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Fernando Alvarez

Universidad Nacional Autonoma de Mexico

Adolfo Gracia

Universidad Nacional Autonoma de Mexico

Rafael Robles

Universidad Nacional Autonoma de Mexico

Jorge Calderon

Universidad Nacional Autonoma de Mexico

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PARASITIZATION OF *CALLINECTES RATHBUNAE* AND *CALLINECTES SAPIDUS* BY THE RHIZOCEPHALAN BARNACLE *LOXOTHYLACUS TEXANUS* IN ALVARADO LAGOON, VERACRUZ, MEXICO

Fernando Alvarez¹, Adolfo Gracia², Rafael Robles¹ and Jorge Calderón¹

¹Colección Nacional de Crustáceos, Instituto de Biología, Universidad Nacional Autónoma de México, Apartado Postal 70-153, México 04510 D.F., México

²Instituto de Ciencias del Mar y Limnología, Universidad Nacional Autónoma de México, Apartado Postal 70-305, México 04510 D.F., México

ABSTRACT *Callinectes rathbunae* and *Callinectes sapidus* in Alvarado Lagoon, Mexico, were sampled monthly for one year to determine the extent of parasitization by the rhizocephalan cirripede *Loxothylacus texanus*. Prevalence levels, host sex ratio, carapace width-weight variation, and distribution of the number of parasites among hosts were analyzed. *Loxothylacus texanus* was present almost exclusively in *C. rathbunae* with a mean prevalence of 7.58%, while less than 1% of all *C. sapidus* were parasitized. *Callinectes rathbunae* constitutes a new host record for this parasite. A study of infection revealed significant variation in prevalence and host size throughout the study period. The sex ratio of parasitized crabs differed from that of the total sample with males being parasitized more often, and the comparison of carapace width-weight relationships revealed lower weights of parasitized crabs.

INTRODUCTION

A number of studies on the rhizocephalan barnacle *Loxothylacus texanus* Boschma parasitizing the blue crab, *Callinectes sapidus*, in the Gulf of Mexico have been published in the last several decades describing: temporal and geographic variation in prevalence (Adkins 1972, Hochberg et al. 1992, Lázaro-Chávez et al. 1996), host size distribution (Christmas 1969, Adkins 1972, Ragan and Matherne 1974), morphological modifications of hosts (Reinhard 1950, Alvarez and Calderón 1996), and the relationship between host size and parasite size (Wardle and Tirpak 1991). The interest in the effect of this parasite on the commercially important blue crab is renewed whenever a new outbreak is detected (Wardle and Tirpak 1991) and few long-term prevalence records have been kept (O'Brien and Overstreet 1991).

Until recently, no published information existed on the extent of the blue crab-rhizocephalan interaction in Mexican waters of the Gulf of Mexico, although parasitized crabs have long been recognized by local fishermen. *Loxothylacus texanus* is well established in the Gulf of Mexico occurring in *C. sapidus* from southern Florida to Campeche (Hochberg et al. 1992, Alvarez and Calderón 1996) and in *C. rathbunae* from central Veracruz to Términos Lagoon, Campeche (Alvarez and Calderón 1996). *Loxothylacus texanus* has been reported outside the Gulf of Mexico in *Callinectes larvatus* in the Canal Zone, Panama (Boschma 1950), and in *C. sapidus* at 4 sites along the Caribbean coast of Colombia (Young and Campos 1988, Alvarez and Blain 1993).

A one year survey for *L. texanus* by monthly samplings of *C. rathbunae* and *C. sapidus* was conducted in Alvarado

Lagoon, southern Veracruz (Figure 1), to determine parasite prevalence levels, host species selectivity, host carapace width-weight variation, and distribution of number of parasites per host.

MATERIALS AND METHODS

Monthly samples (12) of *Callinectes* spp. from Alvarado Lagoon were examined from November 1995 to November 1996 (except October). Data were obtained from the catch of local fishermen. Their catch was collected and processed in the "Cooperativa Primero de Abril", in Alvarado, Veracruz. Crabs were identified, measured (carapace width), weighed, and sexed. Male crabs were classified as parasitized by *L. texanus* if they presented an abnormally shaped abdomen and atrophied first pleopods. Female crabs were considered parasitized if they presented atrophied pleopods with mature abdominal shape. Crabs of both genders were considered parasitized if they exhibited the parasite externa, or bore scars in the abdomen where externa had been attached. All crabs in which morphological modifications were detected, but which did not bear an externa were labeled as "feminized". When present, externa were counted and classified as immature (small, mantle opening not developed) or mature (full-sized, mantle opening fully developed). An average of 177 crabs was examined monthly.

