

# DISTRIBUTION AND PREVALENCE RECORDS OF TWO PARASITIC BARNACLES (CRUSTACEA: CIRRIPIEDIA: RHIZOCEPHALA) FROM THE WEST COAST OF NORTH AMERICA

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## ABSTRACT

New records of rhizocephalan barnacles from the Mexican Pacific are presented. The distribution ranges of *Lernaeodiscus porcellanae* (Lernaeodiscidae) and *Heterosaccus californicus* (Sacculinidae) and their host species are revised. In both cases, the parasites occur in only a fraction of the total geographic range of their hosts. *Lernaeodiscus porcellanae* was found only in the porcellanid crab *Petrolisthes cabrilloi* from Laguna Beach, California to San Quintin, Baja California; while *H. californicus* ranged from Bodega Bay, California to Cedros Island, Baja California parasitizing (from north to south) the majid crabs *Pugettia producta*, *Loxorhynchus grandis*, *L. crispatus*, and *Taliepus nuttallii*. Prevalence records are presented for *Lernaeodiscus porcellanae* and for *H. californicus* parasitizing *P. producta*; in both cases considerable geographical and temporal variation was found.

Rhizocephalan barnacles are extremely specialized cirripedes. All are parasites of other crustaceans, and almost exclusively marine (Høeg and Lützen, 1995). Rhizocephalans induce profound effects upon their hosts. They interfere with host reproduction, for example, causing permanent sterilization (Høeg, 1995). Thus, parasitization by rhizocephalans can have significant negative effects on populations of commercially important species (e.g., Shields and Woods, 1993; Alvarez et al., 1999).

Elucidation of areas of distribution and number of host species is necessary to understand how rhizocephalans achieve stable host-parasite associations, even when they have a negative impact upon host reproduction (Hines et al., 1997). Data on prevalence variation and the distribution pattern of species that parasitize hosts that are not commercially important are extremely scarce. However, this kind of information can be very valuable when determining whether range expansions or acquisition of a new host species has occurred (Hines et al., 1997).

Recent collecting efforts along the west coast of Baja California, as well as the revision of unpublished data coming from several sources, have produced new information on the distribution and prevalence variation of the rhizocephalan barnacles *Lernaeodiscus porcellanae* Müller, 1862 and *Heterosaccus californicus* Boschma, 1933. The two species represent two different families, Lernaeodiscidae Boschma, 1928, and Sacculinidae Lilljeborg, 1860, both within the suborder Kentrogonida Delage, 1884.

The specimens collected in the recent collecting trips have been deposited in the Colección de Invertebrados, Facultad de Ciencias, Universidad Autónoma de Baja California (UABC, uncatalogued), Ensenada, Baja California, Mexico, and in the Colección Nacional de Crustáceos (CNCR), Instituto de Biología, Universidad Nacional Autónoma de México. Prevalence estimates were obtained only from adult hosts. Statistical analysis included the G-test of independence to determine if sex ratio of parasitized crabs differed from that of the unparasitized population. Abbreviations used are: CW or CL, carapace

width or length of host crabs, respectively, and W, for parasite's externa width. Mean values are followed by one standard deviation.

## RESULTS

Order Rhizocephala Müller, 1862  
Suborder Kentrogonida Delage, 1884  
Family Lernaediscidae Boschma, 1928  
*Lernaediscus porcellanae* Müller, 1862

*Previous distribution and hosts.*—Infecting the porcellanid crab *Petrolisthes cabrilloi* from Laguna Beach (33°33'N, 117°47'W), California, USA, to San Quintín, Baja California, Mexico (30°23'N, 115°59'W) (Høeg and Ritchie, 1985).

*Material examined.*—38 externae, Granada Cove Beach (31°52'N, 116°40'W), Ensenada, Baja California, Mexico; coll. E. Campos, March 1996; infecting *P. cabrilloi* (UABC). 11 externae, El Rincón Beach (31°43'N, 116°40'W), Ensenada, Baja California, Mexico; coll. E. Campos, March 1996; infecting *P. cabrilloi* (CNCR 17991).

