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Population Dynamics of Endohelminths of *Channa punctatus* at Raipur, India

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Key words: population dynamics, endohelminths, *Channa punctatus*, species composition, over-dispersion

Introduction

Population biology of caryophyllaeids has been studied in *Catostomus commersoni* (Calentine and Fredrickson, 1965; Lawrence, 1970; Mudry and Arai, 1973; Anderson, 1974, 1976; William, 1979), *Leuciscus leuciscus* and *Leuciscus idus* (Kennedy, 1968, 1969), *Erimyzon oblongus* (Grimmes and Miller, 1976), *Abramis* (Milbrink, 1975) and *Clarias batrachus* (Satpute and Agarwal, 1980; Niyogi *et al.*, 1982). On the other hand, Chappell (1969) and Pennycuick (1971, a, b, c, and d) studied parasite dynamics of *Echinorhynchus clavula,* metacercaria of *Diplostomum gasterostei* and *Schistocephalus solidus* in *Gasterosteus aculeatus.* Kennedy and Burrough (1977) studied dynamics of *Diplostomum spathaceum* and *Tylodelphys clavata* in perch, while Burrough (1978) studied the same in *Rutilus rutilus* (roach) and *Scardinius erythrophthalmus* (rudd). Boxshall (1974 a and b) studied population dynamics of an ectoparasitic copepod, *Lepeophtheirus pectoralis* in *Pleuronectes platessa* L. Also, Chauhan *et al.,* (1981) and Malhotra *et al.,* (1981) have respectively studied distribution and abundance of cestodes and nematodes in 11 and 12 species of fishes of Garhwal Himalayas.

Channa punctatus at Raipur is found to harbour 6 different species of endohelminths, namely, *Pallisentis nagpurensis, Senga* sp. and *Allocreadium* sp. in intestine; encysted metacercariae of *Euclinostomum heterostomum* in liver and *Clinostomum giganticum* in muscle and immature and mature *Isoparorchis hypselobagri* in peritonial folds of abdominal cavity.

The present authors have studied on several aspects of population biology of each species comparatively in one annual cycle, from July in 1981 to June in 1982 so as to candidly assess, species-wise, occurrence of seasonal periodicity, competitive interaction, frequency distribution patterns and the possible basis of regulation of populations.

Materials and Methods

A total number of 695 *Channa punctatus,* procured in the living condition from local tanks and fish markets, were numbered, measured, weighed, sexed and subjected to thorough examination for endohelminths during the period from July in

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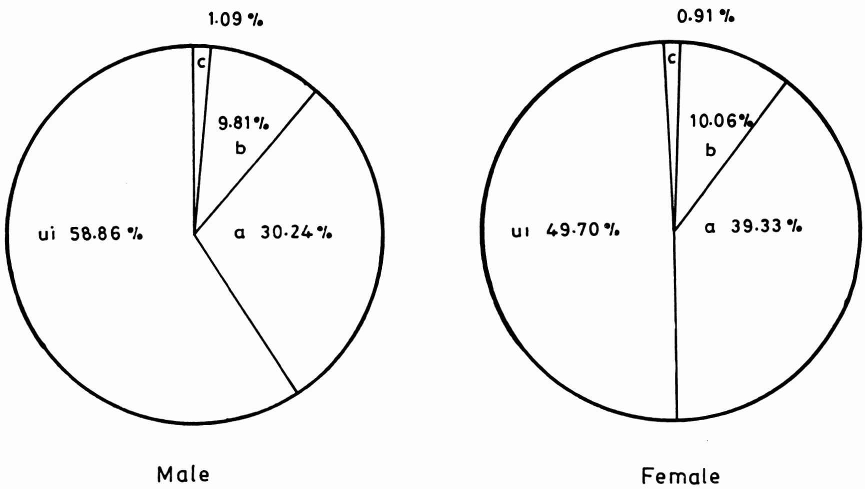

Fig. 1 Percentage of single and concurrent infections in males and females as compared with uninfected *C, punctatus* (a=single infection, b=concurrent infection by 2 spp. and c by 3 spp. respectively. ui=no infection).

1981 to June in 1982. Worms recovered from different tissues were scored species-wise for each fish in single and in concurrent infections. Data obtained were analysed species-wise for the several bio-statistical parameters such as, incidence (% of infection), intensity (total worm burden/number of fishes infected), density (total worm burden/number of fishes examined), relative density (individual species burden × 100/total worm burden), dominance percentage (total burden for month × 100/total burden for year), index of infection [number of worms × number of infected fishes/(number of fishes examined)^2] and frequency distribution in one annual cycle month-wise, sex-wise and age-wise.

Results

Incidence, intensity, density, dominance percentage and index of infection are found generally low during the period from September to December in females and from October to January in males, whereas they are all much higher during the period from January to August (peak in January)

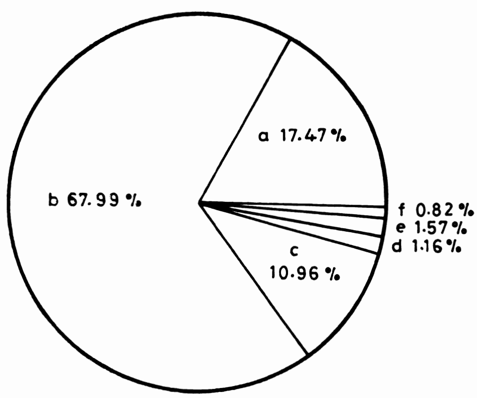

Fig. 2 Species composition on the basis of % of relative densities (a=*E. heterostomum*, b=*P. nagpurensis* c=*Senga* sp., d=*I. hypselobagri*, e=*Allocreadium* sp., f=*C. giganticum*).

in females and from February to September (peak in February and September) in males (Figs. 3, 4, 5, 6 and 7).

