

LENGTH-WEIGHT RELATIONSHIPS OF BLUE, *PARALITHODES PLATYPUS*, AND GOLDEN, *LITHODES AEQUISPINA*, KING CRABS PARASITIZED BY THE RHIZOCEPHALAN, *BRIAROSACCUS CALLOSUS* BOSCHMA

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ABSTRACT

Length-weight relationships and condition factors of nonparasitized blue king crabs, *Paralithodes platypus*, and golden king crabs, *Lithodes aequispina*, in southeastern Alaska were compared with crabs parasitized by the rhizocephalan, *Briarosaccus callosus*. Species, sex, and shell condition were considered in all analyses. Parasitized male blue king crabs and parasitized male golden king crabs weighed significantly less than nonparasitized individuals. Golden king crabs may be more resistant to infection and the effects of *B. callosus* parasitism than blue king crabs. They had a lower prevalence of infection, and the percent difference between the body mass of parasitized and nonparasitized crabs was considerably less. In both crab hosts the prevalence of infection was greater in samples where sublegal or smaller size classes of adults were included in analyses, suggesting that crab growth was reduced by the parasite.

A parasite of lithodid crab species in Alaska is the rhizocephalan barnacle, *Briarosaccus callosus* Boschma (Boschma and Haynes 1969; Boschma 1970; McMullen and Yoshihara 1970; Somerton 1981; Hawkes et al. 1985). The parasite's distribution in Alaskan waters, its life history, and its effects on king crab hosts are almost unknown except that parasitized crabs become castrated (Boschma and Haynes 1969; McMullen and Yoshihara 1970). The prevalence of this barnacle parasite varies between areas and species and is especially high in southeastern Alaska. Parasitism by *B. callosus* might decrease the productivity of king crab stocks through sterilization and may also reduce crab growth rates. Therefore, parasitized crabs of the same size as nonparasitized crabs may weigh less. In this study we examined the influence of *B. callosus* on the length-weight relationships and condition factors of parasitized and nonparasitized blue king crab, *Paralithodes platypus*, and golden king crab, *Lithodes aequispina*.

MATERIALS AND METHODS

Two methods were used to compare the growth of parasitized and nonparasitized crabs. A Fulton's condition factor ($w/l^3 \times 10^{-4}$, where w = weight in grams and l = carapace length in mm) was used for

comparing different individuals of the same species (Ricker 1975). This method assumes that all body parts grow isometrically. The second method used for comparison assumes allometric growth, where different body parts grow at different rates. Constants were determined empirically by linear regression using the model, $w = AL^B$, and logarithms of the carapace lengths and body weights (Everhart et al. 1976, p. 70-71). The length-weight relationships of parasitized and nonparasitized crabs were compared with analysis of covariance (ANCOVA). All mean values (\bar{X}) are given ± 1 standard deviation. Probabilities <0.05 are considered significant and those <0.01 are considered highly significant.

The analysis of length-weight relationships was based on wet weights taken in the field (nearest 25 g) and in the laboratory (nearest gram). Crabs with missing or partially regenerated appendages were not weighed. Carapace lengths were measured to the nearest 1 mm (Wallace et al. 1949). Shell condition was classified according to a four point scale (Somerton and MacIntosh 1983). A new shell condition is found in crabs that have recently molted, and skipmolt crabs are those that have not molted within the last year. Skipmolts or old shell crabs were identified by worn spines and dactyl tips and accumulations of shell epifauna. Infections were diagnosed grossly by the presence of externae or scars, indicative of lost externae. A scar is a short chitinous brown pedicel from which an externa was attached and protrudes from underneath the abdomen.

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Blue King Crab

Male and female blue king crab of various sizes from Muir and Adams Inlets in Glacier Bay (Fig. 1) were measured, weighed, and examined for *B. callosus* by the authors in March 1984. Commercial gear was used but with modified escape ports to prevent loss of juvenile crabs. Data on large male blue king crabs from Lynn Canal and Glacier Bay were also gathered at dockside areas before sale to processors or the public. Since state regulations for southeastern Alaska restrict the commercial harvest of blue king crabs to males ≥ 165 mm in carapace width, all commercial samples, therefore, excluded females and smaller adult males.

