

Helminth Infracommunities in Anuran Amphibia of Nagaland, India

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The prevalence, intensity and species richness of helminth parasites in the anuran host species from climatically varying regions of Nagaland, North-east India were studied and the helminth spectrum analysed with regard to the host, its sex and locality. The study revealed that the richest species composition of helminths occurs in anuran hosts of Dimapur that represents a tropical locale, followed by Mokokchung and Kohima (representing colder and varying altitudinal conditions) in receding order. Of the 13 anuran host species surveyed, *Euphlyctis cyanophlyctis* showed the widest spectrum of helminth parasites, followed by *Polypedates leucomystax*, *Hoplobatrachus tigerinus*, *Rhacophorus nigropalmatus*, *Amolops afghanus*, *Rana sp.* and *Rana khare* in receding order. The occurrence of more helminth species in the anuran hosts of Dimapur and relatively less species in Kohima and Mokokchung has been discussed. Nematodes emerged as the more predominant group among the host species with the more terrestrial or semi aquatic life, whereas the trematodes predominated in those with more aquatic habitat; the monogenean parasite was conspicuously restricted to rhacophorid and hylid hosts dwelling in arboreal habitats.

Key words: Amphibia, Frogs, Helminth, Nagaland, Northeast India, Parasites

The northeastern region of India, known to be an area of high endemism, has a rich diversity of anuran amphibian fauna. Of about 54 species reported from the region, 21 are endemic (Chanda, 1994). Although surveys and geographical studies on helminths of Amphibia are numerous, specific studies pertaining to helminth communities of these hosts relating to the species richness, intensity and diversity of helminth parasites are few (Lees, 1962; Combes, 1968; Plasota, 1969; Hollis, 1972; Frandsen, 1974; Dronen, 1977; Vojtkova, 1982, 1989, 1990; Goater et al., 1987; Aho 1990; Muzzal 1991a,b). In the context of the Indian subcontinent such studies are scanty (Devi and Rao, 1990; Kumari and Madhavi, 1996). In view of their faunal endemism, occurrence of isolationist helminth infections is expected in this region (Diengdoh, 1989; Diengdoh and Tandon, 1991).

Therefore, the present study was taken up with the objective of revealing the diversity of helminth infracommunities of anuran Amphibia of Nagaland State and compare the same with that reported in the amphibian hosts from elsewhere in the country.

MATERIAL AND METHODS

Study area

The study comprises three major localities in the state of Nagaland, which offer varied climatic conditions which are expected to have an impact on the prevalence and abundance of both amphibian hosts and their parasitic fauna (Fig. 1). The climate of Nagaland is 'modified tropical monsoon type' with an average annual rainfall of 250 cm (Husain, 1988); every elevation of the region having its own characteristics has distinctive variations of temperature that differ from altitude to altitude (ranging from 196-3800 m ASL).

Of the localities under survey, Kohima (which is the state capital and district headquarters) lies at the foot

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hill of Japfu peak, covering an altitudinal range of 1444.12- 1590 m ASL, has high rainfall (120-250 cm annually) with relative humidity varying between 60 and 78% during the warm and monsoon rain months (March-May, June-October) of summer and between 40 and 60% during the peak winter months, and mild temperature in summer ranging from 10-30°C and very cold in winter, ranging from 1-6°C. Mokokchung, situated in the north-east part of Kohima, is another district headquarters; its altitude ranges from 1000-1400 m ASL, with somewhat similar rainfall and humidity conditions as in Kohima, the rainy season starts from the month of May and generally lasts till October, sometimes extending even till December, and the temperature is mild to cold through the year, ranging from 8.6- 35°C. Dimapur, another district headquarters and a fast growing commercial town, is identical to any of the low lying tropical plains with an altitude ranging between 195- 260 m ASL and has

humid, hot climate for most part of the year.

Hosts collected/surveyed

A large number of anuran frog species are edible and are, therefore, collected from nature and sold by the natives in Nagaland. The anuran hosts (13 species under 6 genera representing 3 families) were thus randomly collected and surveyed for helminth infection mostly between March and October during 1995-1997 and their localities are given in Table I. The host species were identified following Chanda (1994) and Dutta (1997).