In addition, we analyze and discuss the data derived from the following specimens, although we did not have access to the actual samples. 930 externae, Bird Rock (32°52'N, 117°19'W), La Jolla, California, USA; coll. L. Ritchie, November 1973–November 1975; infecting *P. cabrilloi*. 401 externae, Dike Rock (32°55'N, 117°18'W), La Jolla, California, USA; coll. L. Ritchie, June 1972–October 1975; infecting *P. cabrilloi*. 152 externae, Scripps Institution of Oceanography (SIO) Pier (32°54'N, 117°18'W), La Jolla, California, USA; coll. L. Ritchie, December 1971–March 1974; infecting *P. cabrilloi*. 91 externae, Ensenada Bay (31°53'N, 116°37'W), Ensenada, Baja California, Mexico; coll. L. Ritchie, December 1971–October 1974; infecting *P. cabrilloi*.

*Prevalence records.*—Prevalence of *L. porcellanae* varied considerably in space and time along the coasts of California and Baja California. From north to south, at Dike Rock, La Jolla where a total of 4531 crabs was examined from 28 monthly samples, prevalence fluctuated from 5.6% to 17.9% ( $\bar{x} = 9.69\% \pm 3.94\%$ ) without a defined pattern (Fig. 1). It is interesting to note that hosts with multiple parasite externae were never collected at this site and that 8.45% of parasitized crabs were scarred individuals. The proportion of male and female parasitized crabs did not differ from that of the unparasitized population (G-test,  $\chi^2 = 3.75$ ,  $P > 0.05$ ).

At Bird Rock, La Jolla, prevalence varied from 6.1% to 66.7% ( $\bar{x} = 35.22\% \pm 14.5\%$ ) in the 21 monthly samples examined containing 2657 crabs. Except for the period between February–April 1973, in the remaining 18 samples prevalence was higher than 25% (Fig. 2). At this site 2.7% of parasitized crabs bore multiple externae and 6.67% were scarred crabs. A significantly biased sex ratio of parasitized crabs was found with 45.7% of females parasitized versus only 28.2% of males (G-test,  $\chi^2 = 84.5$ ,  $P < 0.0001$ ).

Prevalence values from SIO Pier, obtained from 13 monthly samples totaling 3811 crabs, ranged between 0.8% and 13.9% ( $\bar{x} = 6.23\% \pm 4.0\%$ ) (Fig. 3). Only 1 out of the 3811 crabs collected at this site presented multiple externae and 6.58% were scarred. The sex ratio of parasitized crabs was the same as that of the unparasitized population (G-test,  $\chi^2 = 0.025$ ,  $P > 0.05$ ).

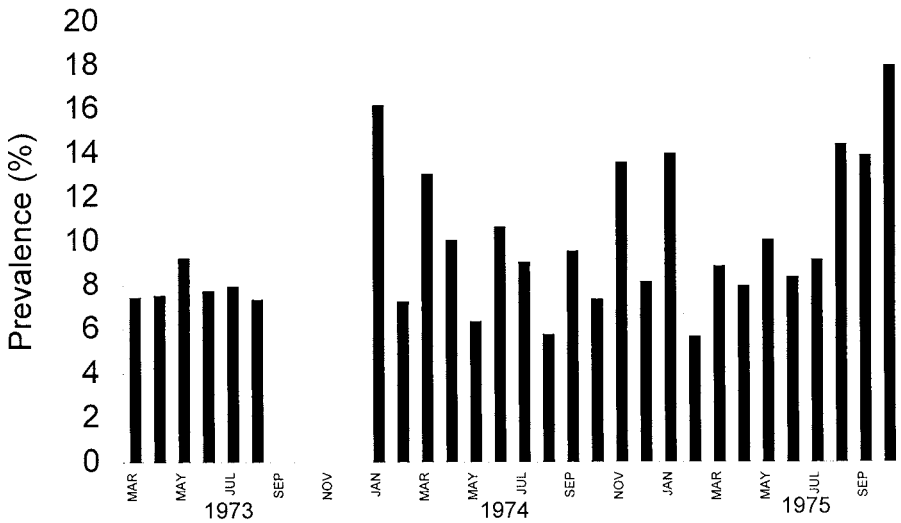


Figure 1. Prevalence variation of *Lernaediscus porcellanae* parasitizing *Petrolisthes cabrilloi* at Dike Rock, La Jolla, California, in the period 1973–1975. Months without bars correspond to samples not taken.

