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Nature of infestation of fishes by *Lernanthropus gibbosus* Pillai and *L. koenigii* Stp. and Lutk. (Copepoda : Anthosomatidae) along the South-west (Trivandrum) coast of India

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Abstract. The nature of distribution, mode of attachment, incidence and intensity of infestation and the nature of damage by two host specific anthosomatid copepod parasites, *Lernanthropus gibbosus* Pillai and *L. koenigii* Stp. and Lutk. infesting fishes *Saurida tumbil* (Bloch) and *Parastromateus niger* (Bloch) respectively, along the South-west coast of India are described. The results show that both these parasites are of serious concern to their hosts causing irreparable damage to the gills both by way of their mode of attachment and feeding activity. The blood circulation of the gills is severely curtailed and the infested gill filaments are completely put out of function.

Keywords. Copepod parasites ; histopathology ; *Lernanthropus gibbosus* ; *L. koenigii* ; host fishes ; *Parastromateus niger* ; *Saurida tumbil.*

1. Introduction

Though copepod parasites of fishes, in general, have been a subject of study on host-parasite relationship (see Kabata 1970 and Natarajan 1975) many copepod families have not yet received ample attention. The family Anthosomatidae, for example, contains many important fish parasites. The genus *Lernanthropus* of this family has been of much interest to taxonomists as it shows some interesting morphological modifications which are suited for its parasitic mode of life.

Lernanthropus gibbosus Pillai and *L. koenigii* Stp. and Lutk. are typical members of the genus. Along the South-west coast of India, the former is parasitic on the greater lizard fish, *Saurida tumbil* (Bloch) and the latter on the black pomfret *Parastromateus niger* (Bloch)—both these fishes are commercially important species noted for their comestible value.

2. Materials and methods

Specimens of *S. tumbil* and *P. niger* were obtained from local fish landings at Shankumughom, Trivandrum. After noting the standard length, weight and sex the gills of each fish were examined. The number, position of attachment and the orientation of the parasites on the gill filaments were recorded. Infected gill filaments, with the parasites *in situ*, were excised and examined under a sterioscopic dissection microscope to study the mode of attachment of the parasites. Normal and infested gill filaments were fixed in 10% neutral buffered formalin, and decalcified in sodium citrate-formic acid decalcifying fluid. Paraffin sections cut at 7 to 10 μ were stained in Azan (Heidenhain) or Harris haematoxylin-aqueous eosin.

3. Observations

3.1. *Nature of distribution on the hosts*

L. gibbosus and *L. koenigii* are parasitic on the gill filaments of their hosts. Specimens of *L. gibbosus* are found to attach themselves to the inner narrow lateral margins of the inner gill filaments (figure 1). While all the holobranchs on both sides are infested, incidence is more on the first and second holobranchs. The basal one-third of the gill filament is apparently the most preferred site of attachment. Usually, only the long egg sacs of the parasite protrude beyond the tip