Statistical analysis of data included: Student's *t*-test, analysis of variance (ANOVA), analysis of covariance (ANCOVA), G-test of independence, and Chi-square test. All crab sizes are reported in millimeters (mm) and weights in grams (g); mean values are followed by \pm one standard error.

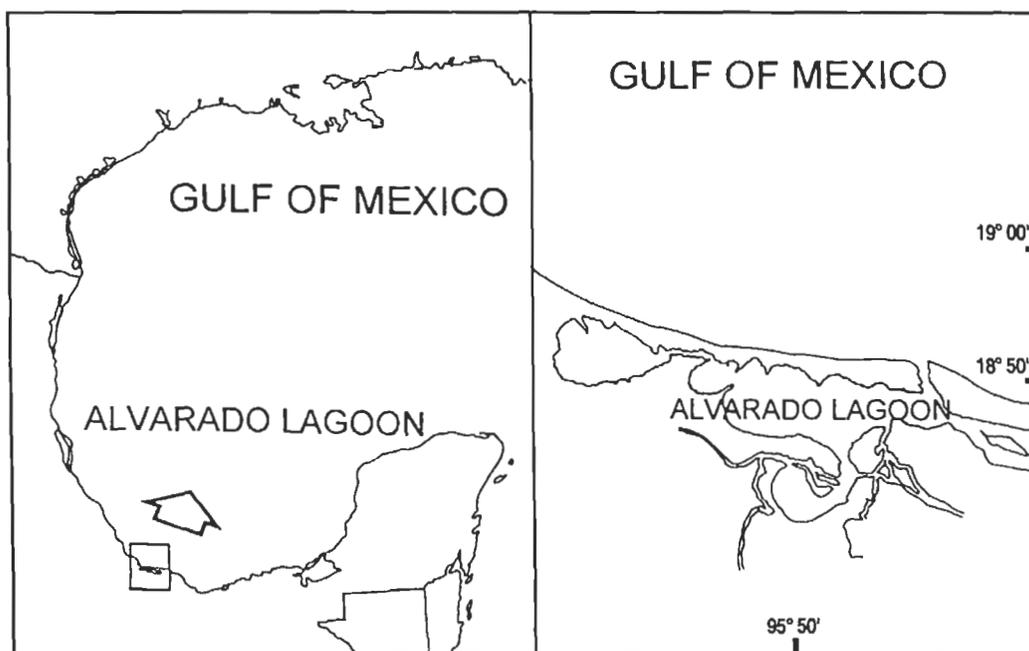


Figure 1. Location of Alvarado Lagoon, southern Veracruz.

RESULTS

A total of 2,132 crabs was examined, which included 668 *C. sapidus* and 1,464 *C. rathbunae*. Overall prevalences were 0.75% (5 crabs parasitized) in *C. sapidus* and 7.58% (111 crabs parasitized) in *C. rathbunae*. The 5 parasitized *C. sapidus* were collected in January (1), March (3), and November (1). Prevalence in *C. rathbunae* varied between 2% and 12% in ten of 12 collections; maximum prevalence was recorded in December (23.68%) whereas no parasitized crabs were collected in March (Figure 2).

One male and 4 female *C. sapidus* were found to be parasitized. Statistical analysis was not performed on this species due to small sample size. Parasitized *C. rathbunae* included 62 males and 49 females (1.26 males per female), while the unparasitized population was represented by 549 males and 804 females (1.46 females per male). Comparison of these values shows that the parasitized condition was not independent of sex (G-test, $P < 0.005$), and that males were parasitized more often than females.

