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Cocoon deposition on three crab species and fish parasitism by the leech *Notostomum cyclostoma* from deep fjords in northern British Columbia

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ABSTRACT: Cocoons of the sanguivorous piscicolid leech *Notostomum cyclostoma* (Johansson) were found on 3 crab species, *Lithodes aequispina*, *Paralithodes camtschatica* and *Chionoecetes bairdi* from deep fjords in the Portland Inlet system, northern British Columbia, Canada. This leech-crab association is convenient for cocoon deposition and dispersal. The leech does not appear to harm its crab hosts. Gut contents of *N. cyclostoma* collected off the crabs were fish-blood meals in various stages of digestion. The haemoflagellate *Cryptobia* sp. was observed in gut and proboscis area of 90 % of the leeches. One leech harbored another haemoflagellate, *Trypanosoma* sp., in its gut. *Cryptobia* sp. and *Trypanosoma* sp. were observed in the blood of 29 % of yellowfin soles *Limanda aspera* from one fjord. No haemoflagellates were observed in 7 other fish species caught coincidentally with the crabs. *L. aequispina* was the most cocoon – infested crab species. In Observatory Inlet, where *L. aequispina* was least common, more cocoons per crab were recorded than from the other fjords, Alice and Hastings Arms. Crabs which had not moulted for some time carried more cocoons than those with newer shells. This was less marked among *C. bairdi* subject to the exoskeleton disease of Black Mat Syndrome on older shells. The most used cocoon deposition site on crabs was the carapace, followed by the merus segments of the posterior limbs.

INTRODUCTION

Notostomum cyclostoma (Johansson) is a marine piscicolid leech recorded from the Seas of Japan and Okhotsk, Bering Sea and the Alaskan coast south to the mouth of the Stikine River (Moore and Meyer, 1951; Epshtein, 1961, 1962). Moore and Meyer (1951) reported on 161 specimens taken from soft-substrate habitats ranging from 9 to 366 m depth. Two leeches were found on skates, one on the red king crab *Paralithodes camtschatica* (Tilesius) and 158 were detached individuals. Also, cocoons of *N. cyclostoma* were found attached to single *P. camtschatica* at each of two locations. Moore and Meyer (1951) suggested from detailed anatomical observations and gut content analysis that *N. cyclostoma* was an active, free-living species which occasionally had fish-blood meals and used crab exoskeletons as cocoon 'nurseries'. On the other hand, Epshtein (1961, 1962) stated that *N. cyclostoma* was a 'specific parasite' of *P. camtschatica* as well as the snow crab *Chionoecetes opilio* (Fabricius) but he provided no evidence nor did he mention cocoon deposition.

In their review, Meyer and Barden (1955) reported that of 10 piscicolid leech-arthropod associations, only 1, involving a shrimp host, represented a parasitic relation *sensu stricto*. The other 9 associations, which included *Notostumum cyclostoma* on crabs, were suggested as being 'nothing more than erratic attachments'. Since their review, feeding observations of piscicolid leeches have been reported on a damaged crab (Hutton and Sogandares-Bernal, 1959), from strictly circumstantial observations on an isopod species (Sawyer and White, 1969) and unequivocally on a mysid species (Burreson and Allen, 1978; Allen and Allen, 1981).

We report here on cocoon deposition by *Notostomum cyclostoma* on 1424 individuals including red king crabs *Paralithodes camtschatica*, golden king crabs *Lithodes aequispina* Benedict and Tanner crabs *Chionoecetes bairdi* Rathbun from deep fjords in northern British Columbia, Canada. *N. cyclostoma* is

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described as a fish- (not crab) blood feeder. Observations on the prevalence of the haemoflagellate *Cryptobia* sp. in gut contents of *N. cyclostoma* and on the examination of blood of coincidental fish catches are discussed.

MATERIALS AND METHODS

Fig. 1 illustrates the fjords comprising the Portland Inlet system in northern British Columbia. Each of the fjords sampled were long, narrow, deep basins isolated by sills; Alice Arm has an 18 to 25 m sill at its mouth, Hastings Arm has a less well defined rise to approximately 55 m at its mouth and Observatory Inlet has a 40 to 46 m sill at its south end (Pickard, 1961).