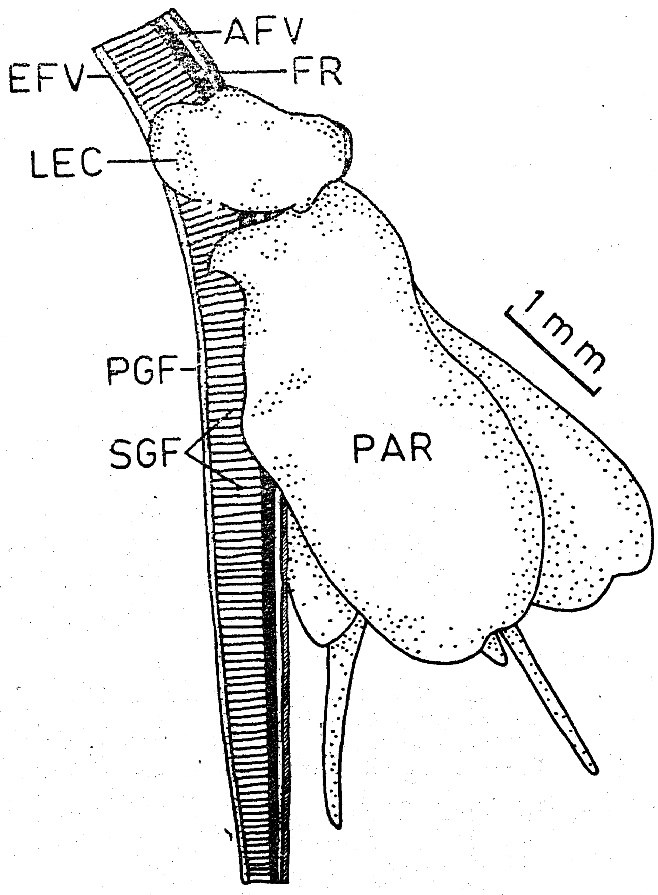
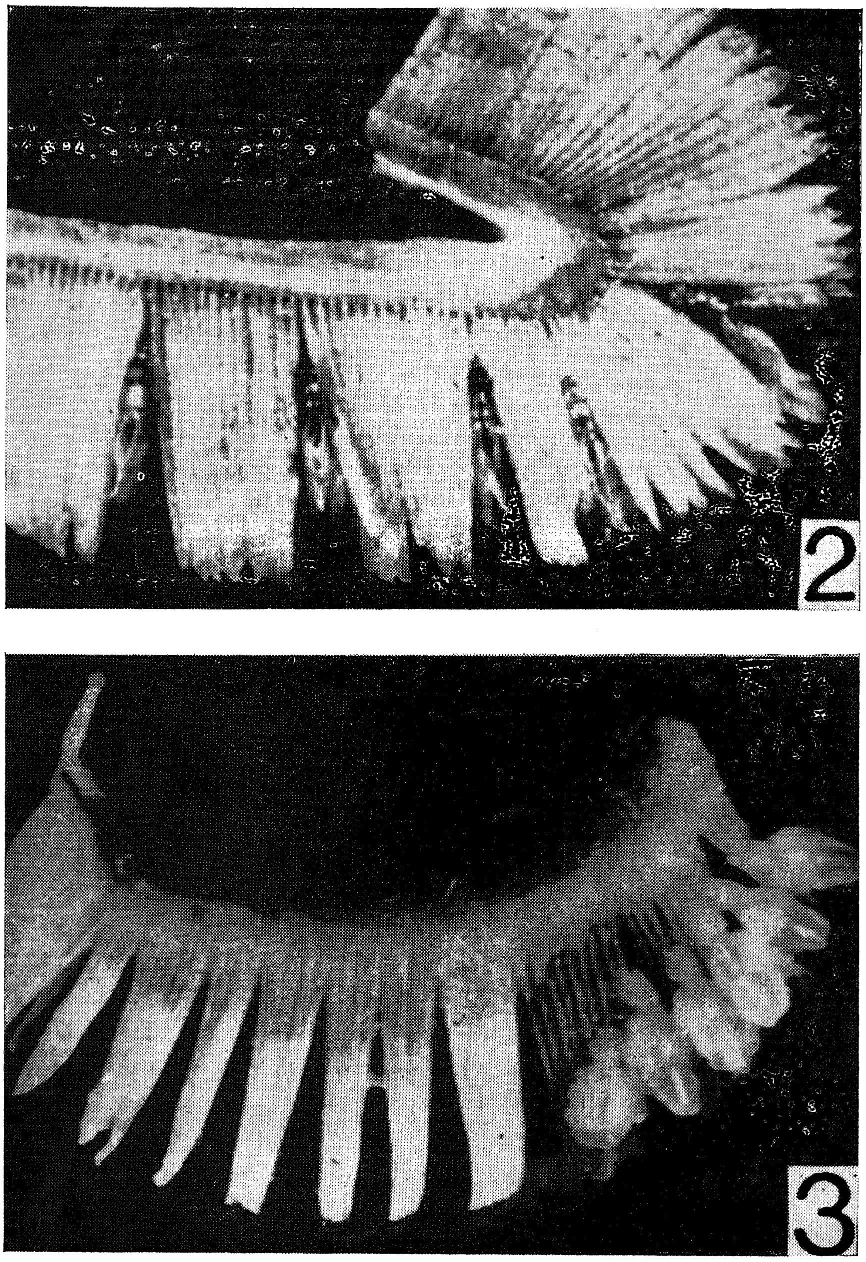