Mean size of parasitized crabs varied significantly between host species (t-test). In *C. sapidus* the overall

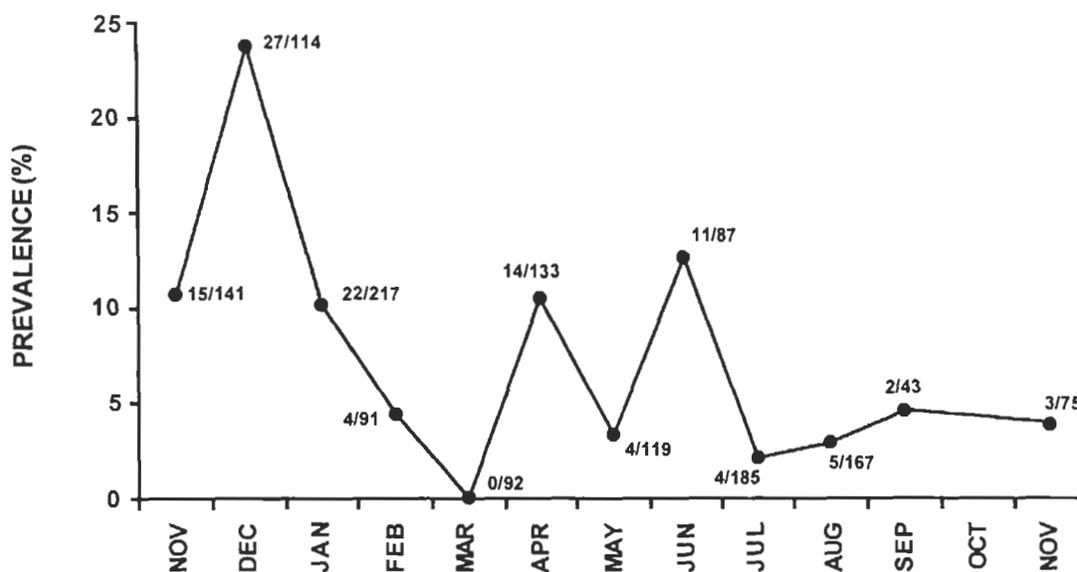


Figure 2. Prevalence of *Loxothylacus texanus* in *Callinectes rathbunae* from Alvarado Lagoon (1995-1996). Sample size indicated as number of parasitized crabs/total examined.

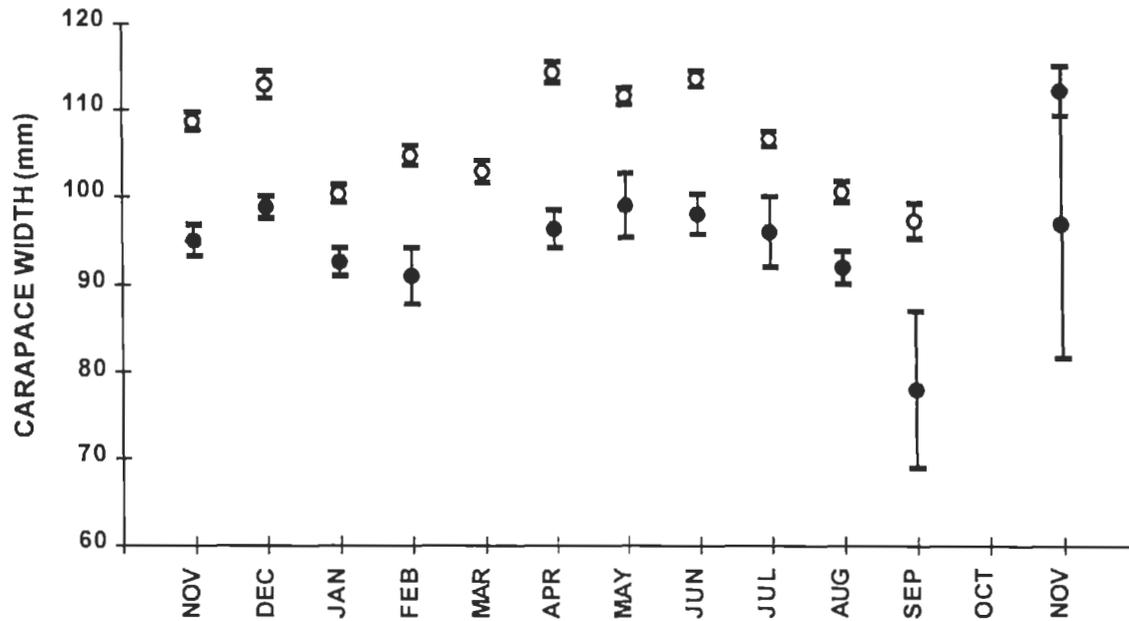


Figure 3. Mean size (CW) of parasitized (solid circles) and unparasitized (open circles) *Callinectes rathbunae* in Alvarado Lagoon (1995-1996); error bars represent \pm one standard error.

