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DISTRIBUTION OF THE HERMIT CRABS *CLIBANARIUS VITTATUS* AND *PAGURUS MACLAUGHLINAE* IN THE NORTHERN INDIAN RIVER LAGOON, FLORIDA: A REASSESSMENT AFTER 30 YEARS

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ABSTRACT

The present distribution of two hermit crabs, *Clibanarius vittatus* and *Pagurus maclaughlinae*, was assessed for comparison with a study done more than 30 yr ago on decapods of the region. *Clibanarius vittatus* presently occurs in low or moderate density only at Sebastian Inlet. Retreat of *C. vittatus* from sites that it formerly occupied is attributed to intolerance of its larvae to low salinities recorded in the lagoon during recent reproductive seasons. *Pagurus maclaughlinae* remains the most abundant and widespread hermit crab in the lagoon. Its present distribution seems unchanged from the reference study despite prolonged periods, sometimes years, during which salinities declined to 12-25 in many areas distant from inlets.

KEY WORDS: *Clibanarius vittatus*, hermit crab distribution, *Pagurus maclaughlinae*, salinity, seagrass

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INTRODUCTION

A system of three bar-built lagoons (Mosquito Lagoon, Banana River, Indian River) spanning 250 km along the central east coast of eastern Florida forms the most biologically diverse estuary in North America (Gilmore, 1985; Dybas, 2002; Duncan et al., 2004). The watershed of the Indian River Lagoon System has more than doubled in size over the past 60 years with the construction of impoundments and canals, and with urban intensification along the lagoon and surrounding regions (Schmalzer, 1995; Duncan et al., 2004). This trend is likely to continue with the anticipated increase over the next century of the present population of 1 million people in the watershed (DeFreese, 1991, 2007; Dybas, 2002). The expanding population and watershed have severely impacted the Indian River Lagoon system by shoreline modification, nutrient loading, and increased freshwater runoff (Smith, 1993; Adams et al., 1996; Kim et al., 2002).

The Brevard County section of the Indian River Lagoon system is highly susceptible to wide variation in salinity due to high residence times, reliance on non-tidal flushing, sensitivity to rainfall variation, evaporation, and geographical distance from inlets to the Atlantic Ocean (DeFreese, 1991; Smith, 1993; Schmalzer, 1995; Phlips et al., 2004; Sumner and Belaineh, 2005). Groundwater discharge into the lagoon adds an additional effect on water quality (Pandit and El-Khazen, 1990; Belanger et al., 2007). Hydrological modifications resulting from human activities have negatively impacted saltwater vegetation, native biodiversity, and seasonal fish nurseries (DeFreese, 1991). Cattail marsh, a historically minor component of lagoonal salt marshes, has been increasing in areas where the influence of freshwater runoff has been greatest (Schmalzer, 1995). Macroinvertebrate populations and community structure in the Brevard County section of the lagoon might also be strongly influenced by significant hydrological variation over time (Clark and DeFreese, 1987; DeFreese, 1991; Turner, 2007).

Pagurus maclaughlinae García-Gómez 1982 [Paguridae] and *Clibanarius vittatus* (Bosc 1802) [Diogenidae] are two species of hermit crab commonly found in the Indian River Lagoon System (Provenzano, 1959; Grizzle, 1974; Lowery and Nelson, 1988; Tunberg et al., 1994). Based on what is known of the natural history of these species, it seems that hydrological conditions in the lagoon system would strongly influence their distributions and abundance. Grizzle (1974) undertook an extensive qualitative survey of decapods in the Brevard County section of the lagoon in the early 1970s, and both species of hermit crab were included in his study. The goal of our study was to describe the current distributions of these two species of hermit crab under present hydrologic conditions in comparison with the distribution observed during Grizzle's study. More importantly, this study was also designed to provide a quantitative baseline to allow more rigorous comparisons in the future.

MATERIALS AND METHODS

Study Species

There were several reasons for choosing *C. vittatus* and *P. maclaughlinae* for this study. Both species are abundant in the lagoon system. Their distributions overlap but are not congruent, and the incongruence seems to be based on habitat preferences and salinity tolerances. Both species are easily recognized in the field, even as juveniles, based on color patterns of their pereiopods. These active epifaunal hermit crabs lend themselves to low-impact sampling both by visual survey in clear waters and by sweep net and return of live animals in murky waters.