Figure 1. Camera lucida drawing showing the mode of attachment of *L. gibbosus* to the gill filament of *S. tumbil.* AFV—afferent filamentar vessel ; EFV—efferent filamentar vessel ; FR— filamentar ray ; LEC— lateral extension of carapace ; PAR—parasite ; PGF—primary gill filament ; SGF—secondary gill filaments.



Figures 2 and 3. **2.** Distribution of *L. gibbosus* on a holobranch of *S. tumbil* (through courtesy of Dr P Natarajan). **3.** Distribution of *L. koenigii* on a holobranch of *P. niger* (through courtesy of Dr P Natarajan).

of the gill filament ; occasionally the modified fourth legs may also project beyond the gill filament. No crowding of the parasites has been observed—two adjacent parasites being separated from each other by as many as seven to fifteen gill filaments (figure 2). The distribution of the parasite on the gills is in such a way that one gill filament is always attacked by only one parasite.

Though *L. koenigii* also prefers to attach itself to the first and second holobranchs on both sides, unlike *L. gibbosus*, it attaches to the outer narrow margin of the outer as well as the inner narrow margin of the inner gill filaments. Specimens of *L. koenigii* are found attached at various levels along the length of the gill filament. One parasite—one gill filament is the rule in *L. koenigii* infestation also. However, a crowding behaviour is discernible. Often adjacent gill filaments are attacked by the parasites so that their bodies tend to overlap (figure 3).

3.2. *Mode of attachment of the parasites*

The organs of attachment of both *L. gibbosus* and *L. koenigii* are the second antennae and the maxillipeds. The claws of the second antennae are thrust through the broad margins of the primary gill filament and they pierce the filamentar ray to effect a firm attachment (figure 7). The lateral lobes of the carapace assure additional anchorage since they are folded over to hold on to the broad margin of the gill filament.

3.3. *Incidence and intensity of infestation*

3.3a. *Lernanthropus gibbosus*: The data on the incidence and intensity of infestation during the period from July to November 1976 (period of occurrence of *S. tumbil* along this coast) are presented in table 1.

Of the 270 host specimens examined 50·37% were infested. The percentage incidence of infestation was higher in the female fish (52·76) than in the male (46·73).

The incidence of infestation was the highest (85·25%) in August. During subsequent months the percentage incidence progressively declined and reached the lowest (20·00%) in November. Except during July, when slightly more males (40·54%) than females (38·60%), were infested in all other months the incidence of infestation was notably higher in females.

A total of 240 specimens of *L. gibbosus* were obtained from 136 specimens of *S. tumbil* ; the mean number of parasites per infested fish (intensity of infestation) being 1·76. Intensity of infestation was higher (1·89) in females than in males (1·54).

The highest intensity of infestation was noted during July, and this trend decreased in August, remained so during September and October and decreased sharply in November.

Specimens of *S. tumbil* examined during the present study ranged from 15 to 37 cm in standard length. The data on the incidence and intensity of infestation by *L. gibbosus* in relation to length of fish are shown in table 2.

Though a regular pattern in the incidence of infestation in relation to the length of the host is not discernible, it seems that the incidence tended to increase with

Table 1. *Lernanthropus gibbosus*—Incidence and intensity of infestation in male and female *Saurida tumbil* in different months during the period from July to November 1976

Month	Number of fish examined			Number of fish infested			Number of *L. gibbosus* from		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
July 1976	37	57	94	15 (40·54)	22 (38·60)	37 (39·36)	25 (1·67)	53 (2·41)	78 (2·11)
Aug. 1976	26	35	61	20 (76·92)	32 (91·43)	52 (85·25)	31 (1·55)	55 (1·72)	86 (1·65)
Sept. 1976	20	38	58	10 (50·00)	23 (60·53)	33 (59·90)	15 (1·50)	42 (1·83)	57 (1·73)
Oct. 1976	11	16	27	3 (27·27)	5 (31·25)	8 (29·63)	4 (1·33)	9 (1·80)	13 (1·63)
Nov. 1976	13	17	30	2 (15·38)	4 (23·53)	6 (20·00)	2 (1·00)	4 (1·00)	6 (1·00)
Total	107	163	270	50 (46·73)	86 (52·76)	136 (50·37)	77 (1·54)	163 (1·89)	240 (1·76)

Percentage incidence and intensity of infestation are given in parentheses.