mean was 111.60 ± 6.01 mm ($n = 5$, range 92-130 mm), while in *C. rathbunae* it was 95.48 ± 0.80 mm ($n = 111$, range 69-122 mm). Due to the small number of parasitized *C. sapidus*, no further analyses were performed. Mean size for parasitized *C. rathbunae* was less than that of the unparasitized population (99 ± 3.61 mm in May to 78 ± 9.04 mm in September); however, no significant differences were encountered (ANOVA with months as treatments) (Figure 3). Mean size of parasitized male (94.25 ± 0.89 mm, $n = 60$, range 78-110 mm) and female crabs (97.02 ± 1.4 mm, $n = 49$, range 69-122 mm) did not differ statistically (t-test).

Carapace width-weight relationships for *C. rathbunae* were significant for both parasitized (% $y = 1.62 X - 100.46$, $n = 54$, $r = 0.68$, $P < 0.001$; & $y = 0.84 X - 25.95$, $n = 41$, $r = 0.46$, $P < 0.01$; Figure 4) and unparasitized crabs (% $y = 2.12 X - 143.55$, $n = 116$, $r = 0.93$, $P < 0.001$; & $y = 1.87 X - 125.23$, $n = 142$, $r = 0.93$, $P < 0.0001$; Figure 5). The slopes of 4 regressions (ANCOVA with carapace width as covariate, $F_{(1,185)} = 26.09$, $P < 0.0001$) were not homogeneous even when the weight values of the 4 categories of crabs overlapped extensively in the 80-110 mm of carapace width interval. Unparasitized males had the highest slope, followed respectively by unparasitized females, parasitized males, and parasitized females.

Of the 111 parasitized *C. rathbunae*, 19 (17.12%) were feminized (12 males and 7 females), and 92 (82.88%) bore externaenae (50 males and 42 females). The number of parasite externaenae per host varied from one to four: 64.86% had one, 14.41% had two, 2.7% had three, and 0.9% had four. The

observed pattern did not conform to a Poisson (random) distribution (Table 1) and may reflect an aggregated pattern since the observed frequencies of multiple externaenae are much higher than expected and the coefficient of dispersion is greater than one ($CD = 1.45$). Throughout the year, the relative frequencies of internal (feminized hosts), immature, and mature parasites did not seem to follow a defined pattern (Figure 6).

DISCUSSION

In Alvarado Lagoon, *C. rathbunae* was the main host for *L. texanus*, even though *C. sapidus* was locally abundant. *Callinectes rathbunae* was parasitized by *L. texanus* only south of Casitas, Veracruz (Alvarez and Calderón 1996). To the north, throughout roughly half of its distribution range, the *C. rathbunae* population was not found to carry *L. texanus*. Examination of collections of crabs from Tamiahua Lagoon, north of Casitas, has shown that while *L. texanus* prevalence in *C. sapidus* can reach 51.5%, no *C. rathbunae* are known to be parasitized in the area (Lázaro-Chávez et al. 1996). In contrast, in Alvarado Lagoon, only 5 *C. sapidus* were found parasitized throughout the present study, while prevalence in *C. rathbunae* reached 23.68%.