Clibanarius vittatus prefers fine muds and seagrass beds (Lowery and Nelson, 1988), where it feeds on detritus and scavenged material (Caine, 1975) and potentially plays a role in detrital reworking of the sediments (Lowery and Nelson, 1988). It is distinguished from other local hermit species by its olive-green color with off-white stripes (Provenzano, 1959; Williams, 1984). Each of the propodi of its walking legs has four pairs of off-white stripes on a green background; the stripes are continuous with similar stripes on the dactyl and carpus (Williams, 1984). The narrow tolerance of its larvae to salinity fluctuations (Young and Hazlett, 1978) could be a major factor confining the distribution of *C. vittatus* to the vicinity of inlets, where the influence of a high and stable salinity is greatest because of tidal exchange with the Atlantic Ocean (Lowery and Nelson, 1988; Philips et al., 2004). Lowery and Nelson (1988) observed no seasonal migration of *C. vittatus* in the Indian River Lagoon System and detected small males and females throughout the year, but they noted that large males move to deeper waters when water temperatures are low from December to March.

Pagurus maclaughlinae, one of the most abundant and widespread hermit crabs in the lagoon system (Grizzle, 1974; Tunberg et al., 1994), is found primarily in seagrass beds (Provenzano, 1959; García-Gómez, 1982), where it grazes on seagrass epiphytes and might play an important role in regulating the structure and composition of seagrass communities (Tunberg et al., 1994). Although there has been some confusion surrounding the six species of *Pagurus* in the Indian River Lagoon System (Provenzano, 1959; García-Gómez, 1982; Tunberg et al., 1994), *P. maclaughlinae* is distinguished from other small hermit species and juvenile *C. vittatus* by the brown and white banding pattern on its limbs. Each pereiopod bears two brown bands on the proximal half of the dactyl, each propodus and carpus has one brown band located centrally, and each merus has two brown bands (García-Gómez, 1982). The bands are visible in juveniles of 1 mm carapace length (S.E. Rhodes-Ondi, Florida Institute of Technology, personal communication). Adult *P. maclaughlinae* are euryhaline and weak osmoregulators (Rhodes-Ondi and Turner, 2010), but salinity tolerance of their larvae is unknown. Seasonal migration of *P. maclaughlinae* has not been reported and is unlikely because it is small and abundant in the lagoon year round.

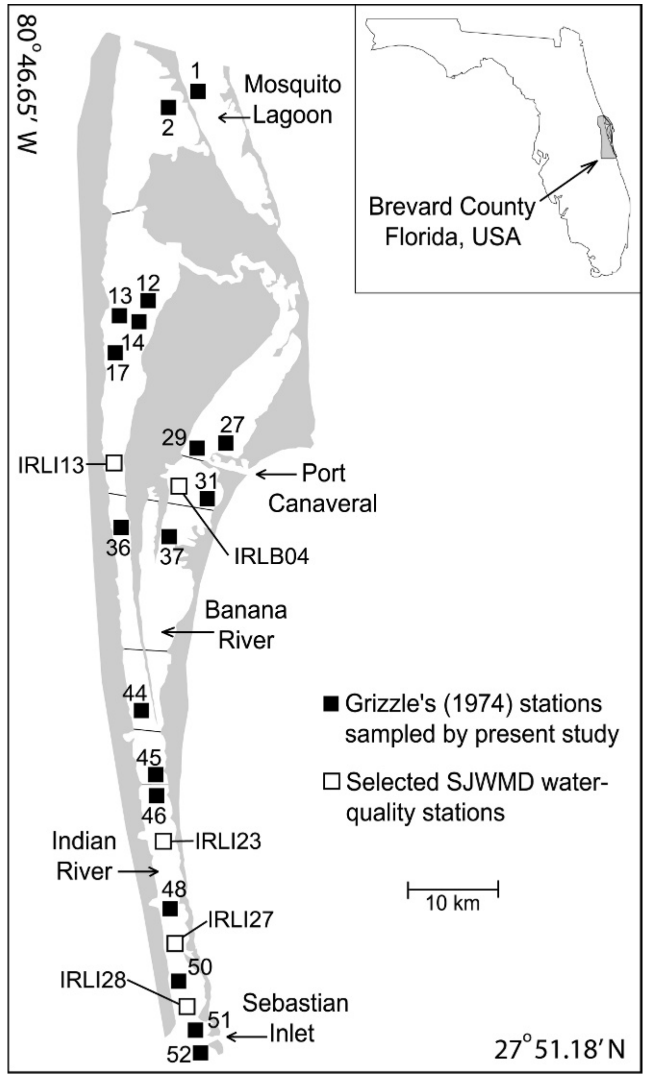

Fig. 1. Brevard County section of the Indian River Lagoon System, showing Grizzle's (1974) stations resampled in present study and selected St. Johns River Water Management District water-quality monitoring stations.

Field Sampling

Between September 2000 and July 2001 we resampled 18 of the 25 stations at which Grizzle (1974) recorded one or both of these hermit species (Fig. 1). We excluded those stations that exceeded a depth of 1 m because of our choice to apply a low-impact sampling technique. The seven excluded stations were located near the other 18 stations. At only one excluded station did Grizzle (1974) record *C. vittatus*.