Table 2. *Lernanthropus gibbosus*—Incidence and intensity of infestation in different length groups of male and female *Saurida tumbil*.

Length group (cm)	Number of fish examined			Number of fish infested			Number of *L. gibbosus* from		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
15–17	9	5	14	3 (33·33)	2 (40·00)	5 (35·71)	3 (1·00)	2 (1·00)	5 (1·00)
17–19	10	20	30	3 (30·00)	7 (35·00)	10 (33·33)	7 (2·33)	13 (1·86)	20 (2·00)
19–21	11	19	30	6 (54·55)	6 (31·58)	12 (40·00)	9 (1·50)	8 (1·33)	17 (1·42)
21–23	7	21	28	2 (28·57)	15 (71·43)	17 (60·71)	2 (1·00)	26 (1·73)	28 (1·65)
23–25	12	10	22	8 (66·67)	—	8 (36·36)	13 (1·63)	—	13 (1·63)
25–27	15	17	32	7 (46·67)	12 (70·59)	19 (59·38)	7 (1·00)	15 (1·25)	22 (1·16)
27–29	17	19	36	7 (41·18)	11 (57·89)	18 (50·00)	8 (1·14)	22 (2·00)	30 (1·67)
29–31	12	11	23	6 (50·00)	7 (63·64)	13 (56·52)	10 (1·67)	12 (1·71)	22 (1·69)
31–33	9	15	24	6 (66·67)	6 (40·00)	12 (50·00)	13 (2·17)	13 (2·17)	26 (2·17)
33–35	5	15	20	2 (40·00)	11 (73·33)	13 (65·00)	5 (2·50)	31 (2·82)	36 (2·77)
35–37	..	11	11	—	9 (81·82)	9 (81·82)	—	21 (2·33)	21 (2·33)
Total	107	163	270	50 (46·73)	86 (52·76)	136 (50·37)	77 (1·54)	163 (1·89)	240 (1·76)

Percentage incidence and intensity of infestation are given in parentheses.
— Zero value. .. Data not available.

the growth of the fish. The highest percentage incidence (81·82) was in the largest fish (35–37 cm group) and the lowest (33·33) in fish of the 17–19 cm length group.

As with the incidence, the pattern of intensity of infestation, though irregular, presented an increasing trend with increasing length of fish. The lowest intensity of infestation (1·0) was in the smallest fish (15–17 cm) and the highest (2·77) in fish of the 33–35 cm length group.

3.3b. *Lernanthropus koenigii*: Specimens of *P. niger* are available along the South-west coast during August to November. The data on the incidence and intensity of *L. koenigii* infestation in different months during August to November 1976 are presented in table 3.

Of the specimens examined 42·0% were infested. Percentage incidence of infestation in male fish (51·36) was considerably higher than in female (36·51). An increasing trend is discernible from August to October. During November, however, there was a decrease.

As many as 75 specimens of *L. koenigii* were obtained from 42 infested fish (mean number per infested fish = 1·79). Intensity of infestation was higher (2·04) in females than in males (1·47). The highest intensity of infestation (2·50) was in August. This decreased during subsequent months to reach the lowest (1·22) in November.

P. niger examined ranged from 11 to 41 cm in standard length. The data on the incidence and intensity of *L. koenigii* infestation in relation to length of fish are presented in table 4.

From the results it would appear that the incidence and intensity of infestation are comparatively high in fish up to 29 cm in standard length.