Incidence, intensity, density, dominance percentage and index of infection of *P. nagpurensis* (Figs. 3b, 4b, 5b, 6b and 7b) and *E. heterostomum* (Figs. 3a, 4a, 5a, 6a and 7a) correspond with the general picture both in females and males; *Senga* sp., on the other hand, has much higher incidence, intensity, density, dominance percentage

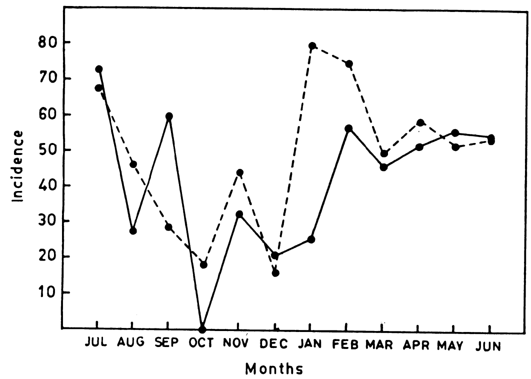

Fig. 3 Incidence of overall endoheiminth infection in male (●—●) and female (●- -●) *C. punctatus*.

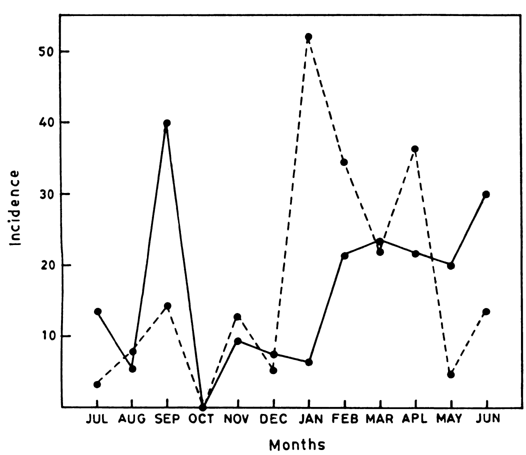

Fig. 3 (a) Incidence of *E. heterostomum* in male (●—●) and female (●- -●) *C. punctatus*.

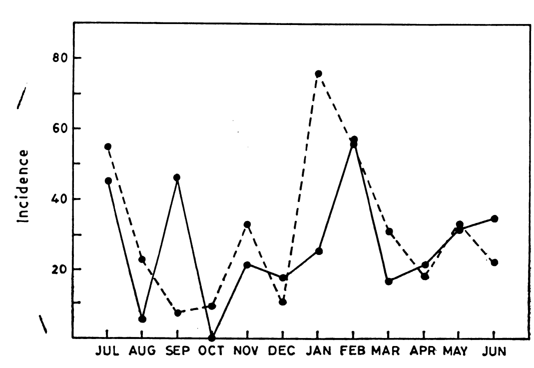

Fig. 3 (b) Incidence of *P. nagpurensis* in male (●—●) and female (●- -●) *C. punctatus*.

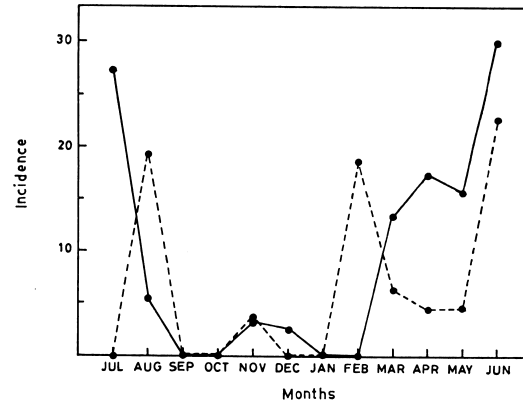

Fig. 3 (c) Incidence of *Senga* sp. in male (●—●) and female (●- -●) *C. punctatus*.

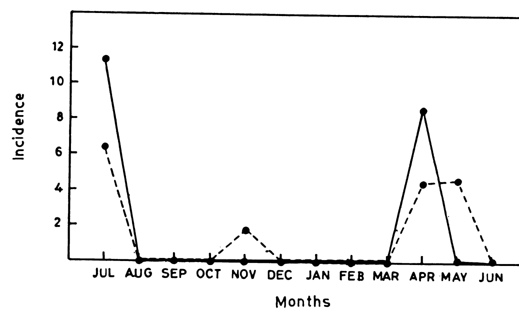

Fig. 3 (d) Incidence of *I. hypselobagri* in male (●—●) and female (●- -●) *C. punctatus*.

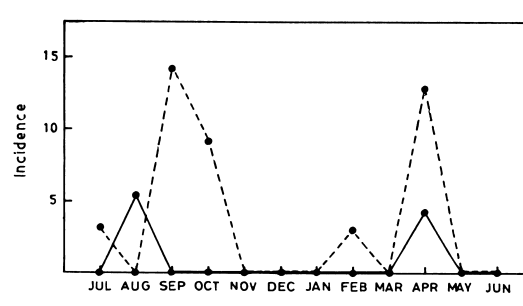

Fig. 3 (e) Incidence of *Allocreadium* sp. male (●—●) and female (●- -●) *C. punctatus*.

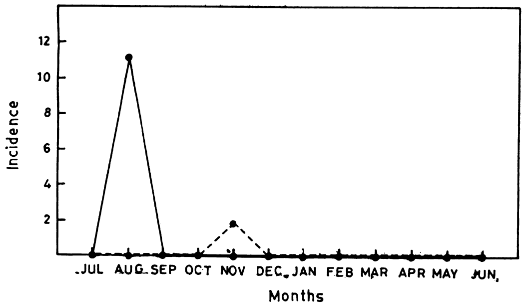

Fig. 3 (f) Incidence of *C. gigantiucum* in male (●—●) and female (●- -●) *C. punctatus.*

and index of infection in May, June and July and is clearly male *C. punctatus* oriented (Figs. 3c, 4c, 5c, 6c and 7c).

Other three endohelminth species viz, *I. hypselobagri, Allocreadium* sp. and *C. giganticum,* however, are only occasionally found (Figs. 3, 4, 5, 6 and 7d, e, f).

Species-wise composition of the endohelminths on the basis of percentage of their relative densities, in one annual cycle is found highest in *P. nagpurensis* at 67.99%; *E. heterostomum* at 17.4%, *Senga* sp. at 10.96%, *Allocreadium* sp. at 1.57%, *I. hypselobagri* at 1.16% and *C. giganticum* at 0.82% followed in decreasing order (Fig. 2).