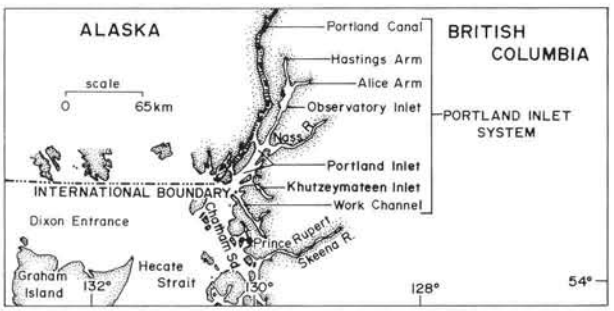

Fig. 1. Map of the north coast of British Columbia showing Portland Inlet system

As the target species was the deep-water *Lithodes aequispina,* individual pots were deployed along the troughs of Alice Arm, Hastings Arm and Observatory Inlet in late October- early November, 1983 and again in late February-early March, 1984. The shallow-water *Paralithodes camtschatica* and ubiquitous *Chionoecetes bairdi* were incidental by-catch. Alaskan side-entry king crab pots measuring 1.8 × 1.8 × 0.9 m with 9.0 × 12.0 cm mesh were deployed to a mean fishing depth of 296 m (range 82 to 505 m). Each pot was baited with two 2 l perforated jars of frozen chopped herring. Soak times, which varied between 20.1 to 47.5 h, were recorded along with the depth of each pot.

During both surveys, many *Notostomum cyclostoma* (70 to 110 mm long) and their cocoons (approximately 7.0 mm long and 5.5 mm wide) were found on crabs. A random subsample of the overall crab catch was examined during the autumn survey. *Lithodes aequispina* and *Paralithodes camtschatica* were measured for carapace length (Wallace et al., 1949) to the nearest mm. Intact *L. aequispina* and *P. camtschatica* were weighed to the nearest 0.05 kg. Crabs missing or regenerating limbs were not weighed. Both king crab species were rated for shell class where Class 1 had recently molted and Class 2 had older shells. Tanner crabs (*Chionoecetes bairdi)* were measured for carapace width (Donaldson et al., 1981) to the nearest mm and a subsample weighed to the nearest 0.05 kg. Shell class was recorded according to new (1), old (2) or very old (3) (Colgate, 1982). The sex of all crabs was noted.

The locality of *Notostomum cyclostoma* cocoons on the carapace (dorsal/lateral), abdomen, limbs and limb segments was noted. Limbs were sampled (clockwise) in sequence always starting at the right cheliped. The position of leeches was not recorded as they were highly mobile and many had detached by the time the catch was sorted on deck.

The gut contents of leeches collected from the three fjords in both surveys were examined microscopically. Each leech was blotted dry and placed in approximately 5 ml Hanks balanced salt solution (pH 7.0 to 7.4). Leeches were cut in 2 approximately one third the distance from the posterior sucker, and the colour, amount and consistency of the gut contents noted. Contents were mixed on a glass slide with Hanks solution, a coverslip applied and the wet mount preparation immediately examined microscopically for flagellates. The front end of the leech was removed anterior to the clitellum, split open and the proboscis freed from the sheath. The cut surface and exposed proboscis were pressed on a slide and examined as described above.

Five leeches collected in early November were kept in 500 ml containers of seawater at 4 °C for long-term monitoring of their gut contents. The seawater was changed every 30 d and on Day 105 they were examined as described above.

During both surveys blood from 58 fish (8 species), caught coincidentally with the crab trapping, was sampled by cardiac puncture using heparinized syringes. The fish samples consisted of 21 yellowfin sole *Limanda aspera* (Pallas), 12 spiny dogfish *Squalus acanthias* Linnaeus, 9 Pacific halibut *Hippoglossus stenolepis* (Schmidt), 6 Pacific cod *Gadus macrocephalus* Tilesius, 4 starry flounder *Platichthys stellatus* (Pallas), 4 walleye pollock *Theragra chalcogramma* (Pallas), 1 sablefish *Anoplopoma fimbria* (Pallas), and 1 Alaska skate *Bathyraja* sp. The blood was examined for haemoflagellates by the wet mount and/or the modified haematocrit centrifugation technique (Bower and Margolis, 1984a).

RESULTS

Characteristics of crab hosts

The total number of each crab species examined and the range and mean of depths at which they were caught was: 789 *Lithodes aequispina* at 128 to 505 m

($\bar{x} = 310.0$), 597 *Chionoecetes bairdi* at 82 to 393 m ($\bar{x} = 290.4$) and 44 *Paralithodes camtschatica* at 101 to 309 m ($\bar{x} = 132.2$). The mean carapace sizes of each species are listed according to fjord in Table 1. Between fjords, crab sizes varied little except for *L. aequispina*. Mean carapace length of Observatory Inlet *L. aequispina* was significantly larger (t-test; $p < 0.001$), than for Alice or Hastings Arms crabs. The approximate mean live weight of the crab species was 1.44 kg for *L. aequispina*, 1.31 kg for *P. camtschatica* and 0.70 kg fo *C. bairdi*.