3.4. *Nature of damage to the host*

L. gibbosus and *L. koenigii* attacking the gills cause destruction of the affected gill filaments. The attachment results in severe displacement of the gill filaments on either side of the parasites. The filaments get pushed laterally so that their broad margins become closely applied together (and later become hypertrophied) thereby reducing the surface area for respiration (figures 4 and 5).

The mode of attachment of the parasite is such that the secondary gill filaments or the respiratory folds on either side of the region of the gill filament enclosed within the lateral extensions of the carapace of the parasite are completely damaged. Since these extensions of the carapace cover a large area of the broad margin of the primary gill filament, the total damage to the respiratory folds is extensive involving not less than 35 to 40 respiratory folds.

On many an occasion, the lateral extensions of the carapace, especially of *L. gibbosus*, were found to reach the entire width of the gill filament. In such cases these prehensile structures grip the filament at the outer margin at the level of the efferent filamentar vessel (figures 1 and 6). The blood vessel collapses under the grip resulting in the occlusion of its lumen. Since the attack is on the inner gill filament, this mode of attachment results in complete enclosure of a part of the gill filament by the broad lateral extensions of the carapace.

The respiratory folds of the gill filaments on either side of the parasite also get damaged. Those lying in close contact with any part of the parasite undergo

Table 3. *Lernanthropus koenigii*—Incidence and intensity of infestation in male and female *Parastromateus niger* in different months during the period from August to November 1976.

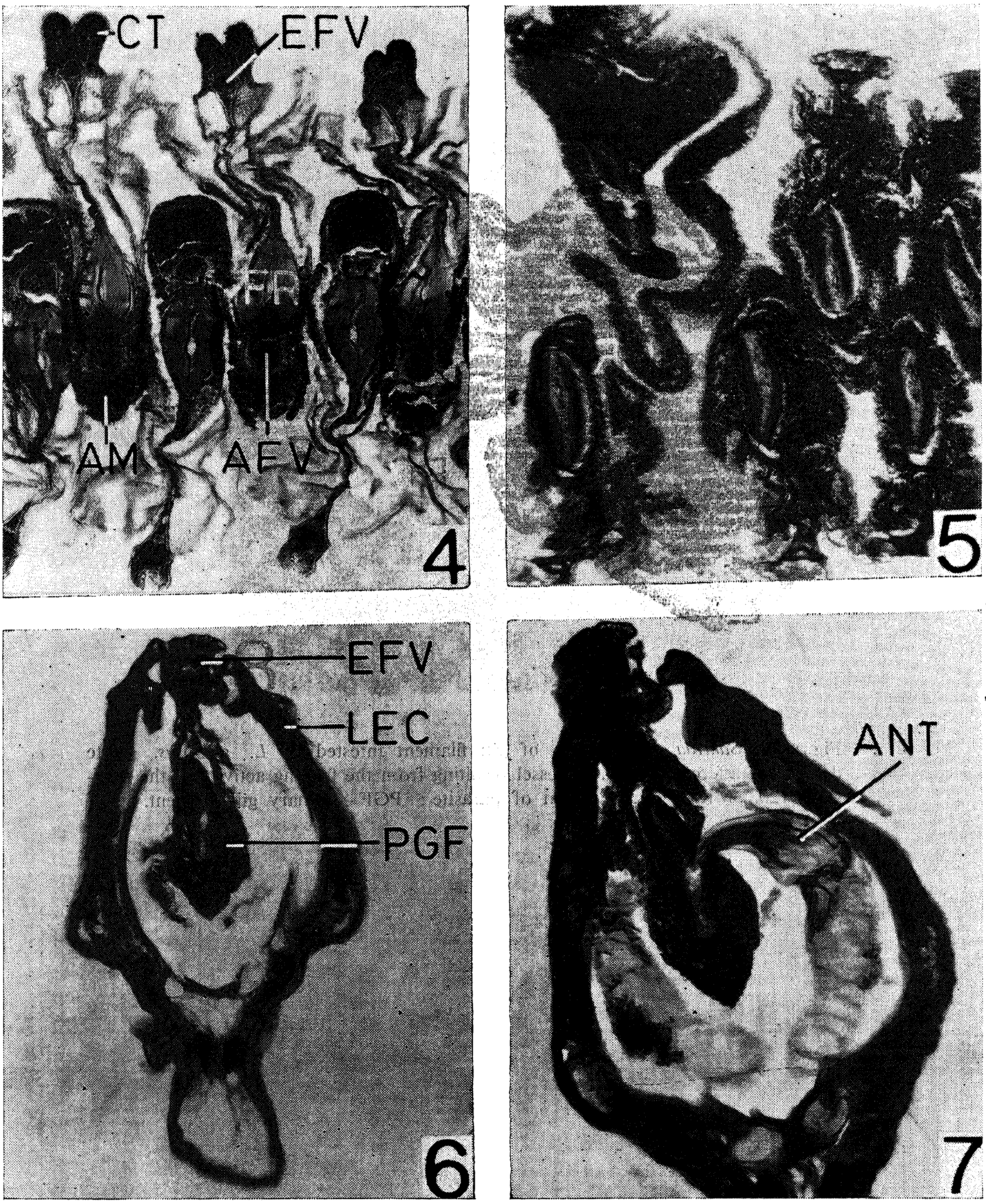
Month	Number of fish examined			Number of fish infested			Number of *L. koenigii* from		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
Aug. 1976	6	24	30	3 (50·00)	7 (29·17)	10 (33·33)	4 (1·33)	21 (3·00)	25 (2·50)
Sept. 1976	10	12	22	3 (30·00)	5 (41·67)	8 (36·36)	4 (1·33)	8 (1·60)	12 (1·50)
Oct. 1976	7	18	25	7 (100·00)	8 (44·44)	15 (60·00)	13 (1·86)	14 (1·75)	27 (1·80)
Nov. 1976	14	9	23	6 (42·56)	3 (33·33)	9 (39·13)	7 (1·17)	4 (1·33)	11 (1·22)
Total	37	63	100	19 (51·36)	23 (36·51)	42 (42·00)	28 (1·47)	47 (2·04)	75 (1·79)