Most rhizocephalans exhibit a loose specificity, commonly parasitizing 2 or more closely-related host species, often of the same genus (Høeg 1995). Conditions that may promote new host species acquisition when a host species and a closely related potential host species

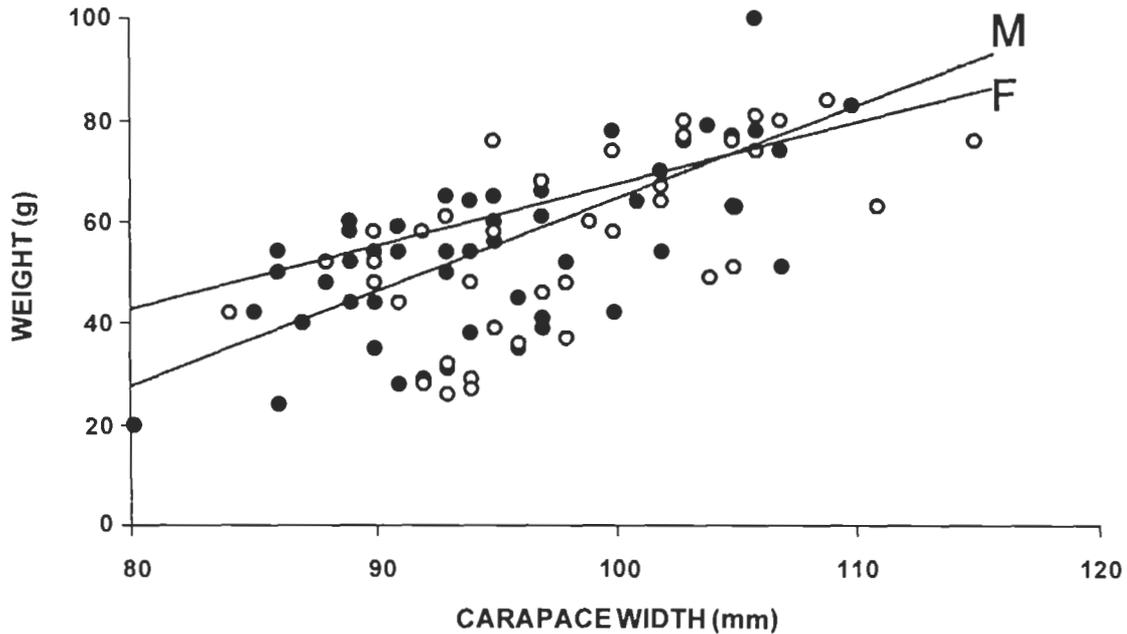


Figure 4. Carapace width-weight relationship of parasitized *Callinectes rathbunae* in Alvarado Lagoon (white circles = females, black circle = males).

occur sympatrically have not been explored. In *Loxothylacus panopaei*, which parasitizes 4 species of xanthid crabs along the east coast of North America, the differential levels of parasitization in each host species may be due to subtle differences in the spatial distribution within the estuary as well as to that of infective parasite larvae (Walker et al. 1992, Alvarez 1993). Within the Gulf of Mexico, the apparent abandonment by *L. texanus* of *C.*

sapidus and its subsequent acquisition of *C. rathbunae* cannot be explained with the available data. However, the observed pattern could also be the result of *L. texanus* parasitizing the less desirable *C. sapidus* where *C. rathbunae* is not available.

Loxothylacus texanus occurs outside the Gulf of Mexico southward to Colombia (Young and Campos 1988, Alvarez and Blain 1993). In Panama, *C. larvatus* has been