Golden King Crabs

Male and female golden king crabs of various sizes

were collected by the authors from Lynn Canal near Haines, AK (Fig. 1), using standard pot gear in May 1984. Commercial catches in November 1983 provided legal sized (≥ 178 mm carapace width) males.

RESULTS

The prevalences of *B. callosus* in the commercial catches of male blue king crabs were 6.3% and 11.6% for Lynn Canal and Glacier Bay, respectively. Samples from Glacier Bay, which contained males and females of all sizes, had a prevalence of 76%. The prevalence in varisized male and female *L. aequispina* collected from the Haines area was 20%.

Linear length-weight relationships of log transformed data best defined our data, since no trends were present in the residuals (differences between predicted lines and actual data) of parasitized or non-parasitized crabs.

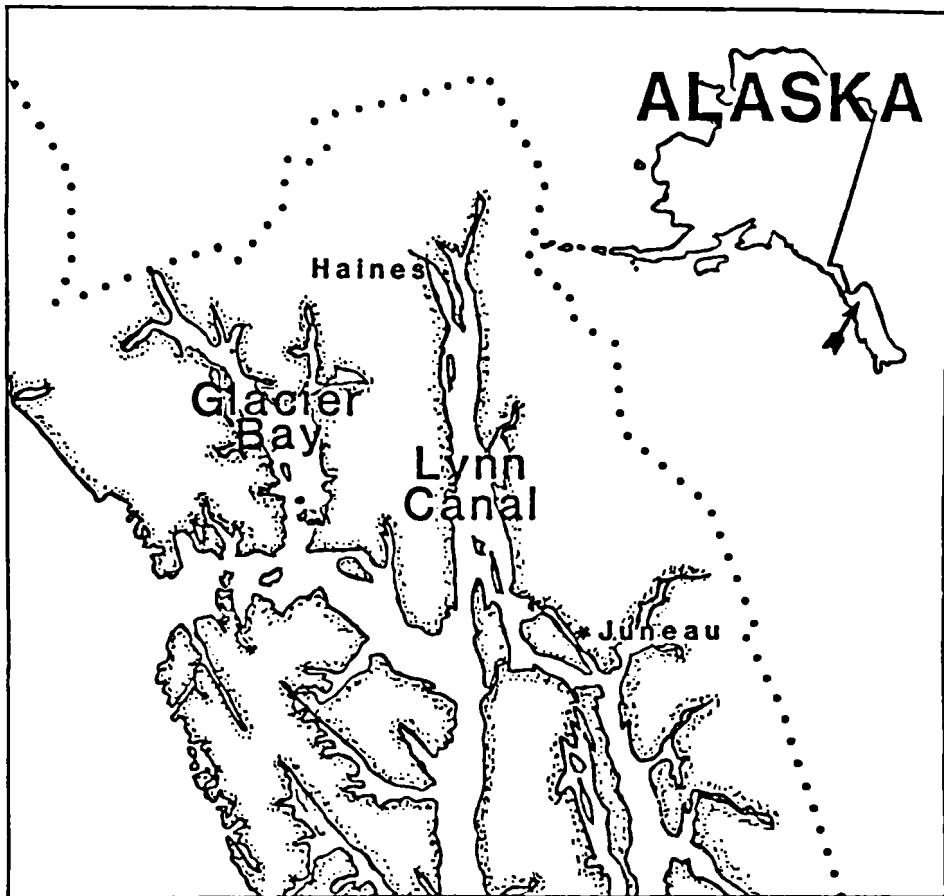


FIGURE 1.—Sampling sites of blue, *Paralithodes platypus*, and golden, *Lithodes aequispina*, king crabs in southeastern Alaska.

Blue King Crab

Glacier Bay and Lynn Canal blue king crab data were pooled. The populations were considered to be identical because the two groups were regarded as having the same linear relationship (ANCOVA). Smaller crabs (<134 mm in carapace length) not common to data sets from both areas and skipmolts were eliminated from this analysis.