Percentage incidence and intensity of infestation are given in parentheses.

Table 4. *Lernanthropus koenigii*—Incidence and intensity of infestation in different length groups of male and female *Parastromateus niger*.

Length group (cm)	Number of fish examined			Number of fish infested			Number of *L. koenigii* from		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
11–14	10	8	18	4 (40·00)	5 (62·50)	9 (50·00)	5 (1·25)	9 (1·80)	14 (1·56)
14–17	7	9	16	5 (71·43)	6 (66·67)	11 (68·75)	8 (1·60)	9 (1·50)	17 (1·55)
17–20	4	7	11	4 (100·00)	3 (42·86)	7 (63·64)	6 (1·50)	5 (1·67)	11 (1·57)
20–23	3	13	16	2 (66·67)	6 (46·15)	8 (50·00)	3 (1·50)	16 (2·67)	19 (2·38)
23–26	5	8	13	2 (40·00)	1 (12·50)	3 (23·08)	2 (1·00)	2 (2·00)	4 (1·33)
26–29	2	6	8	1 (50·00)	2 (33·33)	3 (37·50)	2 (2·00)	6 (3·00)	8 (2·67)
29–32	1	2	3	..	..	..	..	..	..
32–35	2	2	4	..	..	..	..	..	..
35–38	3	6	9	1 (33·33)	—	1 (11·11)	2 (2·00)	—	2 (2·00)
38–41	—	2	2	—	..	..	—	..	..
Total	37	63	100	19 (51·36)	23 (36·51)	42 (42·00)	28 (1·47)	47 (2·04)	75 (1·79)

Percentage incidence and intensity of infestation are given in parentheses.
.. Zero value. — Data not available.