Two data sets exist from Bahía de Todos Santos, Baja California: records collected by L. Ritchie (1971–1974) from Ensenada, and the recent collection (1996) made by one of us (EC) from Granada Cove and El Rincón Beach. Prevalence values in the first data set (9 samples, 938 crabs) ranged from 1.6% to 23.4% ( $\bar{x}$  = 9.94%  $\pm$  6.2%). No multiple externae were found and 4.4% of parasitized crabs were scarred. In March 1996, *L. porcellanae* prevalence ranged from 15% ( $n$  = 250) at Granada Cove to 6.7% ( $n$  = 165) at

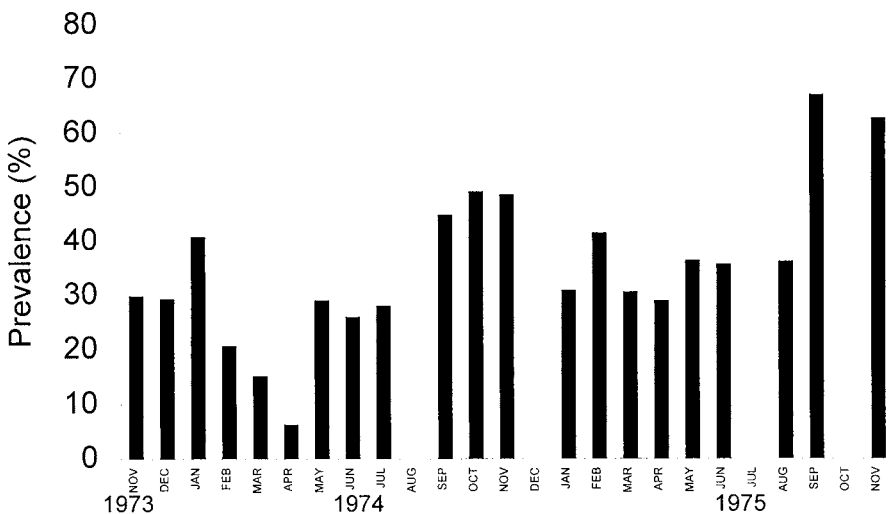


Figure 2. Prevalence variation of *Lernaediscus porcellanae* parasitizing *Petrolisthes cabrilloi* at Bird Rock, La Jolla, California, in the period 1973–1975. Months without bars correspond to samples not taken.

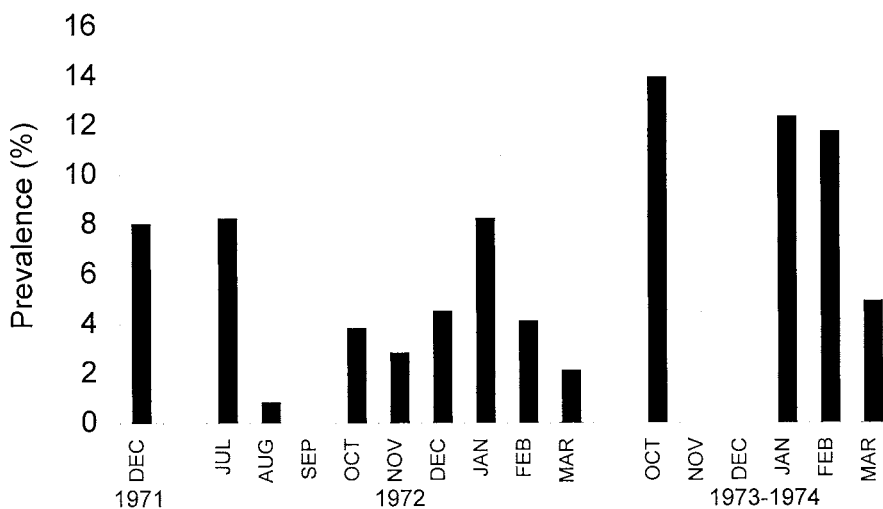


Figure 3. Prevalence variation of *Lernaediscus porcellanae* parasitizing *Petrolisthes cabrilloi* at SIO pier, La Jolla, California, in the period 1971–1974. Months without bars correspond to samples not taken

El Rincón Beach. Size range of parasitized *P. cabrilloi* varied from 3.7 mm to 8.9 mm CW ( $\bar{x} = 5.94 \pm 1.5$  mm CW).

*Remarks.*—The geographic range of *P. cabrilloi* extends from Morro Bay, California to Bahía de Magdalena, Baja California (Garth and Abbott, 1980), about 1033 km; whereas *L. porcellanae* ranges from Laguna Beach, California to San Quintín, Baja California, a distance of approximately 400 km.