Two transect lines 50 m long, 10 m apart, and perpendicular to the shoreline were staked out at each station to sample an appropriate range of depth (0-100 cm) and habitat type (sand, mud, seagrass). If the length of the transect extended into water that exceeded 1 m depth, only the section $\leq$ 1 m depth was sampled. At 5-m intervals, a 1-m^2 PVC quadrat frame was secured at the surface of the water to two PVC poles driven vertically into the substratum at two opposite corners of the frame. Positioning the frame at the surface allowed its effectiveness in often murky water to guide the use of sweep nets to sweep the lagoon floor beneath 16 times in a crisscross pattern. Preliminary sampling revealed that additional hermit crabs were rarely captured after 16 sweeps. During regular sampling, few, if any, hermit crabs were caught in the final few sweeps of each quadrat. Sweep nets measured 30 cm wide and had a mesh size of 3 mm. All matter collected in the sweep nets was emptied and accumulated in a container for live sorting after the last sweep of the quadrat. We recorded the numerical abundance of hermit crabs and presence or absence of vegetation for each quadrat. Temperature (°C) and salinity were recorded at each station.

In addition to the two transects, six throws of the quadrat frame were also made at each station. Randomness was attempted by throwing the frame in different directions. Although the location of each throw was chosen haphazardly, the substratum and depth sampled were controlled. The first three throws made in areas of vegetation (seagrass or drift algae) and three in unvegetated areas were sampled by sweep net. The same parameters and protocol for transect sampling were used for the thrown quadrats. Three random throws were done only in vegetated areas at Station 36 because at the time of sampling this station had no unvegetated areas that were $\leq$ 1 m deep.

A few specimens from most stations were retained and preserved in 10% formaldehyde for positive identification in the laboratory; the others were released in the field. Voucher specimens are deposited in the National Museum of Natural History, Smithsonian Institution, Washington, D.C. (USNM 1078162-1078168).

Data Analysis

A non-parametric Mann-Whitney U test was used to compare densities of *P. maclaughlinae* and *C. vittatus* in vegetated and unvegetated patches. A non-parametric approach was applied because data violated the assumptions of normality and equality of variances and could not be normalized through transformation.

We obtained hydrological information from St. Johns River Water Management District (SJRWMD) spanning a 17-yr period (1987-2004). Salinities from the months of the *C. vittatus* breeding season (April-September) are presented in this paper because it is only the larvae that are susceptible to fluctuations in salinity. No fine-scale salinity data exist from the time of Grizzle's (1974) study. He did, however, report a minimum, maximum, and average salinity over a 4-yr period (January 1968-May

Table 1. A summary of salinity data from the Brevard County Health Department water quality records from January 1968 to May 1971 as reported by Grizzle (1974) and SJWMD water quality records from January 1997 to May 2000, and August 2001 to September 2004.

Water quality station		Jan. 1968-May 1971			Jan. 1997-May 2000			Aug. 2000-Sept. 2004		
Location	*Station*	*Min.*	*Max.*	*Avg.*	*Min.*	*Max.*	*Avg.*	*Min.*	*Max.*	*Avg.*
Cocoa	IRLI13	18.6	33.7	24.7	15.7	25.0	20.1	18.3	35.3	22.6
520 causeway	IRLB04	9.3	34.5	21.8	12.8	21.0	17.2	18.9	28.3	22.9
Malabar	IRLI23	10.0	34.6	22.9	9.9	30.3	17.6	12.9	36.3	20.8
Sebastian Inlet	IRLI28	12.8	36.4	25.7	N/A	N/A	N/A	16.8	37.4	28.1

1971) preceding his study for several stations located within the lagoon system. We here give minimum, maximum, and average salinity over a 4-yr period (January 1997 to May 2000) prior to our study and a 4-yr period (August 2001 to May 2004) following our study at approximately the same water-quality stations that Grizzle (1974) used, for a comparison (Table 1). The paucity of fine-scale salinity data for the northern Indian River Lagoon System before 1987 makes it difficult to infer the hydrological conditions during *C. vittatus* breeding season at the time of Grizzle's study.

Results

The sampling effort yielded 4575 hermit crabs collected at 17 of 18 stations in the Indian River Lagoon system (Fig. 1). Both species were absent from Station 2 in the far northern section of the Indian River near Titusville (Fig. 2A). *Pagurus maclaughlinae* comprised 97% of all hermit crabs collected, and *C. vittatus* accounted for 3%. One *Pagurus pollicaris* Say 1817 and one *P. longicarpus* Say 1817 were caught near Sebastian Inlet (Station 52).