Figures 4 to 7. *Saurida tumbil.* **4.** T.S. of uninfested gill filaments × 120· **5.** T.S. of gill filaments from fish infested by *L. gibbosus* × 120. **6.** T.S. of gill filaments infested by *L. gibbosus.* Note lateral extensions of carapace gripping the efferent filamentar vessel × 120. **7.** T.S. of gill filament infested by *L. gibbosus.* Note penetration of second antenna of parasite into filamentar ray × 160. AFV—afferent filamentar vessel; AM—adductor muscle; ANT—antenna; CT—capping tissue; EFV—efferent filamentar vessel; FR—filamentar ray; LEC—lateral extension of carapace; PGF—primary gill filament.

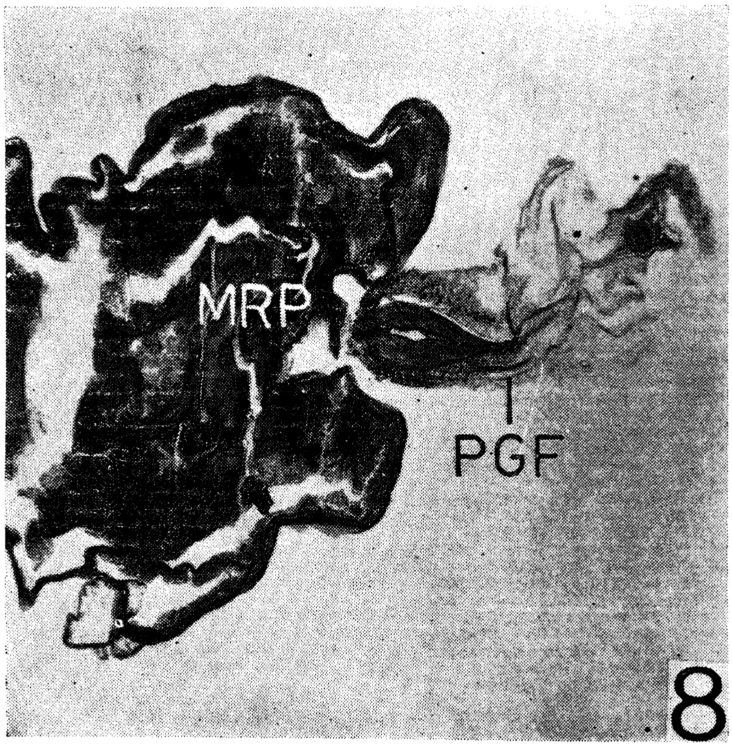


Figure 8. *Saurida tumbil*—T.S. of gill filament infested by *L. gibbosus*. Note damage of afferent filamentar vessel resulting from the feeding activity of the parasite × 120. MRP—mouth region of parasite ; PGF—primary gill filament.

adhesion consequent on the disruption of the normal structure, caused by the constant irritation resulting from the friction with the body of the parasite.

As with *Ergasilus* spp. (Neuhaus 1929; Einszporn–Orecka 1964 ; Kabata 1970). *Lernanthropus* spp. also feed on blood and epithelial tissue of the host, as is evident from the erosion of the soft tissue of the gill around the oral region of the parasite. When the parasites are attached to the outer narrow margin of the outer gill filament the feeding activity of the parasite causes erosion of the soft tissue around the efferent filamentar vessel in particular. But, surprisingly, only on a few occasions was the damage of the blood vessel observed. When the parasite attacks the inner gill filaments the damage is severe. In this position, the inner narrow margin of the filament, bearing the afferent filamentar vessel, is browsed upon by the parasite. The adductor muscle and the connective tissue below the afferent filamentar vessel are completely eroded away resulting in the exposure of the afferent filamentar blood vessel to the attack by the parasite. In transverse sections of the filament, the afferent filamentar vessel is seen to be partially or fully occluded and in many cases, the wall of this vessel is damaged (figure 8). This would evidently cause severe loss of blood, since the blood pressure in this vessel is very high when compared with that in the efferent filamentar vessel. Long strands of blood clots seen trapped among the gill filaments of many infested fish must obviously be the result of the clotting of blood lost through the damaged afferent filamentar vessel. This observation is further confirmed by the fact that, invariably, in all instances where such blood clots were observed, sections of the affected filaments revealed rupture of the afferent filamentar vessel.