Significantly (chi-square test) more skipmolts were found among the nonparasitized crabs (45/237) than the parasitized crabs (9/131). Because skipmolts tend to be heavier than new shell crabs (Somerton and MacIntosh 1983), skipmolting was analyzed as a possible source of bias. In male blue king crabs the new shell crabs had a higher mean weight than the skipmolts at greater carapace lengths, while the skipmolts had a higher mean weight at the smaller lengths (Fig. 2). Although individual linear relationships did not describe the data as well as a common line, the skipmolts were eliminated from further analyses of both blue and golden king crab data.

Subsequently, in the length-weight relationships of male blue king crabs pooled from both areas, with small crabs represented in each group, the nonparasitized crabs were heavier at a highly significant level than the parasitized crabs (ANCOVA) (Fig. 3). Non-

parasitized males were 8.7% heavier than parasitized crabs. Nonparasitized male blue king crabs also had a significantly (*t*-test) higher condition factor (8.5 ± 0.8) than parasitized crabs (7.2 ± 0.6), indicating that nonparasitized crabs were heavier for a given length. Condition factor did not vary with size in nonparasitized blue king crabs but the slope was significant and negative for the parasitized crabs. This indicates that the condition factor of parasitized blue king crabs decreased with increased size.

Only five nonparasitized female blue king crabs were available for length-weight relationships and condition factor comparisons. More samples are needed for further analysis of female blue king crabs.

Golden King Crabs

Males with carapace lengths common to both parasitized and nonparasitized crabs, 117 to 159 mm, provided linear relationships that were parallel and significantly different (Fig. 4). *Briarosaccus callosus* was not present in any of the large commercial-size crabs sampled in 1983; therefore, these samples were excluded from analysis. The percent weight difference between parasitized and nonparasitized male golden king crabs was about 2.6%. Weight conversion in parasitized male *P. platypus* of similar sizes

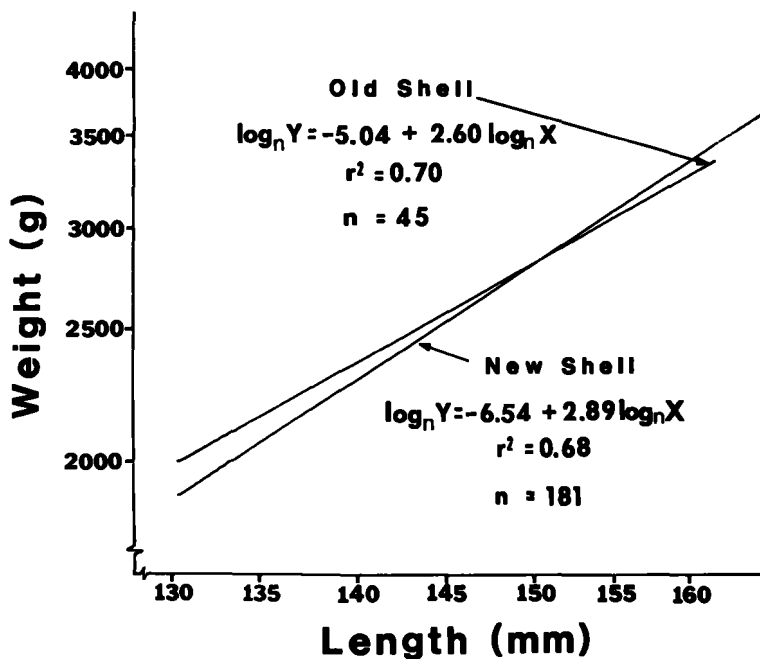


FIGURE 2.—Length-weight linear relationships of new shell and skipmolt nonparasitized male *Paralithodes platypus*.