Frequency distribution (Figs. 8a, b, c, d, e and f; Table 1) reveals that variance is greater than the mean and the k value (by maximum likelihood) is much less than 1, suggesting overdispersion in every species of endohelminths parasitizing *Channa*

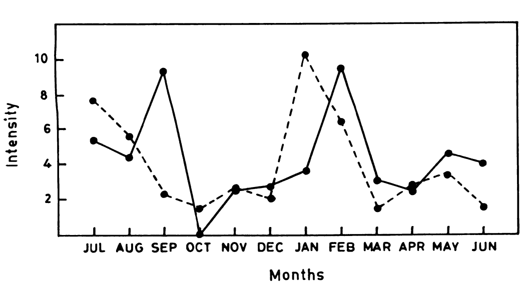

Fig. 4 Worm burden in male (●—●) and female (●- -●) *C. punctatus.*

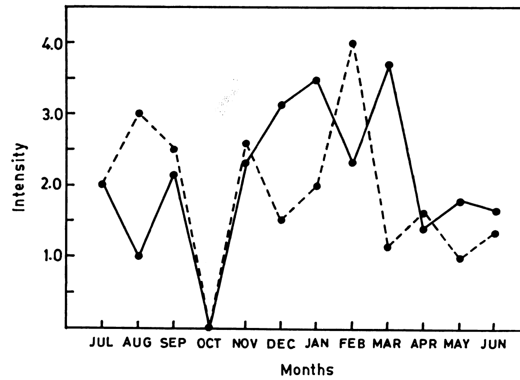

Fig. 4 (a) *E. heterostomum* burden in male (●—●) and female (●- -●) *C. punctatus.*

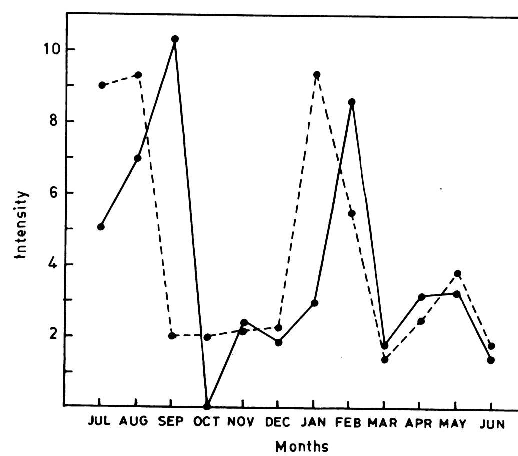

Fig. 4 (b) *P. nagpurensis* burden in male (●—●) and female (●- -●) *C. punctatus.*

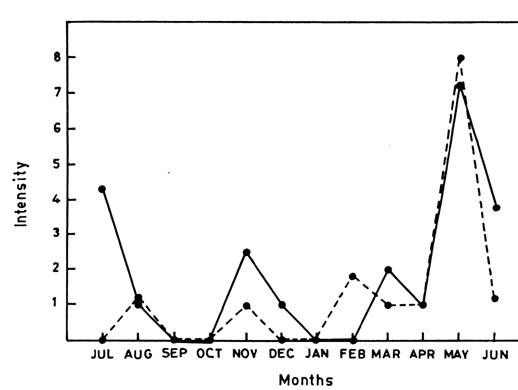

Fig. 4 (c) *Senga* sp. burden in male (●—●) *C. punctatus.*

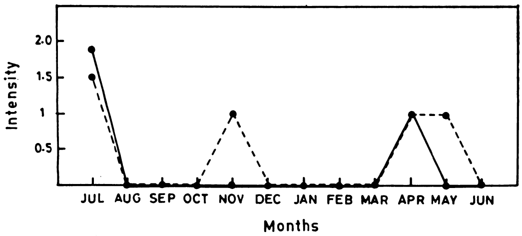

Fig. 4 (d) *I. hypselobagri* burden in male (●—●) and female (●- -●) *C. punctatus*.

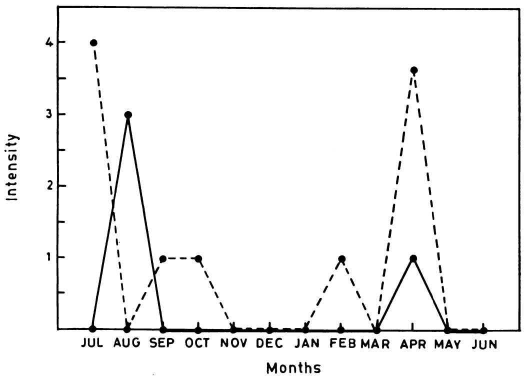

Fig. 4 (e) *Allocreadium* sp. burden in male (●—●) and female (●- -●) *C-punctatus*.

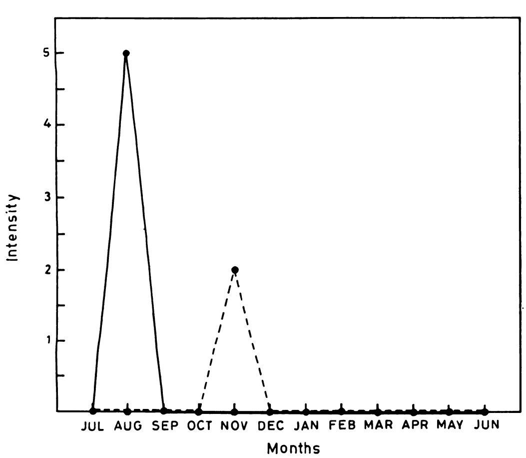

Fig. 4 (f) *C. giganticum* burden in male (●—●) and female (●- -●) *C-punctatus*.

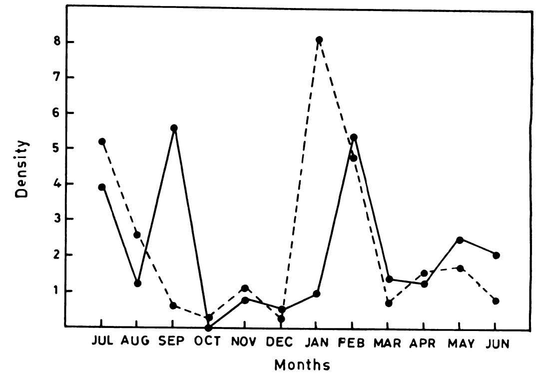

Fig. 5 Density of overall endohelminths in male (●—●) and female (●- -●) *C. punctatus*.