Methodology

Under confinement the anurans do not feed and they tend to get rid of their worm burden (Smyth and Smyth, 1980). Therefore, immediately after the catch the frogs were autopsied and their various organs examined. The recovered parasites were processed following

Table I : Host species surveyed for helminth parasites in Nagaland

| Host species | Locality (number of host examined) | | |
|---|------------------------------------|---------|------------|
| | Kohima | Dimapur | Mokokchung |
| <i>Euphlyctis cyanophlyctis</i> (Schneider) Dubois | 60 | 108 | 50 |
| <i>Limnodynastes limnocharis</i> (Gravenhorst) | 20 | 5 | 15 |
| <i>L. mawphlangensis</i> (Pillai & Chanda) | - | - | 2 |
| <i>Rhacophorus nigropalmatus</i> Boulenger | 4 | - | 40 |
| <i>R. reinwardtii</i> Kuhl & Van Hasselt | 8 | - | - |
| <i>Polypedates leucomystax</i> (Gravenhorst) | 25 | 25 | 47 |
| <i>Hyla annectens</i> Jerdon | 79 | - | - |
| <i>Rana liebighii</i> Gunther | 1 | - | - |
| <i>R. nagalandensis</i> Kiyasetuo | - | - | 18 |
| <i>R. khare</i> Kiyasetuo & Khare | - | - | 10 |
| <i>Rana</i> sp. | - | 43 | - |
| <i>Amolops afghanus</i> (Günther) | - | - | 23 |
| <i>Hoplobatrachus tigerinus</i> (Daudin) | - | 23 | - |

standard methods of fixation and preservation. Identification of the parasites is based on Yamaguti (1958, 1959, 1961, 1963a, b, 1971) and CIH keys (nos. I-X) of nematode parasites of vertebrates.

The data were analyzed following Margolis et al. (1982) and Muzzal (1991a, b). Prevalence is the percentage of host individuals infected in a sample of host species examined. Intensity is the number of individuals of a particular parasite species in each infected host. Mean Intensity represents the mean number of individuals of a particular parasite species per infected host, whereas abundance is the mean number of individuals of a particular parasite species per host examined. Species richness is the number of helminth species per host. Similarity index of parasite species between the various host species was calculated following Sørensen's formula as given by Odum (1971).

Voucher specimens of the parasite species appearing to be new (e.g. *Cryptotropa* sp. and *Batrachotrema* sp.) have been deposited in the helminthological collection of the Zoological Survey of India, Kolkata and their account is being published separately.

RESULTS

Altogether six hundred and six anuran hosts (frogs) comprising 13 species falling under 3 families and 8 genera from Nagaland were examined for helminth infection in the survey. The collection comprised a total of 204 anuran hosts representing 5 species from Dimapur, 197 hosts representing 7 species from Kohima, and 205 hosts representing 8 species from Mokokchung (Table I). Of the 13 host species, only 3 were found common to all the 3 localities and only 1 was found to occur throughout the year in the 3 localities surveyed. The frog hosts from all the localities were found infected with at least 1 or more of the 28 helminth parasites recovered (12 trematodes, 2 metacercarial stages, 2 cestodes including 1 adult form and 1 plerocercoid larva, 11 nematodes and 1 acanthocephalan (Table II).

Data pertaining to the locality and host-wise prevalence and intensity of the parasite species recovered during the study are presented in Tables III, V and VII. Similarity indices of parasite species in relation to the various host species from the three localities surveyed are given in Tables IV, VI and VIII

and the parasite species richness is presented in Table IX.