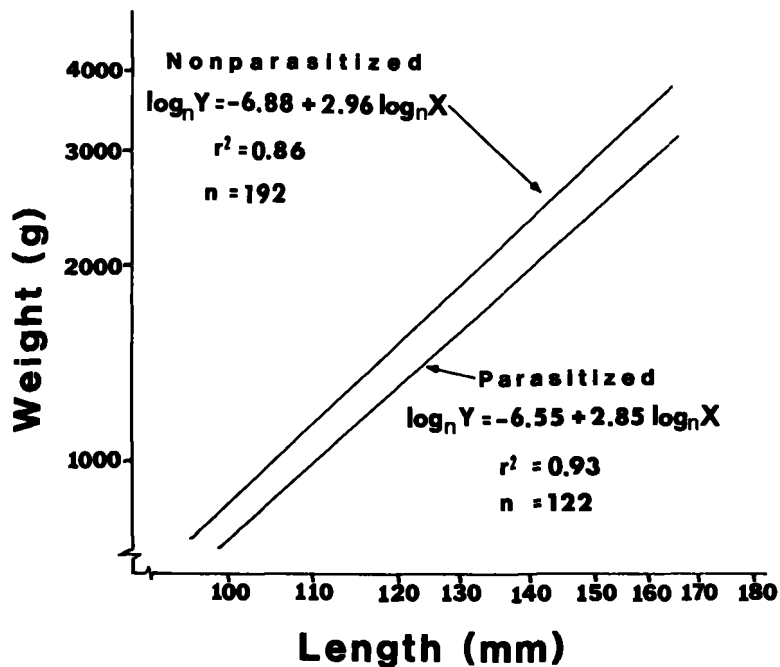


FIGURE 3.—Length-weight linear relationships of parasitized and nonparasitized male *Paralithodes platypus* with skipmolts eliminated.

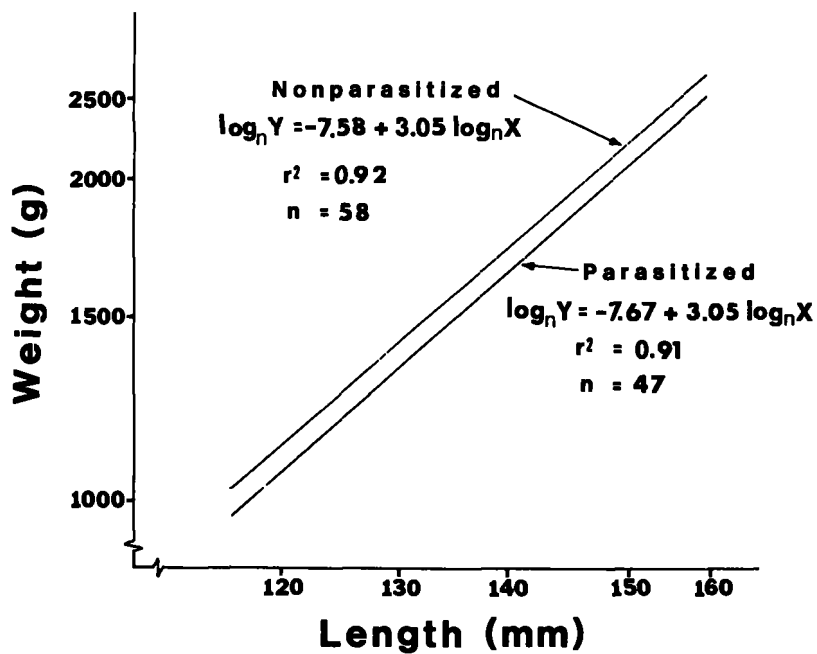


FIGURE 4.—Length-weight linear relationships of parasitized and nonparasitized male *Lithodes aequispina* after elimination of 1983 data.

was inhibited considerably more than in parasitized male *L. aequispina*. The condition factor for nonparasitized male *L. aequispina* (6.5 ± 0.5) was also greater at a highly significant level than for male parasitized crabs (6.1 ± 0.4). The condition factor in parasitized and nonparasitized male golden king crabs did not vary significantly with size.