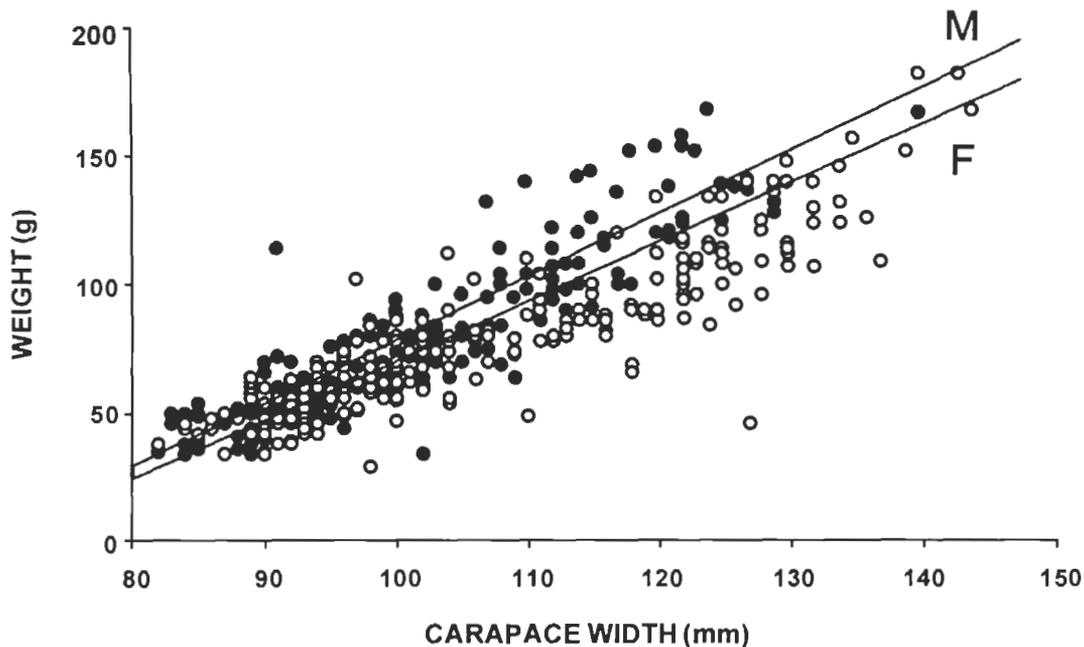


Figure 5. Carapace width-weight relationship of unparasitized *Callinectes rathbunae* in Alvarado Lagoon (white circles = females, black circles = males).

TABLE 1

Distribution of externae of *Loxothylacus texanus* in 1,445 *Callinectes rathbunae* from Alvarado Lagoon. Feminized crabs (n = 19) with no externae are not included. Observed frequencies are compared (Chi-square test) to the expected frequencies of a Poisson (random) distribution.

Number of externae per host	Observed frequencies	Expected frequencies	(O - E) ² /E
0	1,353	1,332.61	0.312
1	72	107.94	11.966
2	16	4.37	30.951
3	3	0.118	70.38
4	1	0.0024	414.669
Total	1,445	1,445.04	$\chi^2 = 528.288, p < 0.0001$

reported as a host species for *L. texanus* (Boschma 1950); unfortunately no other data from the region are available, and the parasitization of other species of *Callinectes* by *L. texanus* cannot be ruled out.

As has been reported in other studies on blue crabs parasitized by *L. texanus* in the Gulf of Mexico, in Alvarado Lagoon there is significant variation in prevalence throughout the annual cycle. This is probably due to the varying intensity of host recruitment synchronized with high temperatures and the parasite's reproductive activity

(Hochberg et al. 1992, Lázaro-Chávez et al. 1996). Maximum prevalences of *L. texanus* in Alvarado Lagoon (3.09% in *C. sapidus* and 23.68% in *C. rathbunae*) are low and intermediate, respectively, compared to those from other reports from the Gulf of Mexico (Table 2). Mean prevalence of *L. texanus* in *C. sapidus* in the present study is extremely low (0.5%), while in *C. rathbunae* it can be considered high (6.28%). The size ranges of parasitized crabs of both host species in Alvarado Lagoon are intermediate between the smaller parasitized crabs from Louisiana and Texas and