Excessive mucus exudation is pronounced in *Lernanthropus* spp. infestation. Often, the branchial chamber of infested host is seen filled with mucus so that when the operculum is lifted up a thick film of mucus extends between the opercular rim and the outer margin of the branchial chamber. Presumably, on such occasions the opercular opening is occluded by mucus and this would naturally interfere with the free flow of the respiratory current.

Though hypertrophic changes of the affected tissue is common in gill infestations by copepods (see Kabata 1970), in *Lernanthropus* spp. infestation the affected gill filaments did not show hypertrophic changes. However, the soft tissue of the filaments adjacent to that parasitised was found to become hypertrophied. A large number of active mucous cells and lymphocytes are discernible in the hypertrophied tissue.

4. Discussion

Lernanthropus gibbosus and *L. koenigii* of the famlly Anthosomatidae are much more adapted, than the members of the family Ergasilidae, for a parasitic mode of life—their structural modifications, mode of attachment to the host and the nature of distribution on the host tissue being more specialised for a parasitic existence. Though they are closely related species, *L. gibbosus* and *L. koenigii* infest two different host fishes, *Saurida tumbil* and *Parastromateus niger* respectively, occurring along the South-west coast of India.

The only previous work on the nature of infestation by these parasites is that of Natarajan (1975), who observed that *L. gibbosus* and *L. koenigii* occur on both the outer and inner gill filaments of their respective host, with higher incidence on the inner filaments. In the present instance his observation applies only to *L. koenigii*. *L. gibbosus*, on the other hand, was found to be highly selective for the inner narrow lateral margins of the inner gill filaments.

In general the mode of attachment of these parasites to the gill filaments conforms to that reported by Natarajan (1975). However, a significant aspect which Natarajan failed to notice is that the claws of the second antennae of the parasites pierce the filamentar ray. According to Natarajan "...the mode of attachment of these parasites (*Lernanthropus* spp.) is similar to that of *Hermilius longicornis*..." in which "...the terminal joints of the second antennae penetrate into the gill tissue and the second antennae encircle the filamentar ray...". The present observations show that the terminal joints (claws) of the second antennae not only penetrate into the gill tissue but they peirce the filamentar ray, effecting a firmer attachment. Similarly, the fact that the lateral extensions of the carapace may, at times, extend over the whole width of the gill filament and grip over the efferent filamentar blood vessel was also not observed by Natarajan. The present observations are significant since, the fracture of the filamentar ray as a result of the penetration of the claws of the second antennae and the simultaneous destruction of the afferent blood vessel (by the feeding activity of the parasite) and the efferent filamentar vessel (which collapses under the strong grip by the carapace) aggravate the severity of the infestation by these parasites and lead one to consider them more injurious than was formerly believed to be.

L. gibbosus and *L. koenigii* cause severe damage to the blood circulation in the gills of their hosts, since the attack affects the afferent filamentar blood vessel, the pressure of blood in which is much higher than that in the efferent vessel. Fish blood clots very rapidly, lest the damage of the afferent vessel would lead to serious blood loss which may prove fatal.

Damage of the afferent vessel, which by itself is quite serious, is aggravated by the occlusion of the efferent vessel, as a result of the strong grip by the lateral extensions of the carapace. Thus the overall damage to the gill filament renders the affected gill filament almost out of function. Such serious cases of infestation have not so far been reported for anthosomatid gill parasites.

Yet another interesting observation is that *L. koenigii* attached to the outer narrow margin of the outer gill filaments, damages the efferent filamentar vessel only very rarely. But attached to the inner margin of the inner gill filament they damage the afferent vessel. Why the parasite prefers the well-protected afferent vessel to the more easily accessible efferent vessel is not clear. Probably the requirements of the parasite cannot be completely satisfied by seeking the contents of the efferent vessel. It is noteworthy that the preferred site of attachment of *L. koenigii* (and the exclusive site of attachment of *L. gibbosus*) is the inner margin (bearing the afferent filamentar vessel) of the inner gill filament. It may probably be for avoiding competition, but it is in conformity with its crowding habit that *L. koenigii* attaches itself to the outer gill filaments.

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