Fig. 2A illustrates an adult *Notostomum cyclostoma* on the carapace of *Lithodes aequispina*. A few specimens of a smaller fish leech, *Malmiana* sp., were also found on *L. aequispina*.

Occurrence of *Notostomum cyclostoma* cocoons

Some cocoons observed during both field trips had hatched as identified by a small hole near the cocoon edge, a few were observed in the act of hatching and the majority were intact. Time constraints, however, did not allow for cocoon ageing.

Table 1. *Notostomum cyclostoma*. Sizes of its 3 host crab species from Portland Inlet system, Oct/Nov, 1983

Location	*Lithodes aequispina* Carapace length (mm)		*Paralithodes camtschatica* Carapace length (mm)		*Chionoecetes bairdi* Carapace width (mm)	
	n	$\bar{x} \pm$ SD	n	$\bar{x} \pm$ SD	n	$\bar{x} \pm$ SD
Alice Arm	627	130.0 ± 16.4	37	120.9 ± 16.4	184	126.0 ± 12.0
Hastings Arm	138	126.6 ± 24.1	7	126.1 ± 17.8	120	121.0 ± 21.2
Observatory Inlet	24	153.3 ± 20.2	–	– –	–	– –
Total	789	130.1 ± 18.6	44	121.7 ± 16.5	304*	130.1 ± 17.8

