson and Kauffman 1998). Reef fish species differ in the extent to which their recruitment seasonality varies in different parts of the Caribbean (Robertson and Kauffman 1998): for example, while four *Stegastes* species have somewhat strong late summer peaks of recruitment in the Northwest Caribbean (Booth and Beretta 1994, Mcghee 1995), they have weaker seasonality in the Southwest Caribbean, with their recruitment peaks at least 6 months earlier in the year (Robertson 1990). Furthermore, pomacentrid species may have different seasonal recruitment peaks at different locations on a single island in the same year (Booth and Beretta 1994, Caselle and Warner 1996). Damselfish recruitment occurs during September in Puerto Rico (McGehee 1995), year-round with fall pulses in the Netherlands Antilles (Luckhurst and Luckhurst 1977), and from June to September in Barbados (peak for *Stegastes partitus*; Tupper and Hunte 1994). In our study, damselfish exhibited summer/fall recruitment pulses. Other species appear to have consistent recruitment patterns throughout the Caribbean. For example, *H. flavolineatum* has been found to recruit throughout the year in St. Croix (McFarland et al. 1985, Shulman and Ogden 1987), with reports of recruitment peaks in summer and fall throughout the Caribbean (Miller et al. 2001, Appeldoorn et al. 1997, this study). For *O. chrysurus*, recruitment peaks found in the present study (during August-October) were similar to those found by Watson et al. (2002) in seagrass habitats in Tortola.

In recent years, considerable knowledge has been gained regarding fish use of nearshore habitats such as seagrass meadows or mangrove lagoons in the Caribbean (e.g., evaluation of nursery value or trophic linkages) (Nagelkerken et al. 2000a, 2000b, Cocheret et al. 2003, Mumby et al. 2004, Chittaro et al. 2005); however, few studies have been conducted on fish recruitment to seagrass habitat around the Caribbean. This is a component that is often overlooked in studies characterizing the nursery roles of seagrass and mangroves for tropical fishes in the Caribbean (Nagelkerken et al. 2000a, 2000b, 2001, Cocheret et al. 2002, Mumby et al. 2004, Chittaro et al. 2005).

Our study has demonstrated differences in recruitment intensity among species and months within a year of study. We recognize that this is a short-term study. It may or may not be indicative of typical recruitment patterns but provides valuable comparative information on recruitment from the Caribbean region. The observed variability in recruitment indicates the need for frequent sampling. Our results imply that the functioning of any seagrass bed incorporates strong seasonal patterns which need to be accommodated in any study wishing to understand their importance to fisheries.

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