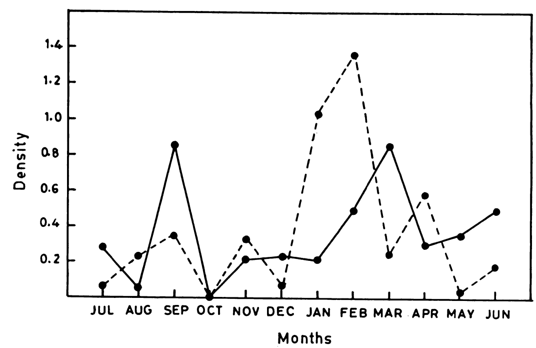

Fig. 5 (a) Density of *E. heterostomum* in male (●—●) and female (●- -●) *C. punctatus*.

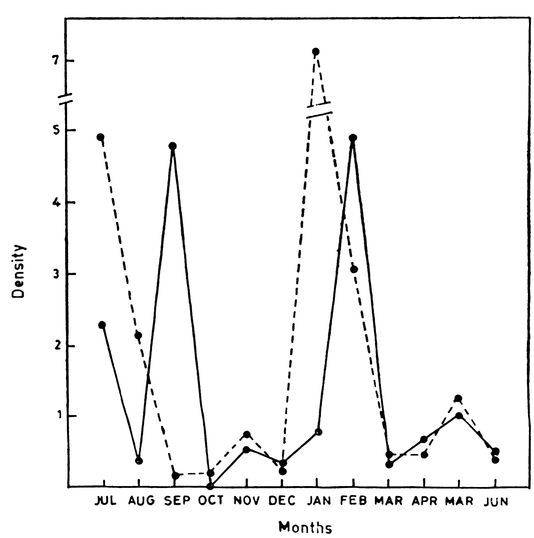

Fig. 5 (b) Density of *P. nagpurensis* in male (●—●) and female (●- -●) *C. punctatus*.

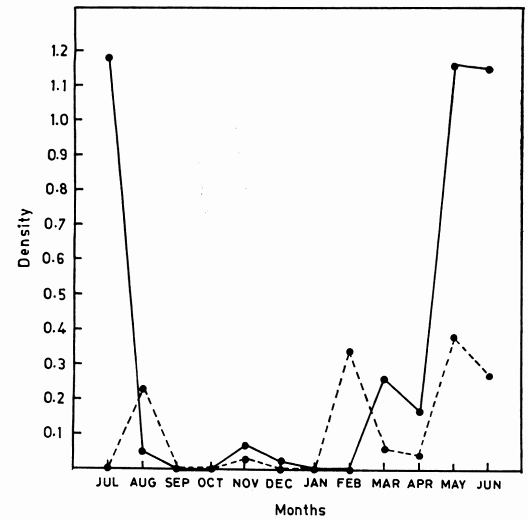

Fig. 5 (c) Density of *Senga* sp. in male (●—●) and female (●- -●) *C. punctatus*.

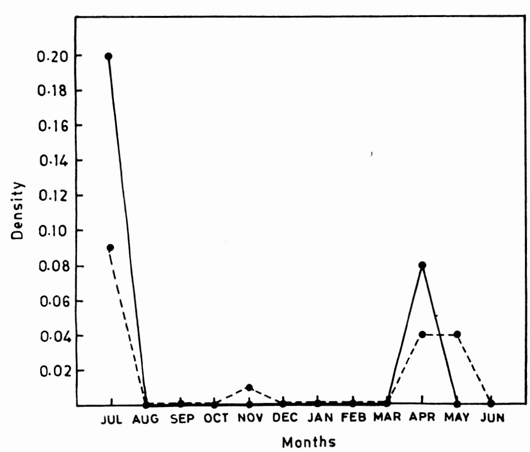

Fig. 5 (d) Density of *I. hypselobagri* in male (●—●) and female (●- -●) *C. punctatus*.

punctatus. Both negative binomial distribution (NBD) and log series have excellent fit, when tested with Chi square test.

Data on concurrent infections, when analysed statistically using coefficient of co-occurrence correlation (Table 2), or coefficient of partial association (Table 3), reveal negative interaction of *P. negpurensis* with *Senga* sp.; *P. nagpurensis* with *I. hypselobagri; I. hypselobagri* or *Allocreadium* sp.

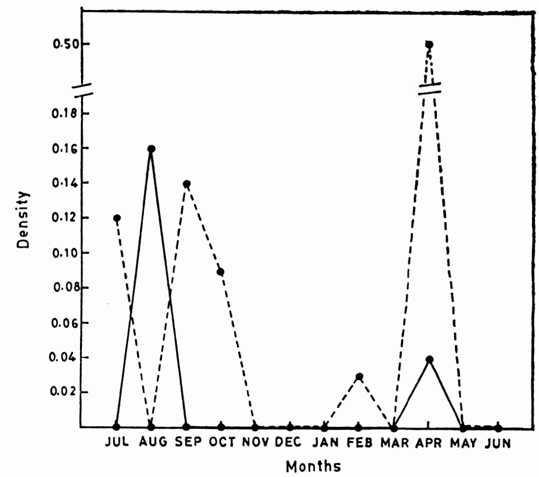

Fig. 5 (e) Density of *Allocreadium* sp. in male (●—●) and female (●- -●) *C. punctaus*.

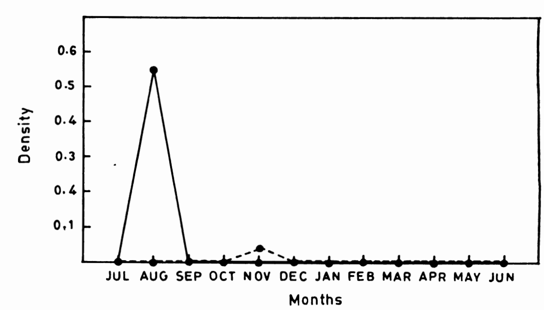

Fig. 5 (f) Density of *C. giganticum* in male (●—●) and female (●- -●) *C. punctatus*.

with *C. giganticum* and so on.

Discussion

Dogiel (1958) observed that fishes in summer months generally harbour greater number and varieties of helminth infection. Thomas (1964) reported greater intensity of helminth infections in *Salmo trutta* during spawning. Niyogi *et al.* (1982), in their study of population dynamics of caryophyllaeids in *Clarias batrachus* at Raipur, observed much greater susceptibility to infection during the period from March to August and argued that the recruitment period of caryophyllaeids coincided with the spawning period of these fishes.