Clibanarius vittatus was found only at five stations (Fig. 2A) and at moderate densities only near Sebastian Inlet (Station 51, 4.1 m^{-2}; Station 52, 0.5 m^{-2}; Table 2). The nearest SJRWMD water-quality station (IRLI28, Figs. 1, 3A) historically had high salinities during the breeding season of *C. vittatus* and within the range favorable for larval survival. At each of the other three stations (1, 29, 50), *C. vittatus* was represented by only one specimen (0.04 m^{-2}; Table 2). A SJRWMD water-quality station (IRLI27, Fig. 1, 3B) located near Station 50 had historically more variable salinities during the months of the *C. vittatus* breeding season. Salinities were high and favorable for larval survival during the first 4 yr of this time series (1987-1990) and in 2000 but were outside the range for larval survival during much of the breeding season during the 11 yr preceding this study (1991-2001, 2000 excepted). Station 29, located directly west of Port Canaveral and its locks, might have been subject to influxes of ocean water, but salinities at a SJRWMD station (IRLB04, Figs. 1, 3E) located just south of Station 29 were low during the 6 yr (1995-2000) preceding this study and varied with a pattern similar to that of a nearby station in the more isolated Indian River (IRLI13, Figs. 1, 3D). Station 1 was located in the Mosquito Lagoon, an area that is generally hypersaline. No *C. vittatus* were found in the central region of the northern Indian River Lagoon System. SJRWMD water-quality stations (IRLI23, IRLI13) in these areas had low and highly variable salinity for the entire 17-yr record (Figs. 1, 3C, 3D). Density of *C. vittatus* did not vary significantly between vegetated areas and bare sand (Mann-Whitney $U = 2129$; $P > 0.05$; Table 3).

Pagurus maclaughlinae was the only species of hermit crab at 12 of 18 stations (Fig. 2A), at which the range of densities of this small hermit crab was 0.8-53.5 m^{-2} (Table 2). This species co-occurred at a similar range of densities at five other stations with *C. vittatus* (Fig. 2A, Table 2). Mean density of *P. maclaughlinae* was significantly higher in vegetated areas than on bare sand (Table 4; Mann-Whitney $U = 23{,}980$; $P \leq 0.01$).

Discussion

Grizzle (1974) recorded five species of hermit crab in his qualitative 1971-1972 survey of decapod crustaceans in the Brevard County section of the Indian River Lagoon System. Only two species, *C. vittatus* and *P. maclaughlinae* (as *P. bonairensis*; see García-Gómez, 1982), occurred within the lagoon, and they were among the most abundant of 44 species of decapods in Grizzle's (1974) survey. The other three species of hermit crab were less abundant and were confined to the vicinity of inlets.

Grizzle (1974) recorded *C. vittatus* at one station in Mosquito Lagoon, three stations near Port Canaveral, and four stations in the southern part of the Brevard section of the lagoon near Sebastian Inlet (Fig. 2B). Grizzle (1974) did not report hermit crab abundances, but he collected *C. vittatus* alone at three of the eight stations where this species was present (stations 29, 48, and 51). He noted also that *C. vittatus* was common at the remaining five stations (Grizzle, 1974; R. Grizzle pers. comm.). In the present study, we found *C. vittatus* at five of Grizzle's (1974) stations. This species occurred at moderate to low densities at the two stations nearest Sebastian Inlet, but only one individual was found at each of the other three stations where Grizzle (1974) had reported them as common.

Authors of other studies have suggested that salinity affects the estuarine distribution of *C. vittatus* in North Carolina (Wells, 1961), Tampa Bay (Strasser and Price, 1999), Texas (Fotheringham and Bagnall, 1976), lagoons in the western Gulf of Mexico (Raz-Guzman et al., 2004), and the Indian River Lagoon system (Lowery and Nelson, 1988). The low abundance and absence of *C. vittatus* from stations around Port Canaveral and north of Sebastian Inlet in the present study can be attributed to the low and variable salinity in these regions during the several years prior to our study.

Adult *C. vittatus* tolerate wide ranges of salinity and temperature (Fotheringham, 1975; Sabourin and Stickle, 1977; Sharp and Neff, 1980). Warm-acclimated adult *C. vittatus* tolerate ranges of 6-35°C and salinities of 2-40 (Young, 1980). The extremes of these ranges are rarely recorded in the Indian River Lagoon System (Fig. 3).