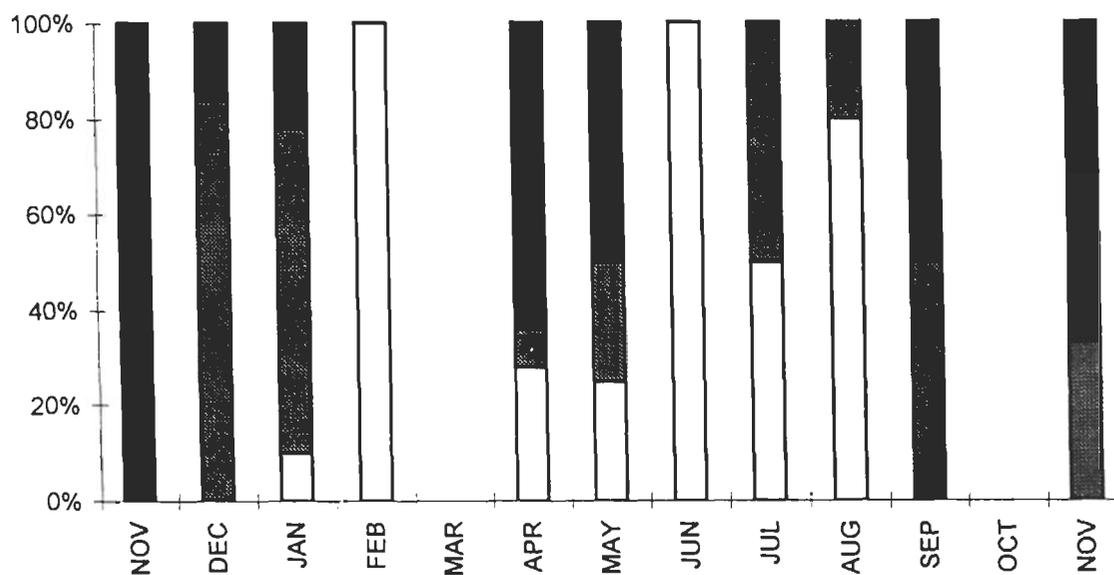


Figure 6. Frequency distribution of *Loxothylacus texanus* in *Callinectes rathbunae* by developmental stage: white bars represent internal parasites (feminized hosts), gray bars represent immature parasites, and black bars represent mature externae. In March 1996, no parasitized crabs were found in the sample. In October 1996, no sample was taken.

TABLE 2

Mean and maximum *Loxothylacus texanus* prevalence and host size range variation of *Callinectes sapidus* and *Callinectes rathbunae* in the Gulf of Mexico; only externa bearing crabs are considered.

Authority	Locality	Host Species	Mean prevalence (%) \pm 1 s.d.	Maximum prevalence (%)	Host size range (mm)
Adkins, 1972	Louisiana, USA	<i>C. sapidus</i>	4.83 \pm 4.8	17.10	30-95
Wardle and Tirpak, 1991	Galveston, Texas, USA	<i>C. sapidus</i>	8.22 \pm 13.7	53.00	43-100
Hochberg et al., 1992	west coast of Florida, USA	<i>C. sapidus</i>	1.40 \pm 1.3	5.10	35-170
Lázaro-Chávez et al., 1996	Tamiahua Lagoon, Mexico	<i>C. sapidus</i>	17.6 \pm 19.7	51.50	45-115
Present study	Alvarado Lagoon, Mexico	<i>C. sapidus</i>	0.50 \pm 1.06	3.09	95-130
Present study	Alvarado Lagoon, Mexico	<i>C. rathbunae</i>	6.28 \pm 6.51	23.68	69-122

the large parasitized individuals found in Florida (Table 2). No pattern of variation associated with geographic distribution is apparent, except that the smallest parasitized crabs occur in the northern Gulf of Mexico.

Although an abnormal abdominal shape combined with atrophied pleopods in *C. sapidus* and *C. rathbunae* are unmistakable signs of parasitization by *L. texanus*, reported prevalence values are mostly based on externa-bearing crabs (Reinhard 1950, Alvarez and Calderón 1996). In Alvarado Lagoon 17.12% of all parasitized crabs showed signs of parasitization but did not bear externa, and were classified as feminized, while in Tamiahua Lagoon, almost half (48%) of all parasitized crabs were feminized (Lázaro-Chávez et al. 1996). These 2 studies show that the margin of error of prevalence estimates that do not consider feminized crabs can be considerable.

The sex ratio of parasitized *C. rathbunae* in Alvarado Lagoon suggests that males are preferentially parasitized. No explanation for this biased sex ratio is apparent, since there is no evidence that infective female cyprid larvae show any selective behavior, at least in *L. panopaei* (Alvarez et al. 1995). In contrast, in Tamiahua Lagoon, although males were more abundant, female *C. sapidus* were parasitized more often (Lázaro-Chávez et al. 1996).

The number of *C. rathbunae* with multiple externa of *L. texanus* occurred in a higher proportion than expected under a random distribution. No mechanism other than chance encounters between infective cyprid larvae and susceptible hosts is currently known to determine the number of parasite externa that emerge from a single host (Walker et al. 1992).

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