* Not all *Chionoecetes bairdi* examined for cocoons were measured

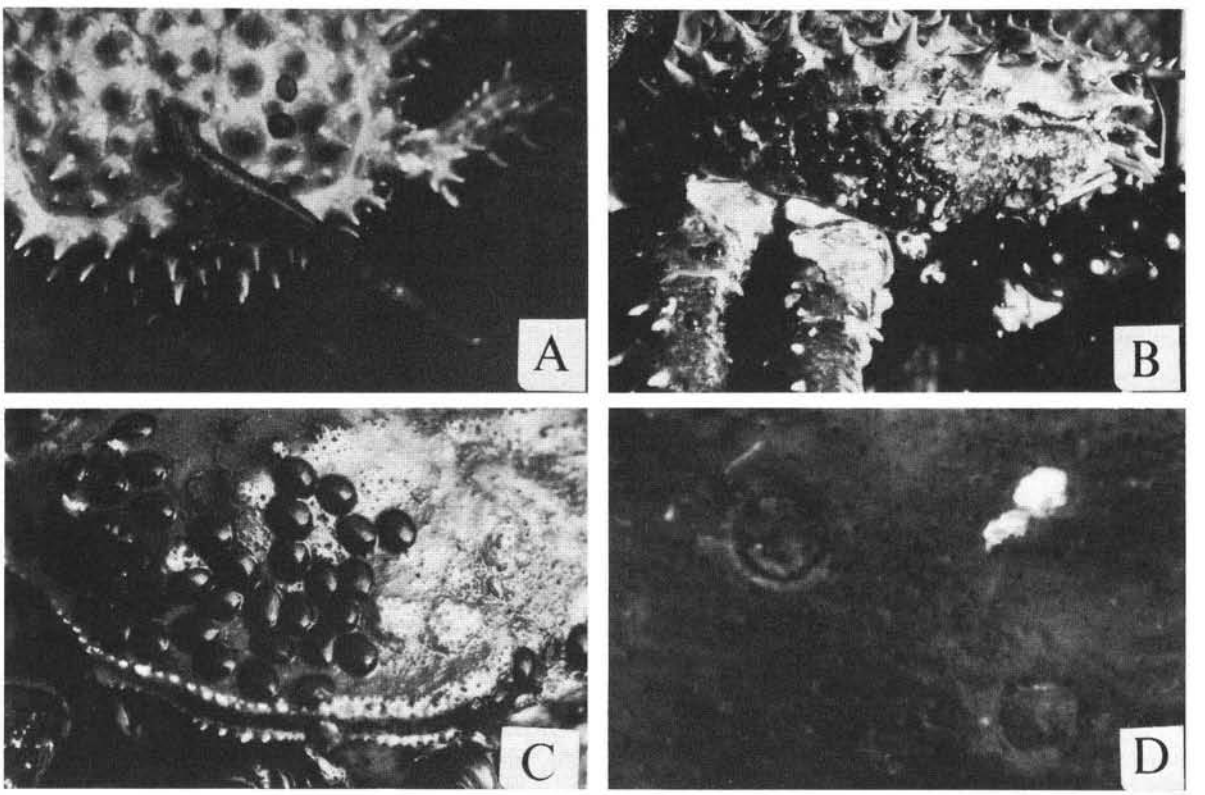

Fig. 2. *Notostomum cyclostoma*. (A) Individual distended with fish blood, on the carapace of *Lithodes aequispina*; (B) cocoons on lateral carapace surface of *L. aequispina*; (C) cocoons on dorsal carapace surface of *Chionoecetes bairdi*; (D) fresh feeding scar of *N. cyclostoma* on a halibut *Hippoglossus stenolepis* taken from a crab pot. Blood was oozing from upper left-hand scar. Scar diameter: ca. 7 mm

Table 2. *Notostomum cyclostoma*. Percent occurrence of cocoons according to fjord, depth, host sex or host shell class in Portland Inlet system

	Lithodes aequispina		*Paralithodes camtschatica*		*Chinoecetes bairdi*	
	n	% with cocoons	n	% with cocoons	n	% with cocoons
Alice Arm	627	87.9	37	21.8	184	46.2
Hastings Arm	138	70.3	7	57.1	413	52.3
Observatory Inlet	24	100	0	–	0	–
All fjords	789	85.2	44	27.3	597	50.4
Depth range (m)						
101–150	74	73.0	43	25.6	48	41.7
151–200	13	84.6	0	–	35	11.4
201–250	97	89.7	0	–	20	15.0
251–300	91	74.7	0	–	86	41.9
301–350	208	87.0	1	100	324	62.4
351–400	289	87.8	0	–	80	40.0
Male	360	84.4	28	35.7	573	52.7
Female	429	85.8	16	12.5	24	4.2
Shell Class 1	336	74.4	38	15.8	74	14.1
Shell Class 2	453	93.2	6	100	458	56.4
Shell Class 3	–	–	–	–	65	50.8

Table 3. *Notostomum cyclostoma*. Number of cocoons per crab host species according to fjord and host shell class within Portland Inlet system

Crab host	Shell class	Alice Arm Hosts n	Alice Arm Cocoons $\bar{x} \pm SD$	Hastings Arm Hosts n	Hastings Arm Cocoons $\bar{x} \pm SD$	Observatory Inlet Hosts n	Observatory Inlet Cocoons $\bar{x} \pm SD$	All fjords Hosts n	All fjords Cocoons $\bar{x} \pm SD$
Lithodes aequispina	1	279	11.9 ± 15.1	53	7.3 ± 13.1	4	48.3 ± 58.1	336	11.6 ± 16.3
	2	348	27.1 ± 26.6	85	28.0 ± 36.4	20	147.3 ± 91.7	453	32.6 ± 41.9
Paralithodes camtschatica	1	32	0.8 ± 2.9	6	2.7 ± 3.9	0	– –	38	1.1 ± 3.1
	2	5	8.6 ± 5.2	1	1.0 ± –	0	– –	6	7.3 ± 5.6
Chinoecetes• *bairdi*	1	6	1.8 ± 3.3	65	0.8 ± 2.5	0	– –	71	0.9 ± 2.5
	2	171	3.5 ± 6.3	290	5.7 ± 7.8	0	– –	461	4.9 ± 7.4
	3	7	1.9 ± 3.2	58	3.9 ± 6.0	0	– –	65	3.7 ± 5.8

• Shell class not recorded for all specimens

Table 4. *Notostomum cyclostoma*. Location and comparison of cocoon counts on various body areas of 789 *Lithodes aequispina* from Portland Inlet system

Body location	No. of cocoons $\bar{x} \pm SD$	Range	Mann-Whitney u-test comparisons of mean cocoon numbers according to body area: Comparisons	Test statistic•	p
Carapace	19.4 ± 27.4	0–231	Carapace : Limbs	842,715.0	< 0.05
Abdomen	1.4 ± 3.8	0–37	Abdomen : Carapace	824,534.5	< 0.05
Limbs	2.9 ± 9.2	0–95	Limbs : Abdomen	607,550.0	N.S.
Dorsal carapace	8.9 ± 13.1	0–120	Dorsal : Lateral	627,543.5	N.S.
Lateral carapace	10.5 ± 17.7	0–142			
Anterior limbs••	0.1 ± 0.8	0–16	Anterior : Posterior	527,958.5	< 0.01
Posterior limbs•••	2.8 ± 8.7	0–82			

N.S. = Not significant
• Degrees of freedom are 789, 789 in all cases; •• Limbs 1, 2, 7, 8; ••• Limbs 3, 4, 5, 6