Euphlyctis cyanophlyctis, occurring in all 3 localities, exhibited the widest spectrum of helminth parasites represented by altogether 16 species and 4 groups, excluding Monogenea. The spectrum included 7 trematode (5 in adult stage and 2 metacercarial stages), 2 cestode, 6 nematode and 1 acanthocephalan species. Of the 3 localities studied, *E. cyanophlyctis* in Dimapur had the highest number of species in comparison with the other two localities and lacked *Cathaemasia* sp. metacercaria and *O. gozei*; this host in Kohima harboured 10 species and did not include *G. ellipticum*, *H. mehransis*, metacercaria of *Proalarioides* sp., *Icosiella* sp. 1 and *Kalicephalus* sp. Here also, the female frogs showed higher prevalence of trematode and cestode infections, occurring equally in male and female hosts. In Mokokchung only 6 species were represented, 2 trematode, 2 nematode, 1 plerocercoid larva and 1 acanthocephalan. Six trematode species, 1 plerocercoid larva and 4 nematode species were found parasitizing *E. cyanophlyctis* of Dimapur. All the trematode species and the plerocercoid larva showed a higher prevalence in female hosts and the same was true for nematode species except *Aplectana* sp. 1 and *A. bifonis* which showed an equal prevalence in males and females. *H. mehransis* was recovered from only 2 female hosts. In Mokokchung also both the trematodes showed higher prevalence in females. Only females were found infected by plerocercoid larva. Out of 108 hosts examined in Dimapur, 6 were found infected with 1, 13 with 2, 5 with 3, 1 with 4, 6 with 5 and 1 with 7 species, respectively. In Kohima, out of the 60 hosts 6 were with 1, 2 with 2, 6 with 3, 7 with 4, 5 with 5 and 1 with 6 species, respectively, the rest being uninfected. In Mokokchung, 5 hosts were found infected with 1, 15 with 2, 8 with 3, 3 with 4 and 5 with 5 species of parasites out of the 50 hosts examined.

L. limnocharis was collected from all the 3 localities surveyed and everywhere only 2 species, *G. tigrinum* and *Oxysomatium* sp., were found parasitizing this host. In Dimapur only 2 males were found infected by *G. tigrinum* and in Kohima and Mokokchung its infection was more prevalent in female hosts. *Oxysomatium* sp. showed more preference for male hosts in Dimapur and Kohima than for males in

Table II : Helminth parasites and their anuran hosts* in Nagaland

| Parasite Species | a | b | c | d | e | f | g | h | i | j | k | l | m |
|-----------------------------------|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Monogenea : | | | | | | | | | | | | | |
| <i>Polystoma indicum</i> | - | - | - | - | - | - | - | - | - | + | + | - | + |
| Trematode Adult | | | | | | | | | | | | | |
| <i>Gorgoderina ellipticum</i> | - | - | - | - | - | - | - | + | - | - | - | - | - |
| <i>Diplodiscus amphichrus</i> | - | - | - | - | - | - | - | + | - | - | + | - | - |
| <i>Diplodiscus mehrai</i> | - | - | - | - | - | - | - | + | - | - | - | - | - |
| <i>Halipegus mehransis</i> | - | - | - | - | - | - | - | - | - | - | - | - | + |
| <i>Mesocoelium monas</i> | - | - | - | - | - | - | - | - | + | - | - | - | - |
| <i>Cryptotropa sp.</i> | - | - | + | - | - | + | + | + | - | - | - | - | + |
| <i>Ganeo tigrinum</i> | - | - | - | + | - | + | + | + | - | - | - | - | - |
| <i>Haematoloechus almorai</i> | - | - | - | + | - | - | + | + | + | - | - | - | - |
| <i>Pleurogenoides gastroporus</i> | + | - | - | - | - | - | + | - | + | - | - | - | - |
| <i>Batrachotrema sp.</i> | + | - | - | - | - | - | + | - | - | - | - | - | - |
| <i>Mehraorchis ranarum</i> | - | - | - | - | - | - | + | - | - | - | - | - | - |
| Trematode: Metacercaria | | | | | | | | | | | | | |
| <i>Cathaemasia sp.</i> | - | - | - | - | - | - | - | + | - | - | - | - | - |
| <i>Proalarioides sp.</i> | - | - | - | - | - | - | - | + | - | - | - | - | - |
| Cestode: | | | | | | | | | | | | | |
| <i>Baerietta baeri</i> | - | - | - | - | - | - | - | + | - | + | - | - | - |
| <i>Plerocercoid larva</i> | - | - | - | + | - | - | + | + | - | - | + | + | + |
| Nematode: | | | | | | | | | | | | | |
| <i>Aplectana sp. 1</i> | + | + | - | + | + | - | + | + | + | - | + | - | + |
| <i>Aplectana sp. 2</i> | - | - | - | - | - | - | - | - | - | - | + | + | + |
| <i>Oxysomatium sp.</i> | + | + | - | + | + | + | + | - | - | + | + | - | + |
| <i>Cosmocercella sp.</i> | - | - | - | - | - | - | - | + | + | + | + | + | + |
| <i>Rhabdias ranae</i> | + | - | - | - | - | - | - | + | - | - | - | - | - |
| <i>Oswaldocruzia goezei</i> | - | - | - | - | - | - | - | - | + | - | - | - | - |
| <i>Ophidascaris sp.</i> | - | - | - | - | - | - | + | - | - | - | - | - | - |
| <i>Amplificaecum sp.</i> | - | - | - | - | - | - | - | + | - | - | - | - | + |
| <i>Icosiella sp.1</i> | - | - | - | + | - | - | - | - | + | - | - | - | - |
| <i>Icosiella sp.2</i> | - | - | - | - | - | - | - | + | - | - | - | - | + |
| <i>Kalicephalus sp.</i> | - | - | - | - | - | - | - | + | - | - | - | - | - |
| Acanthocephala: | | | | | | | | | | | | | |
| <i>Acanthocephalus bufonis</i> | - | - | - | + | - | - | + | + | - | - | - | - | + |