The identity of *L. porcellanae* from the California and Baja California coasts is still uncertain. Müller (1862) described *L. porcellanae* from an unidentified host from the coast of southern Brazil; Reinhard (1950) recorded *L. porcellanae* from North Carolina parasitizing *Petrolisthes galathinus*, and finally Boschma (1969) recorded it from the Pacific coast of the United States, from the SIO Pier, but parasitizing *P. eriomerus* not *P. cabrilloi*. Since Boschma's (1969) paper, it has been assumed that *L. porcellanae* is the parasite of *P. cabrilloi* along the California–Baja California coasts. However, at least two questions arise from the above information. Is it the same *Lernaediscus* species that is parasitizing four species of hosts in both the Pacific and Atlantic oceans, as well as in the northern and southern hemispheres? Did Boschma (1969) misidentify *P. cabrilloi*, recognizing it as *P. eriomerus*, since after extensive collections for many years in the area (12,352 crabs examined) *P. cabrilloi* is the only porcellanid crab that has been found parasitized by a rhizocephalan? Future comparative studies of the different populations now recognized as *L. porcellanae* may demonstrate the existence of several different species of *Lernaediscus*.

Table 1. Prevalences of *Heterosaccus californicus* parasitizing the majid crab *Pugettia producta* along the west coast of North America, localities are arranged from north to south.

Locality	Prevalence (%)	n
Bodega Bay	1	103
Monterey Bay	3	≥ 100*
Cayucos	5	87
Montana de Oro	8	53
Sunset Palisades	5	167
Hollister Ranch	33	179
Coal Oil Point	19	3,855
Laguna Beach	8	25

\* Prevalence for Monterey Bay was estimated by combining data from Boolootian et al. (1959) and from collections made by A. Hines (unpubl.).

Family Sacculinidae Lilljeborg, 1860  
*Heterosaccus californicus* Boschma, 1933

*Previous distribution and hosts.*—Bodega Bay to San Diego, California, USA; parasitizing the spider crabs *Loxorhynchus grandis* Stimpson, 1857; *L. crispatus* Stimpson, 1857; *Pugettia producta* Randall, 1839; and *Taliepus nuttallii* Randall, 1839 (Garth and Abbott, 1980; O'Brien, 1984).

*Material examined.*—1 externa, Hollister Ranch, California, USA; coll. J. O'Brien, 2 November 1982; infecting *Taliepus nuttallii* (68 mm CL). 1 externa (25 mm W), Punta Norte, Cedros Island (28°22'N, 115°5'W), Baja California, Mexico; coll. E. Campos, 6 January 1987; infecting *T. nuttallii* (69 mm CL).

*Prevalence records.*—Reported prevalence levels of *H. californicus* parasitizing *P. producta* vary markedly among sites from Bodega Bay to Laguna Beach, with the highest values in the southern portion of their common range in Hollister Ranch (33%) and Coal Oil Point (19%) (Table 1). Santa Cruz Island was the only collecting site from which a sizable number (>25) of potential (i.e., adult *P. producta*) hosts were collected, but no parasites were observed. Data on the geographical variation of prevalence on the other host species are unavailable.

*Remarks.*—The present record extends the known range of *H. californicus* to a total of 1310 km from Bodega Bay, California to Cedros Island, Baja California. Extensive collections in Oregon and Washington have never produced any parasitized crabs (Kozloff pers. comm. to O'Brien), suggesting that Bodega Bay could be the northern limit of the parasite. *H. californicus* parasitizes *Pugettia producta* from Bodega Bay to Laguna Beach; occurring to the south only in the other three host species, in *Loxorhynchus grandis* in Corona del Mar, in *L. crispatus* in San Diego, and in *T. nuttallii* (Hollister Ranch, California to Cedros Island, Baja California). It is noteworthy that although almost one in five adult *P. producta* were parasitized by *H. californicus* on the mainland site of Coal Oil Point, *P. producta* populations on nearby Santa Cruz Island were not parasitized (n = 69).