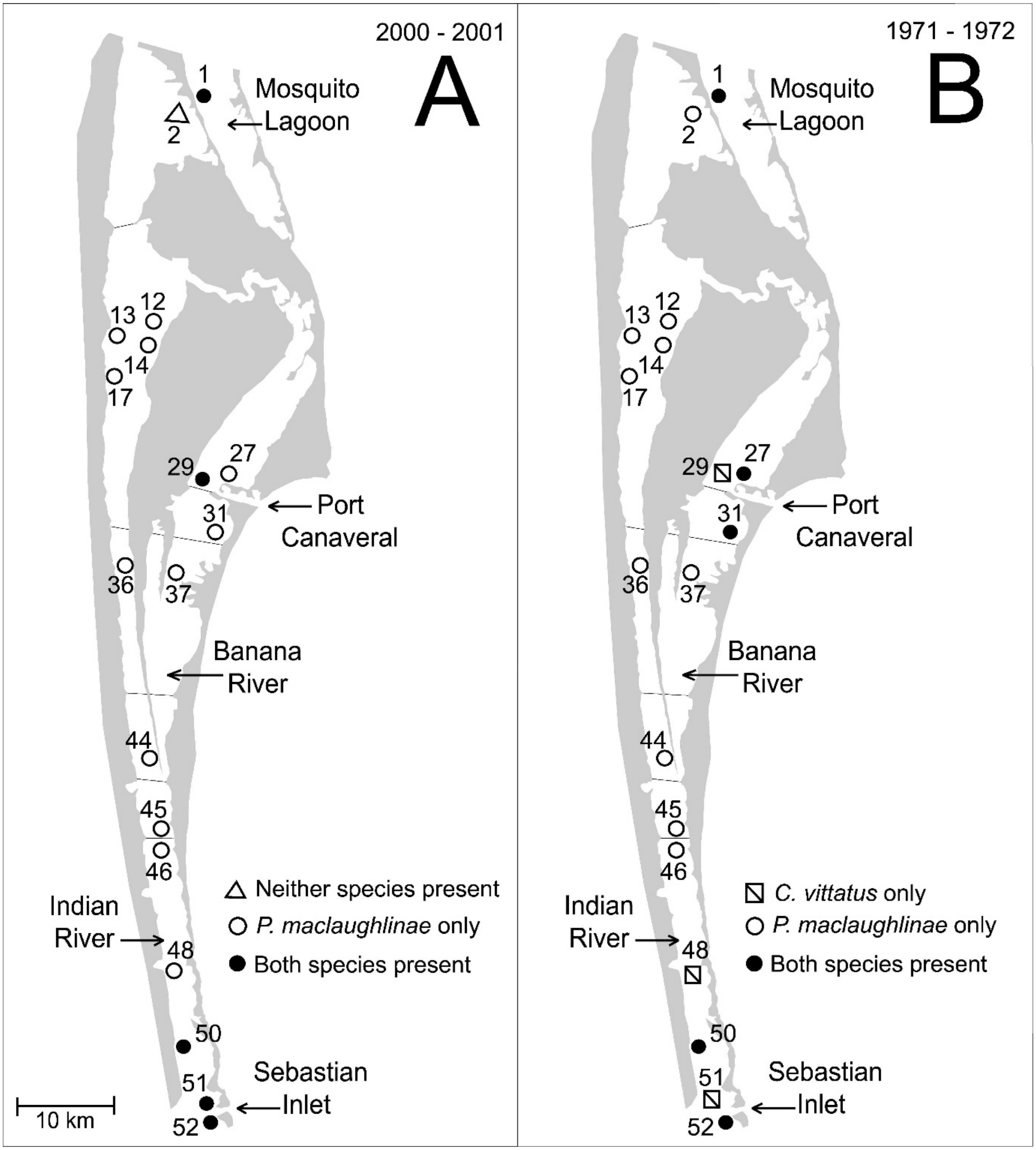

Fig. 2. Distribution of *Clibanarius vittatus* and *Pagurus maclaughlinae* in the northern Indian River Lagoon System. A. Present study, 2000-2001. B. Data from Grizzle (1974), 1971-1972. Species key: △ = neither species present; ○ = *P. maclaughlinae* only; ⧅ = *C. vittatus* only; ● = both species present.

Larval *C. vittatus* are much less tolerant of fluctuations in salinity (Young and Hazlett, 1978; Young, 1979) and are especially affected by low and variable salinities. Larval development to first crab stage at a salinity of 35 takes 57 days and at a salinity of 25 takes 91 days (Kircher, 1967). Young and Hazlett (1978) found that metamorphosis to juvenile crab was achieved only at salinities of 25-30 in combination with temperatures of 25-30°C. Young (1979) found that larval *C. vittatus* can only "hyperosmoconform" at salinities < 25, stressing their cellular osmoregulatory capabilities and resulting in poor survival. Based on these studies, larval *C. vittatus* probably require two months at $\geq$