*a= *R. khare*, b= *R. nagalandensis*, c= *R. liebigii*, d= *Rana sp.*, e= *L. mawphlangensis*, f= *L. limnocharis*, g= *H. tigrinus*, h= *E. cyanophlyctis*, i= *A. afghanus*, j= *H. annectens*, k= *R. nigropalmatus*, l= *R. reinwardtii*, m= *P. leucomystax*

. New host record

Mokokchung. Out of the 5 *L. limnocharis* examined from Dimapur, 1 was infected with 1 and 2 with 2 species. In Kohima of the 20 hosts examined, 7 were with 7 and 2 with 2 species and in Mokokchung 2 were with 1 and 2 with 2 species out of the 15 hosts examined.

L. mawphlangensis, only 2 male specimens of which were collected from Mokokchung, had only nematode infection by 2 species.

Rhacophorus nigropalmatus, available only in

Kohima and Mokokchung sites, exhibited parasitisation by 8 helminth species in all. The spectrum of parasites in *R. nigropalmatus* in Kohima included the monogenean, *P. indicum* and 2 nematodes, whereas in Mokokchung frogs it was represented by one trematode, plerocercoid larva and 4 nematode species in addition to *P. indicum*. This frog species had 1 male infected by *P. indicum* in Kohima. In Mokokchung male frogs showed a higher prevalence than the female both for *P. indicum* and *D. amphichrus*; *Oxysomatium sp.* was equally prevalent

in the two sexes. For *R. ranae* males had higher prevalence than females in Kohima. In Mokokchung the male frogs had a higher prevalence of plerocercoid larva and all the nematode species, except *Cosmocercella* sp. Only 4 hosts were examined from Kohima and out of these 2 were infected with 1, 1 with 2 and 1 with 3 species. Of the 40 hosts examined from Mokokchung, 2 were infected with 2, 2 with 3, 4 with 4, 4 with 5 and 1 with 6 parasite species.

Rhacophorus reinwardtii, collected only from sites in Kohima showed a relatively poor parasite spectrum comprising only 2 forms, plerocercoid larva and the nematode, *R. ranae*. Only 1 male was infected by the plerocercoid larva; *R. ranae* was equally prevalent in male and female hosts. Out of the 8 hosts examined, 1 was infected with 1 helminth species and 1, with 2.

Polypedates leucomystax was available in all the 3

localities under study and showed a rich parasitic fauna comprising 13 species, representing all the 5 groups of helminth parasites. In Mokokchung the acanthocephalan group was conspicuous by its absence. In Kohima this host had only 1 male infected by *M. monas*; *Aplectana* sp.1 was recovered from 2 female hosts. *Aplectana* sp.2 was prevalent in both males and females; *Oxysomatium* sp. and *R. ranae* showed higher prevalence in male than in female. The same host in Dimapur had only 1 male infected with *G. tigrinum*; the plerocercoid larva showed higher prevalence in male than in female and so did all the 4 nematode species and *A. bufonis*. The prevalence trend for nematodes was somewhat different in Mokokchung; *Aplectana* sp.1 and *R. ranae* showed less prevalence in male than in female, while *Aplectana* sp.2 showed higher prevalence in female than in male and both sexes showed an equal