Many other reports that may refer to *H. californicus* are inconclusive since they refer to rhizocephalans as "sacculina" (Boschma, 1933, 1950; MacGinitie and MacGinitie,

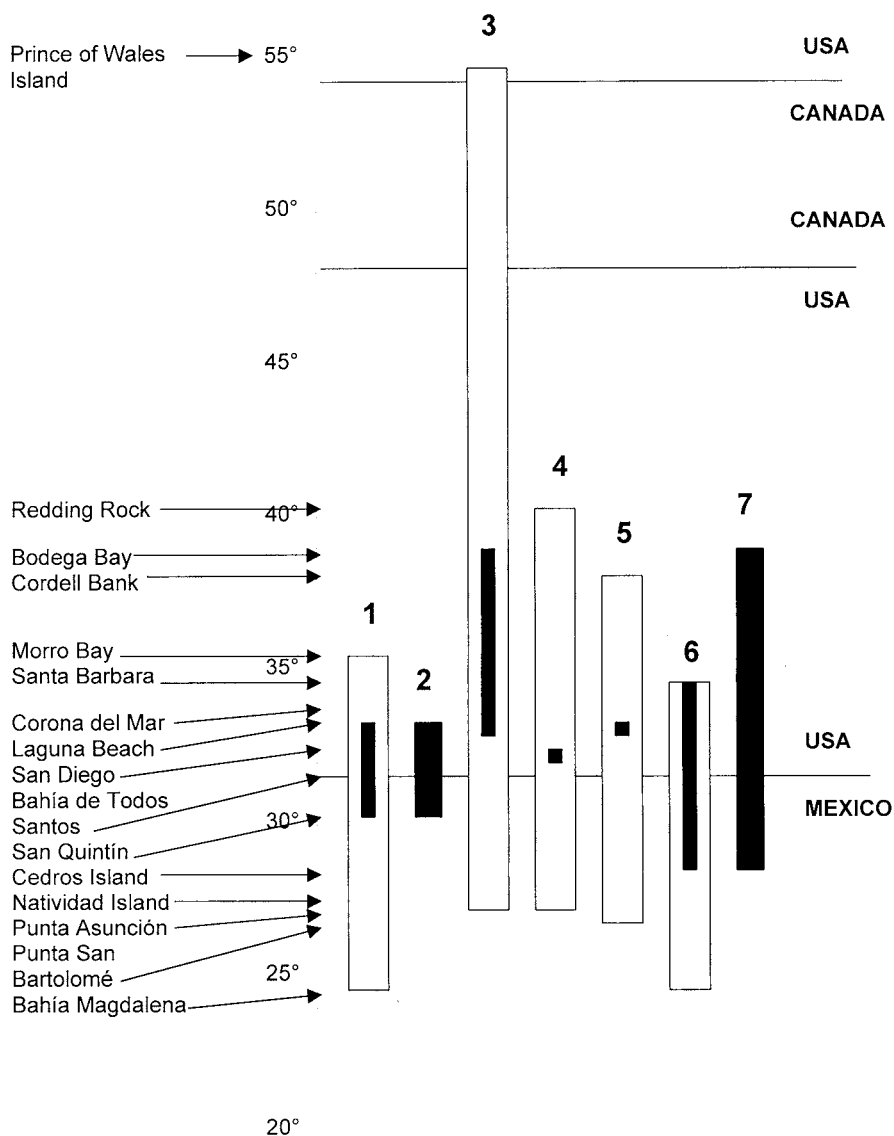


Figure 4. Schematic representation of the geographic ranges of host and parasite species along a latitudinal gradient, open rectangles represent host species and solid rectangles represent parasite species. Parasite ranges appear inside host ranges in 1, 3, 4, 5, and 6; parasite ranges alone are represented in 2 and 7. Numbers of rectangle correspond to species as follows: 1, *Petrolisthes cabrilloi*; 2, *Lernaediscus porcellanae*; 3, *Pugettia producta*; 4, *Loxorhynchus crispatus*; 5, *L. grandis*; 6, *Taliepus nuttallii*; 7, *Heterosaccus californicus*

1949; Boolootian et al., 1959; Ricketts and Calvin, 1968). Boschma (1955) reports the presence of *H. californicus* in the crab *Notolopos lamellatus* from Corinto, Nicaragua, based on samples taken in 1885; however, this specimen “differs from previously described specimens”, making it a doubtful record.

Table 2. Annual prevalence (%) of *Heterosaccus californicus* parasitizing *Pugettia producta* at Coal Oil Point, California.