Nonparasitized female *L. aequispina* ($n = 77$) were heavier than parasitized females ($n = 43$) over most of the length range. The linear relationships were significantly different but not parallel, preventing a comparison of the intercepts. Condition factors were not significantly different between the parasitized (5.9 ± 0.5) and nonparasitized (5.7 ± 0.4) females. Condition factors varied significantly with size and in the nonparasitized crabs but not in the parasitized crabs.

DISCUSSION

Weights and, consequently, condition factors were significantly lower in male blue and golden king crabs parasitized by *B. callosus*. A difference in mean weight was also present in female blue king crabs that were parasitized, although an adequate comparable sample size of nonparasitized females was not available. The prevalence of the parasite was considerably greater in king crab populations where sub-legal or smaller size classes of adult crabs were included in the sample number. In blue king crabs from Glacier Bay, the inclusion of females in the sample also raised prevalence figures since females had a significantly higher prevalence of barnacle parasitism than male crabs. A potential reason for increased barnacle prevalence in smaller crabs could include differential mortality such that fewer parasitized crabs survive to larger size classes. Other explanations include reduced molting frequencies, reduced number of instars and/or reduced growth represented by a reduction in relative molt increment (Hawkes et al. in press). However, reduced weights in parasitized crabs within the same size classes as nonparasitized individuals suggest that growth of the host crab is decreased by *B. callosus*. The higher parasite prevalence in smaller crabs also supports this conclusion.

Parasitized crabs may develop significantly less body tissue after molting, which is likely to be a cumulative effect occurring over more than one season. Although the complete life history of *B. callosus* is unknown, other species of Rhizocephala are known to require at least 9 to 12 mo to reach reproductive maturity and develop an externa in host crabs (Ritchie and Høeg 1981). In males that be-

come castrated and weight loss of testes is insignificant in total body mass (0.2%) and does not account for the weight difference observed. Also testes weigh less than the interna and externa of the parasite. In female king crabs a considerable amount of the wet body weight can be attributed to the egg clutch and ovaries. Consequently, gonadal atrophy, nonovigerous conditions and reduced somatic growth rates all may account for the lesser weights observed in parasitized female king crabs.

The percentages of weight difference between parasitized and nonparasitized males was considerably different between the two species of king crabs. Golden king crab was less affected by the parasite, sustaining less growth inhibition due to barnacle parasitism than parasitized blue king crabs. Parasitized golden king crabs have significantly higher hemolymph protein concentrations in comparison to either their nonparasitized conspecifics or parasitized blue king crabs. The additional protein may be attributed to the presence of lectins, specific carbohydrate-binding proteins suspected of playing a role in crustacean immunity (Shirley et al. 1985).

If we are correct, reduced crab growth as an effect of *B. callosus* parasitism would conflict with data from other peltogastrid rhizocephalans (O'Brien and Van Wyk 1985). Other rhizocephalan species tend to be more prevalent on larger crab hosts, making enhanced growth or enhanced survivorship a plausible effect of parasitism. Another explanation is that parasitized crabs have less somatic growth and, as a result, have fewer molts. Molting is a time of greatest mortality for most decapods, and those with lower molting frequencies would have greater survival. The probability of infection may also be greater in certain size classes. Behavioral differences or sampling bias could affect the parasite's relative frequency within the host population. Sacculinidae appear to be distributed differently within host populations (O'Brien and Van Wyk 1985). *Pugettia producta* is a majid crab from California and does not molt after reaching maturity. When parasitized by the rhizocephalan *Heterosaccus californicus*, there is no significant effect on molt increments of juveniles and the pubertal molt increment is not affected in adults. However, *P. producta* that are parasitized pass through fewer instars before reaching maturity, and the mean size of these individuals is significantly less than in nonparasitized crabs (O'Brien 1984). Blue crabs, *Callinectes sapidus*, also have retarded growth when parasitized by *Loxothylacus texanus*, with most adults appearing as miniature adult females (Overstreet 1978).

Prevalence of the parasite as a function of host size and field length-weight comparisons are still only indirect measurements of host growth. Consequently, further laboratory studies measuring growth directly in parasitized king crabs are needed to positively prove our hypothesis.

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