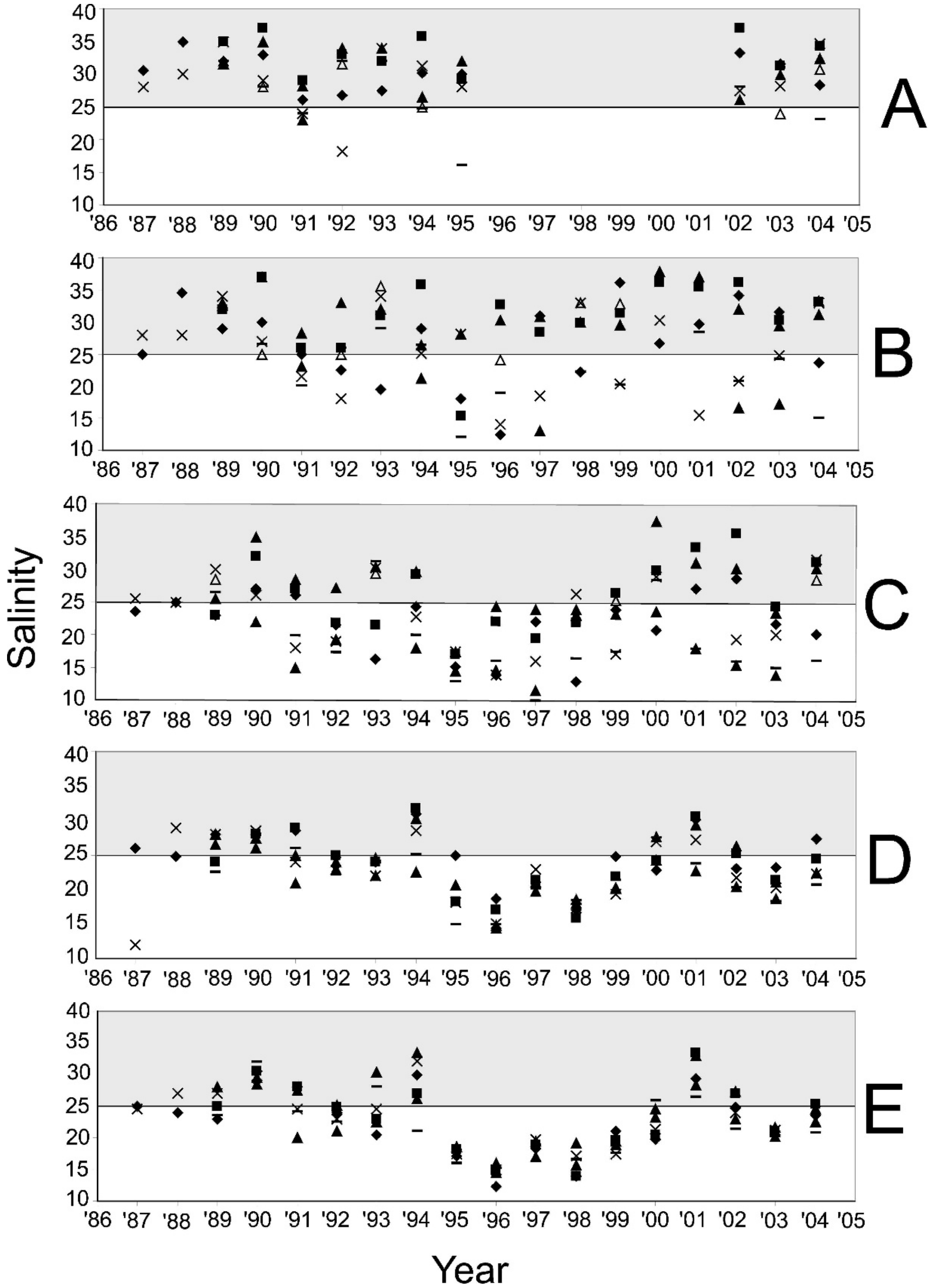

Fig. 3. Salinities at Brevard County water-quality monitoring stations (Fig. 1) during the *Clibanarius vittatus* breeding season from data obtained from St. Johns River Water Management District (1987-2004). Shaded boxes indicate optimal salinity range for *C. vittatus* larvae. A. IRLI28 (Indian River, 4 km north of Sebastian Inlet). B. IRLI27 (9.7 km north). C. IRLI23 (25.7 km north). D. IRLI13 (58.7 km north). E. IRLB04 (Banana River, 4.8 km south of Port Canaveral). Monthly data points: ◆ = April; ■ = May; ▲ = June; × = July; △ = August; — = September.

Table 2. Station data. Latitude and longitude were determined using map coordinate datum WGS84/NAD83. Densities are expressed as means ± standard deviations. N/A, data not recorded.