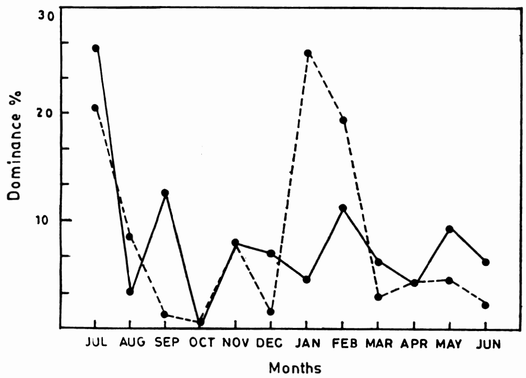

Fig. 6. Dominance % of overall endohelminths in male (●—●) and female (●- -●) *C. punctatus*.

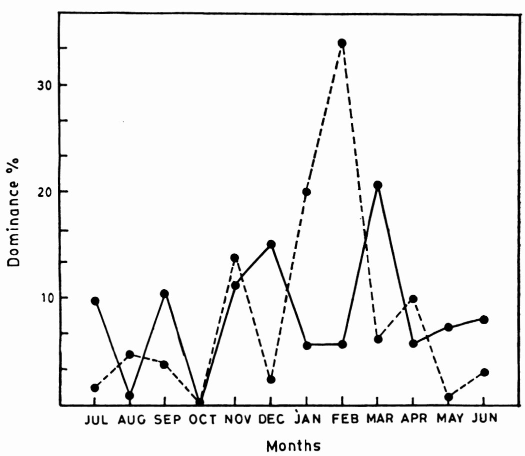

Fig. 6 (a) Dominance % of *E. heterostomum* in male (●—●) and female (●- -●) *C. punctatus*.

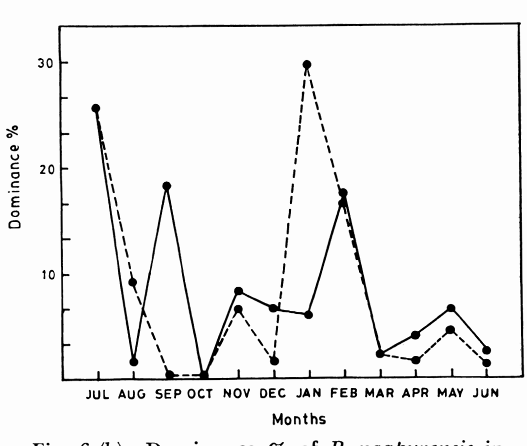

Fig. 6 (b) Dominance % of *P. nagpurensis* in male (●—●) and female (●- -●) *C. punctatus*.

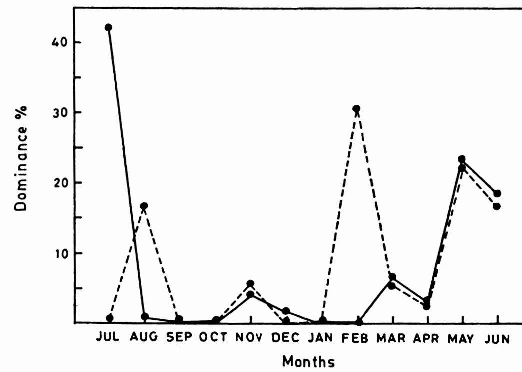

Fig. 6 (c) Dominance % of *Senga* sp. in male (●—●) and female (●- -●) *C. punctatus*.

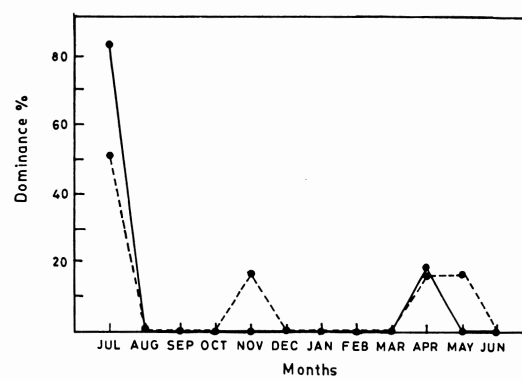

Fig. 6 (d) Dominance % of *I. hypselobagri* in male (●—●) and female (●- -●) *C. punctatus*.

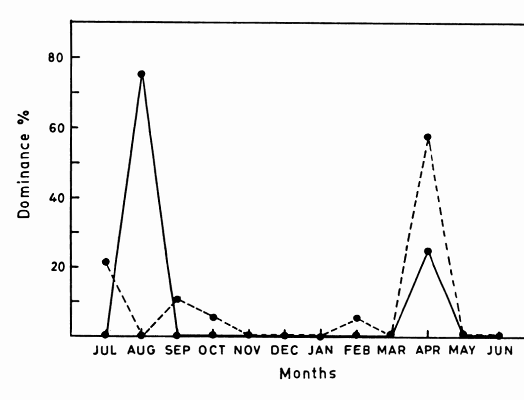

Fig. 6 (e) Dominance % of *Allocreadium* sp. in male (●—●) and female (●- -●) *C. punctatus*.

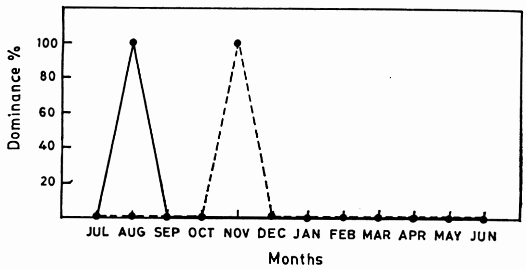

Fig. 6 (f) Dominance % of *Clinostomum giganticum* (metacercariae) in male (●—●) and female (●- -●) *C. punctatus*.

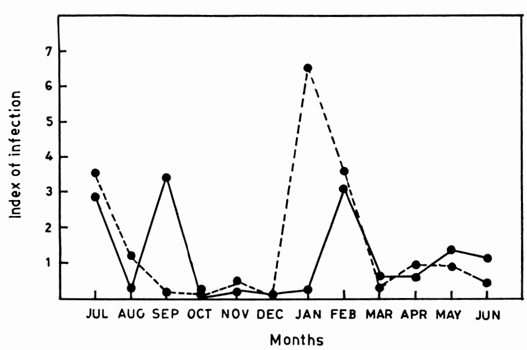

Fig. 7 Index of overall infection in male (●—●) and female (●- -●) *C. punctatus*.