Year	Prevalence (%)	n
1976	18.5	810
1977	20.5	1,636
1978	14.0	1,245
1979	11.3	565

## DISCUSSION

With the available data, the pattern that emerges is one in which both *L. porcellanae* and *H. californicus* parasitize their hosts in only a fraction of the total geographic range. The extensive parasite-free host areas could act as sources of recruits for host populations if they declined locally. Similar distribution patterns have been described for other rhizocephalan species (Alvarez and Calderón, 1996; Hines et al., 1997). The following discussion deals with each of the two rhizocephalans separately.

*LERNAEODISCUS PORCELLANAE*.—Although *L. porcellanae* is one of the best studied rhizocephalans in the world, since its entire life cycle has been followed in the laboratory, including larval development, metamorphosis, and settlement (Ritchie and Høeg, 1981; Høeg, 1985; Høeg and Ritchie, 1985, 1987), this represents the first account of its distribution and geographical variation of prevalence. The available data show that *L. porcellanae* occurs along 400 km in the California and Baja California coasts, parasitizing a single host, *P. cabrilloi*, and covering about 39% of the known range of the host (Fig. 4).

*L. porcellanae* probably has a very stable distribution that shows little or no change through time. The data from the three localities within La Jolla show that even when they are very close to each other, contrasting prevalence levels are maintained. The Bahía de Todos Santos data show that a parasitized population has persisted within the bay for at least the last 25 yrs, with very similar prevalence levels. Similarly, during at least 12 yrs, *Loxothylacus panopaei* which parasitizes nine species of crabs in the western Atlantic and Caribbean, showed a remarkably stable range parasitizing *Panopeus lacustris*, only along a 50 km stretch in the Indian River Lagoon, Florida (Hines et al., 1997).

From the 1971–1975 data, it also becomes apparent that multiple externae are present only at Bird Rock, except for 1 case at SIO Pier, where mean prevalence was the highest ( $\bar{x} = 35.22\% \pm 14.5\%$ ), while in the rest of the collecting sites where no multiple externae appeared, mean prevalence did not reach 10%. Scarred crabs were present in all months in the three sites within La Jolla, not showing any seasonality; however, percentage of scarred crabs decreased in Ensenada with only 4.4%.

*HETEROSACCUS CALIFORNICUS*.—*H. californicus* shows a more complicated pattern of host utilization (Fig. 4). In the northern section of its range, it occurs in *Pugettia producta* from Bodega Bay to Laguna Beach, California. In the central portion, from Corona del Mar to San Diego, California, *H. californicus* parasitizes its four known host species, *P. producta*, *Loxorhynchus crispatus*, *L. grandis*, and *T. nuttallii*. To the south, *H. californicus* occurs only in *T. nuttallii*, from Coal Oil Point, California to Cedros Island, Baja California.

The highest prevalences of *H. californicus* in *P. producta* were generally found in the southern portion of their common distribution area (Hollister Ranch and Coal Oil Point),

Table 3. Seasonal prevalence (%) of *Heterosaccus californicus* parasitizing *Pugettia producta* at Coal Oil Point, California from 1976 to 1979.

Season	Prevalence (%)	n
Jan–Mar	15.7	1,011
Apr–Jun	23.5	710
Jul–Sep	20.8	1,180
Oct–Dec	11.2	1,355

with lower prevalences in the north (Table 1). However, at a short distance further south a prevalence of 42% has been reported for *H. californicus* on *L. grandis*, although only at one site and the number of parasitized crabs collected was low ( $n = 3$ ) (Allen, 1976). Both, *L. grandis* and *L. crispatus* appear to be exploited over a short span of 130 km from Corona del Mar to San Diego, California. This pattern of high prevalence in a very small area may be due to high density of the two species of *Loxorhynchus* at this locality, although local environmental conditions may be important as well. Annual prevalence of the parasite at Coal Oil Point varied as much as two-fold (11–20%) over a 4-yr period (Table 2). Analysis of the same data pooled by season (Table 3) reveals that lowest prevalences occurred during the colder months of the year (October through March).

The distribution ranges of the four host species of *H. californicus* overlap extensively (Fig. 4). At a different scale, all four host species inhabit the kelp forest as adults (although the two species of *Loxorhynchus* are benthic while *P. producta* and *T. nuttallii* are commonly found on kelp stipes and the canopy) and occupy the intertidal zone as juveniles. The differential parasitization of each one along a latitudinal gradient may reflect spatio-temporal changes in relative abundance of both infective larvae and vulnerable hosts.

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