Station	Date sampled	Latitude	Longitude	Nearest water-quality station	Water temperature (°C)	Salinity	Crab density (m^{-2})	
							P. maclaughlinae	*C. vittatus*
1	25-Feb-01	28°47.44′N	80°47.26′W	N/A	28	40	2.2 ± 2.65	0.04 ± 0.189
2	1-Jul-01	28°46.50′N	80°48.37′W	IRLI 13	N/A	N/A	0	0
12	14-Jul-01	28°31.65′N	80°43.84′W	IRLI 13	N/A	N/A	18.2 ± 29.04	0
13	14-Apr-01	28°31.60′N	80°46.65′W	IRLI 13	N/A	N/A	35.9 ± 51.33	0
14	14-Jul-01	28°31.50′N	80°43.99′W	IRLI 13	N/A	N/A	53.5 ± 39.31	0
17	17-Feb-01	28°28.18′N	80°45.75′W	IRLI 13	N/A	N/A	14.2 ± 16.04	0
27	23-Sep-00	28°25.15′N	80°37.85′W	IRLB 04	29	40	5.8 ± 7.64	0
29	1-Nov-00	28°24.38′N	80°39.59′W	IRLB 04	25	29	24.3 ± 23.27	0.04 ± 0.196
31	11-Oct-00	28°21.67′N	80°37.45′W	IRLB 04	25	30	4.0 ± 4.36	0
36	20-Sep-00	28°19.04′N	80°42.53′W	IRLI 13	31	37	2.0 ± 2.24	0
37	3-Feb-01	28°19.03′N	80°39.48′W	IRLB 04	17	40	6.0 ± 5.01	0
44	20-Jan-01	28°8.93′N	80°36.48′W	IRLI 23	14	40	5.1 ± 5.15	0
45	10-Sep-00	28°5.25′N	80°34.99′W	IRLI 23	N/A	32	7.6 ± 6.50	0
46	9-Sep-00	28°5.24′N	80°34.81′W	IRLI 23	31	37	0.8 ± 1.12	0
48	13-Sep-00	27°57.87′N	80°32.49′W	IRLI 27	N/A	35	2.2 ± 4.14	0
50	20-Sep-00	27°52.84′N	80°30.05′W	IRLI 27	31	35	1.4 ± 1.85	0.04 ± 0.189
51	28-May-01	27°51.38′N	80°27.32′W	IRLI 28	N/A	N/A	1.6 ± 1.69	4.1 ± 3.64
52	7-Apr-01	27°51.18′N	80°27.23′W	IRLI 28	29	37	0.6 ± 1.47	0.5 ± 1.14

25°C and at salinities ≥ 25 to grow and reach first crab stage during the breeding season of April to September (Lowery and Nelson, 1988).

The variability in salinity during the breeding season of *C. vittatus* over a 17-yr period (1987-2004) indicates that most of the Brevard County section of the Indian River Lagoon System exceeded the tolerance of *C. vittatus* larvae for most years (Fig. 3). It is, however, likely that larvae of *C. vittatus* penetrate the lagoon deeply during dry periods when evaporation plays an enhanced role in elevating salinity within the lagoon system (Sumner and Belaineh, 2005). Occasional penetration of the lagoon by *C. vittatus* is indicated by the presence of nine specimens found by one of us (RLT unpubl.; USNM 1078169-1078171) during an unrelated visual shoreline survey in May 2005 at stations 45 and 46 in the Indian River Lagoon near Melbourne and one specimen at a location in the Banana River Lagoon halfway between stations 37 and 44. The ten specimens included juveniles and adults with shield lengths of 2.8-14.9 mm, the smallest of which might have been a recruit from 2004 based on sizes given by Lowery and Nelson (1988). This survey was subsequent to the present study and followed a dry period in 2001-2004 during which salinities did not decline as strongly (Fig. 3). Grizzle (1974) reported relatively high average salinity values for the years (1968-1971; Table 1) preceding his study, which probably accounts for his recorded distribution of *C. vittatus* deep within the lagoon system. Individuals established in these areas might fail to produce recruits during times of average or below-average salinity, resulting in recession of the population to the inlets where salinity is less variable.

Grizzle (1974) collected *P. maclaughlinae* at 22 stations. We collected *P. maclaughlinae* at all stations except Station 2; it was also collected at two stations (29, 51) where Grizzle (1974) had found only *C. vittatus*. In contrast to *C. vittatus*, which has receded from the lagoon system, the distribution of *P. maclaughlinae* has remained largely unchanged. The only change in distribution between the two studies occurred at Station 2 in the far northern part of the Indian River Lagoon and Station 48 in the southern part of the lagoon. Grizzle (1974) recorded only *P. maclaughlinae* at Station 2, but no hermit crabs of either species were found in the present study. At the time of our sampling, this

Table 3. Densities of *Clibanarius vittatus* in vegetated and unvegetated quadrats. Densities are expressed as means ± standard deviations. Density of *C. vittatus* did not significantly differ between the vegetated and unvegetated habitats (Mann-Whitney $U = 2129$; $P > 0.05$).