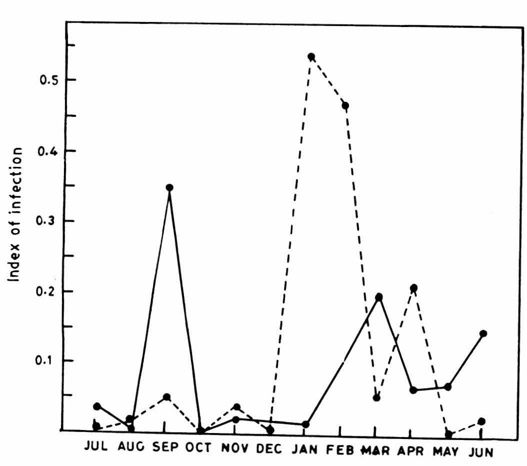

Fig. 7 (a) Index of infection of *E. heterostomum* in male (●—●) and female (●- -●) *C. punctatus*.

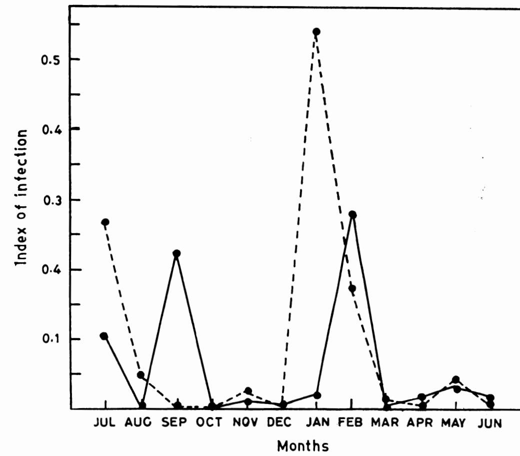

Fig. 7 (b) Index of infection of *P. nagpurensis* in male (●—●) and female (●- -●) *C. punctatus*.

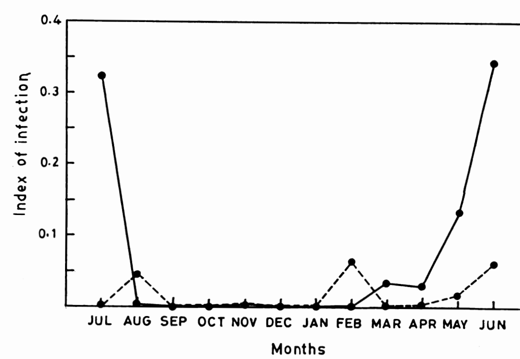

Fig. 7 (c) Index of infection of *Senga* sp. in male (●—●) and female (●- -●) *C. punctatus*.

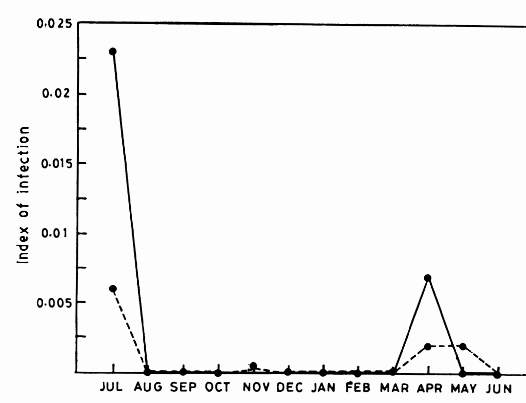

Fig. 7 (d) Index of infection of *I. hypselobagri* in male (●—●) and female (●- -●) *C. punctatus*.

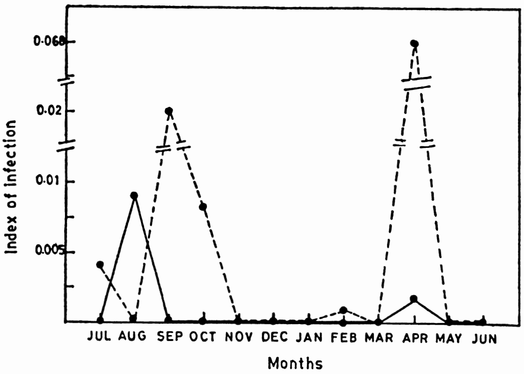

Fig. 7 (e) Index of infection of *Allocreadium* sp. in male (●—●) and female (●- -●) *C. punctatus*.

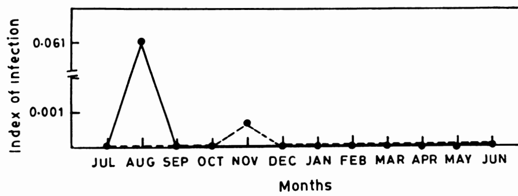

Fig. 7 (f) Index of infection of *Clinostomum giganticum* (metacercariae) in male (●—●) and female (●- -●) *C. punctatus*.

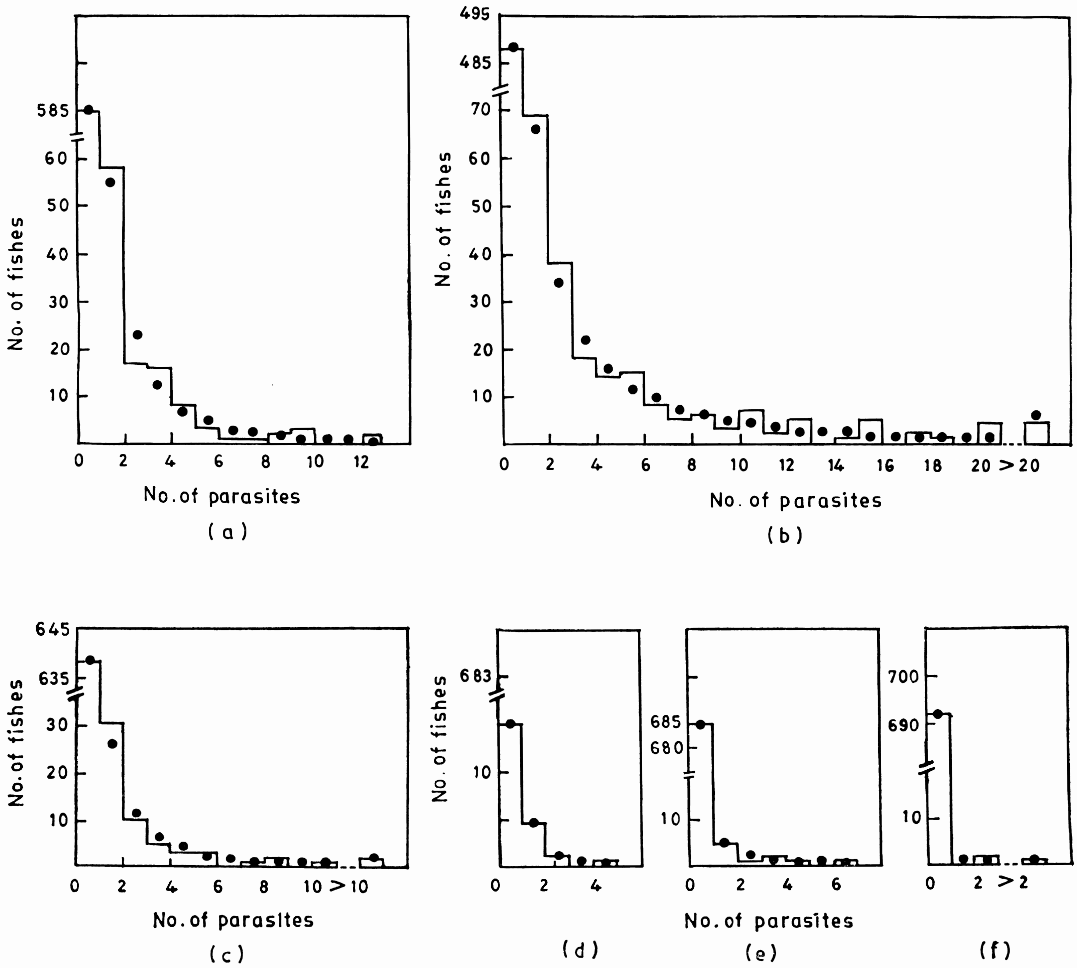

Fig. 8 Frequency distribution histogram of (a) *E. heterostomum*, (b) *P. nagpurensis*, (c) *Senga* sp., (d) *I. hypselobagri*, (e) *Allocreadium* sp. and (f) *C. giganticum* and fitness by the negative binomial (solid circle).

Table 1 Summary of frequency distribution of the six endohelminth spp. parasitizing *C. punctatus* at Raipur in one annual cycle

Estimates	*Euclinostomum heterostomum* (Metacercaria)	*Pallisentis nagpurensis*	*Senga.* sp.	*Isoparorchis hypselobagri*	*Allocreadium* sp.	*Clinostomum giganticum* (Metacercaria)
Mean no. of parasites (X)	0. 367	1. 427	0. 230	0. 244	0. 033	0. 017
Variance (S^2)	1. 411	15. 449	1. 589	0. 047	0. 113	0. 103
k by maximum likelihood	0. 126	0. 149	0. 049	0. 027	0. 009	0. 002
Chi square (X^2) with NBD	5. 30	3. 51	1. 21	0. 00	0. 12	0. 00
	(P>50%) *	(P>99%)	(P>90%)	(P>100%)	(P>90%)	(P>100%)

* Values in parenthesis indicate probabilities of Chi square.

Table 2 Incidence, intensity and coefficient of correlation for co-occurrence in concurrent infections

Species	Incidence (%)		Intensity		Coefficient correlation for co-occurrence	
	Male	Female (%)	Male	Female	Male	Female
(i) Single infection—						
Species A	5. 44	7, 92	2. 75	1. 53	—	—
B	18. 80	24. 39	4. 18	5. 05	—	—
C	4. 35	4. 57	3. 12	1. 60	—	—
D	0. 81	0. 91	1. 33	1. 33	—	—
E	0. 27*	1. 52	1. 00	2. 20	—	—
F	0. 54	—	5. 00	—	—	—
(ii) Concurrent infection—						
A&B	5. 44	7. 62	(2. 05, 4. 55)	(2. 80, 7. 52)	0. 0523	0. 1564
A&C	1. 90	0. 60	(1. 85, 5. 42)	(2. 00, 1. 50)	0. 0616	−0. 0377
A&D	—	0. 30*	—	(1. 00, 1. 00) *	0. 00	0. 00
A&E	0. 27	0. 30*	(1. 00, 3. 00)	(2. 00, 1. 00) *	0. 00	0. 00
B&C	1. 36	0. 91	(1. 60, 3. 60)	(1. 00, 2. 33)	−0. 0579	−0. 0580
C&D	0. 81	—	(1. 33, 1. 00)	—	0. 00	0. 00
D&E	—	0. 30*	—	(1. 0, 6. 0) *	0. 00	0. 00
AB&C	0. 81	0. 30*	(3. 66, 2. 00, 1. 33)	(3. 0, 1. 0, 1. 0) *	0. 65	Not calculated
AB&F	—	0. 30*	—	(8. 0, 2. 0, 2. 0) *	0. 00	Not calculated
AC&D	0. 27*	—	(1. 00, 10. 0, 4. 0)	—	—	—
AC&E	—	0. 30*	—	(5. 0, 1. 0, 1. 0) *	0. 00	Not calculated

A=*E. heterostomum* (metacercaria): B=*P. nagpurensis*: C=*Senga* sp.: D=*I. hypselobagri*: E=*Allocreadium* sp.: F=*Clinostomum giganticum* (metacercaria): *=based on single observation.

Recovery by them of a large number of immature worms in the caryophyllaeid populations from *C. batrachus* during spawning period supported their contention. They rightly argued against a temperature—dependent rejection response as propounded by kennedy (1968, 1969) in his study of *Caryophyllaeus laticeps* infection of *Catostomum commersoni* which was found to have higher infection during winter.

Das and Das (1983) observed that *Channa punctatus* feeds actively during late autumn (November) and through winter (December-February), matures in late spring and early summer (March-April),

Table 3 Partial association coefficient of *Euclinostomum heterostomum* (A), *Pallisentis nagpurensis* (B), *Senga* sp. (C), *Isoparorchis hypselobagri* (D), *Allocreadium* sp. (E) and *Clinostomum giganticum* (F) in concurrent infections

S. No.	Partial Association	Coefficient
1.	CoAB. C+	0.174
2.	CoAB. C−	0.257
3.	CoBC. A+	−0.413
4.	CoBC. A−	−0.290
5.	CoAC. B+	0.145
6.	CoAC. B−	0.138
7.	CoDE. F+	0.00
8.	CoDE. F−	−0.452
9.	CoDF. E+	0.00
10.	CoDF. E−	−0.016
11.	CoEF. D+	0.00
12.	CoEF. D−	−0.013

Co=Coefficient

aestivates during mid summer (May-June) and breeds in late June, continuing spawning throughout rains (July-August/September).