Station	Crab density (m^{-2})	
	Vegetated	Unvegetated
1	0	0.1 ± 0.35
29	0	0.1 ± 0.32
50	0	0.1 ± 0.33
51	4.8 ± 3.54	4.0 ± 5.66
52	0.5 ± 1.41	0.4 ± 0.67

Table 4. Densities of *Pagurus maclaughlinae* in vegetated and unvegetated quadrats. Densities are expressed as means ± standard deviations. Density of *P. maclaughlinae* significantly differed between the vegetated and unvegetated habitats (Mann-Whitney $U = 23980$; $P \leq 0.01$).

Station	Crab density (m^{-2})	
	Vegetated	Unvegetated
1	3.2 ± 2.68	0.1 ± 0.35
12	24.2 ± 35.18	13.1 ± 22.46
13	85.2 ± 60.79	12.6 ± 22.79
14	63.7 ± 38.14	22.8 ± 26.01
17	23.0 ± 17.55	8.6 ± 12.41
27	7.4 ± 8.09	0.6 ± 0.55
29	35.2 ± 23.66	6.9 ± 4.95
31	5.3 ± 5.33	2.4 ± 2.14
36	2.0 ± 2.23	N/A
37	6.4 ± 7.71	6.6 ± 3.15
44	10.7 ± 6.03	2.7 ± 2.36
45	10.1 ± 8.01	5.0 ± 3.32
46	1.5 ± 1.13	0
48	3.5 ± 4.84	0
50	2.0 ± 2.00	0.2 ± 0.44
51	1.7 ± 1.69	0
52	0.9 ± 1.84	0.3 ± 0.62

station was characterized by large areas of decomposing vegetation and anoxic sediment, perhaps reflective of a catastrophic decline of shoalgrass beds described by Morris and Virnstein (2004) for this region. At Station 48 Grizzle (1974) recorded only *C. vittatus*, but we found only *P. maclaughlinae*. At the time of our sampling, this station was characterized primarily by seagrass and few bare sand patches; habitat type for this station was unfortunately not described by Grizzle (1974). In the present study, the distribution of *P. maclaughlinae* was strongly associated with the presence of seagrass and drift algae. Grizzle (1974) collected *P. maclaughlinae* ''especially from shallow grass bed areas''. Gore et al. (1981) and Virnstein et al. (1983) found strong statistical associations of *P. maclaughlinae* with seagrasses. The preference of *P. maclaughlinae* for seagrass beds over bare sand was confirmed in a laboratory study by Tunberg et al. (1994), who also found that preference varied by species of seagrass. Salinity does not seem to influence the distribution of *P. maclaughlinae*. Rhodes-Ondi and Turner (2010) found that adult *P. maclaughlinae* are able to tolerate a broad range of salinities (10-45) while keeping the osmotic pressure of the hemolymph 45-154 mOsmol above ambient values in short- and long-term trials. Salinity tolerance of larval *P. maclaughlinae* has not been reported but might be important for our understanding of the distribution of this species. Given the affinity of *P. maclaughlinae* for seagrass over bare sand as described by this and other studies, it is more likely that the distribution of this species is influenced more by habitat type than by changes in salinity. Gore et al. (1981) ranked *P. maclaughlinae* (as *P. bonairensis*) third among 38 species of decapod crustacean in abundance and fifth in biomass from seagrass and drift-algal communities in the lagoon. *Pagurus maclaughlinae* ranked 25th of 164 invertebrate taxa from seagrass beds in the lagoon and was rare among 125 taxa from sand flats in a study by Virnstein et al. (1983). These and other studies (Lowery and Nelson, 1988; Tunberg et al., 1994) indicate that *P. maclaughlinae* is a significant component of the seagrass fauna throughout the Indian River Lagoon system.

Our failure to detect a habitat preference for *C. vittatus* might be due to the low densities of this species in the present study. Lowery and Nelson (1988) found a strong association of *C. vittatus* with mud and seagrass habitats, but this species also occurred in a variety of other biotopes, including the intertidal shore. We do not believe that the change in distribution of *C. vittatus* is due to change in habitat type. Grizzle (1974) recorded this species ''mainly from seagrass beds, and along the shoreline'' but did not describe the type of habitat at each station. Although we can not compare habitat type with Grizzle's (1974) study, we did not find any site that was devoid of either seagrass or bare sand patches (except for Station 2) both of which are preferred habitat of *C. vittatus*.

Larval salinity tolerance might be the primary determinant of *C. vittatus* distribution in the Indian River Lagoon System. Our study provides both historical and quantitative data that can be used in future studies to evaluate further the linkage between larval salinity tolerance of *C. vittatus* and its distribution within the lagoon system.

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