Data presented above make it obvious that *C. punctatus*, like *C. batrachus*, is more susceptible to endohelminth infection during maturation and spawning time, and is more resistant during winter. Further, *P. nagpurensis* (in intestine) is the most dominant species; *E. heterostomum* (encysted in liver) and *Senga* sp. (intestine) are next in order of relative densities; while *I. hypselobagri*, *Allocreadium* sp. and *C. ciganticum* have been reduced to an accessory status. Occurrence of *C. giganticum* only 3 times (twice in male and once in female) in 695 fishes examined during one annual cycle is suggestive that it is being competitively excluded. Further, *Senga* sp. found more in males than in females, with highest incidence, intensity and density during May, June, July in the whole annual cycle is clearly an example of temporal segregation (cf. *P. nagpurensis* and *E. heterostomum*, which show peak in January in females and during February and September in males).

Frequency distribution was used to describe ecological interaction between host and parasite (Crofton, 1971 a, b) and between different species of parasites (Pennycuick, 1971 a, b, c and d) which generally have an over dispersed distribution, k value being less than 3. Crofton (1971 a, b) observed that the greater is the over dispersion, the smaller is the k value, and further, the lower is the pathogenicity of the parasite, the greater is the oscillation in number of parasites and the higher is the equilibrium level of parasite population. In more over dispersed populations (when k value is less than 1) the parasite is considered harmless. Thus, pathogoenicity of the parasite contributes to the stability of the population. In the present study, of the six different endohelminths species, each of which is over dispersed and has k value less than 1, *Pallisentis nagpurensis* shows greatest oscillation in number of worms (1 to 45), followed by *Senga* sp. (1–20), *E. heterostomum* (1 to 12), *I. hypselobagri* (1 to 4), *Allocreadium* sp. (1 to 6) and *C. giganticum* (1 to 8). *P. nagpurensis* (with relative density at 67.99%) thus has perhaps attained the highest equilibrium level and is perhaps the oldest of the species parasitizing *Channa punctatus*.

Studies on co-occurrence correlation and partial association coefficients (Tables 2 and 3), based on data from concurrent infections, both in males and females, suggest a competitive interaction between *P. nagpurensis* and *Senga* sp. (Table 3); the number of worms of either species is never more than one if infection of the other species is there already, viz, when *Senga* sp. is more than one (3, 4, or 5) in number, *P. nagpurensis* is never more than one (cf. its range of 1–45 in single infection); likewise, when *P. nagpurensis* is more than one (say 4), *Senga* sp. is never more than one, competitive interaction is obvious in other three species. *I. hypselobagri* or *Allocreadium* sp. never co-occurs with *C. giganticum*.

Negative co-occurrence correlation coefficient could be due to non reciprocal cross immunity (Shad, 1966). In the event of reciprocal cross immunity (immunity due to shared antigens), such antagonism between species would not occur (cf. *P. nagpurensis* and *E. heterostomum*, where co-occurrence correlationship coefficient is fairly high). Calentine and Fredrickson (1965) opined that presence of *Glaridacris* in *Catostomus commersoni* possibly prevented procercoid of other species from becoming established.

Read (1956) and Laurie (1957) had suggested that helminth parasites secrete quantities of organic acids of low molecular weight and other substances of an enzymatic or antigenic character which may perhaps make the environment biochemically hostile to other species.

Kennedy and Burrough (1977), too, observed competitive interaction between *D. gasterostei* and *T. clavata*. Niyogi *et al.*, in their study of concurrent infections of caryophyllaeids in *C. batrachus* (under communication), suggested competitive exclusion of *Djombangia indica* and the accessory status (near exclusion) of *Pseudocaryophyllaeus indica* to be possibly due to non reciprocal immunity.

The present authors venture to suggest that competitive interaction between *P. nagpurensis* and *Senga* sp. and the accessory status of *I. hypseloobagri, Allocreadium* sp. and *C. giganticum* are the natural consequence of non reciprocal cross immunity.

Summary

The results of analysis on population dynamics of endohelminths in *C. punctatus* at Raipur are summarized as follows:

1. Incidence, intensity, density, relative density, dominance percentage, index of infection and frequency distribution, in one annual cycle, of 6 endohelminth species parasitizing *C. punctatus* were worked out by month, sex and age.

2. Infection was found generally low during the period from September to December in females and from October to January in males and higher during the period from January to August (peak in January) in females and from February to September (peak in February and September) in males.

3. Species composition showed *Pallisentis nagpurensis* to have highest relative density at 67.99%; *Euclinostomum heterostomum* at 17.47%, *Senga* sp. at 10.96% *Allocreadium* sp. at 1.57%, *Isoparorchis hypselobagri* at 1.16% and *Clinostomum giganticum* at 0.82% follow in decreasing order.

4. Data on frequency distribution of all species suggest that they are over-dispersed and both NBD and log series show excellent fit in each case.

5. Negative interaction seems obvious between *P. nagpurensis* and *Senga* sp., between *P. nagpurensis* and *I. hypselobagri, I. hypselobagri* or *Allocreadium* sp.. and *C. giganticum* on analysis of data on concurrent infections by coefficient of co-occurrence correlationship and partial association.

6. The negative interaction is suggested by the authors to be possibly due to non reciprocal cross immunity.

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インド *Raipur* 地区の *Channa punctatus* における内部寄生蠕虫の寄生状況

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著者らは1981年7月から1982年6月までの1年間にわたり，ライプルから *Channa punctatus*（タイワンドジョウ属の1種）の695匹を採集し，その内部寄生蠕虫の種類とその寄生密度を検討した．その結果，*Pallisentis nagpurensis* (67.99%), *Euclinostomum heterostomum* (17.47%), *Senga* sp. (10.96%), *Allocreadium* sp. (1.57%), *Isoparorchis hypselobagri* (1.16%) および *Clinostomum giganticum* (0.82%) の6蠕虫がみとめられ，その感染は雌で9～12月，雄で10～1月に低く，また雌で1～8月，雄で2～9月に高かった．一方，この6蠕虫についての相互関係をも検討した．