Table III: Prevalence and intensity of helminth parasites in anuran hosts in Kohima (1444.12-1590 m ASL), Nagaland

| Host (No. examined) | Parasite (No. of hosts infected) | Prevalence % (M/F)* | Total no. of parasite recovered | Intensity | Mean Intensity \pm S.D. | Abundance \pm S.D. | Median value for Frequency |
|------------------------------|----------------------------------|---------------------|---------------------------------|-----------|---------------------------|----------------------|----------------------------|
| <i>E. cyanophlyctis</i> (60) | <i>D. mehrai</i> (13) | 21.68 (38.4/61.5) | 30 | 2-6 | 2.3 \pm 1.15 | 0.5 \pm 1.08 | 2 |
| | <i>G. tigrinum</i> (20) | 33.3 (30/70) | 79 | 1-11 | 3.95 \pm 3.84 | 1.31 \pm 2.87 | 2 |
| | <i>H. almorai</i> (15) | 25 (40/60) | 42 | 1-6 | 2.8 \pm 1.74 | 0.7 \pm 1.48 | 2 |
| | <i>Cathaemasia</i> sp. (2) | 3.3 (0/100) | 6 | 2-4 | 3 \pm 1 | 0.1 \pm 0.58 | 3 |
| | <i>B. baeri</i> (2) | 3.33 (50/50) | 11 | 2-9 | 5.5 \pm 3.5 | 0.18 \pm 1.18 | 5.5 |
| | Plerocercoid (5) | 8.3 (20/80) | 8 | 1-4 | 1.6 \pm 1.34 | 0.13 \pm 0.57 | 1 |
| | <i>Aplectana</i> sp. 1 (2) | 3.33 (100/0) | 3 | 1-2 | 1.5 \pm 0.5 | 0.05 \pm 0.28 | 1.5 |
| | <i>Oxysomatium</i> sp. (15) | 25 (26.6/73.3) | 26 | 1-7 | 1.7 \pm 1.67 | 0.43 \pm 1.11 | 1 |
| | <i>O. goezei</i> (4) | 6.6 (50/50) | 17 | 2-7 | 4.2 \pm 2.2 | 0.23 \pm 1.18 | 4 |
| | <i>A. bufonis</i> (2) | 3.33 (100/0) | 2 | 1 | 1 | 0.03 \pm 0.26 | 1 |
| <i>L. limnocharis</i> (20) | <i>G. tigrinum</i> (3) | 16 (33.3/66.6) | 11 | 3-4 | 3.6 \pm 0.58 | 0.55 \pm 1.36 | 4 |
| | <i>Oxysomatium</i> sp. (8) | 40 (75/25) | 25 | 2-6 | 3.1 \pm 1.46 | 1.25 \pm 1.8 | 2.5 |
| <i>R. nigropalmatus</i> (4) | <i>P. indicum</i> (1) | 25 (100/0) | 4 | 4 | 4 | 1.0 \pm 2 | - |
| | <i>Oxysomatium</i> sp. (2) | 50 (50/50) | 8 | 2-6 | 4 \pm 2 | 2.0 \pm 2.8 | 4 |
| | <i>R. ranae</i> (3) | 75 (66.6/33.3) | 8 | 2-4 | 2.6 \pm 1.5 | 2.0 \pm 1.63 | 2 |
| <i>R. reinwardtii</i> (8) | Plerocercoid (1) | 12.5 (100/0) | 1 | 1 | 1 | 0.12 \pm 0.35 | - |
| | <i>R. ranae</i> (2) | 25 (50/50) | 3 | 1-2 | 1.5 \pm 0.5) | 0.37 \pm 0.74 | 1.5 |
| <i>P. leucomystax</i> (25) | <i>M. monas</i> (1) | 4 (0/100) | 2 | 2 | 2 | 0.08 \pm 0.4 | - |
| | <i>Aplectana</i> sp. 1 (2) | 8 (0/100) | 10 | 4-6 | 5 \pm 1 | 0.4 \pm 1.41 | 5 |
| | <i>Aplectana</i> sp. 2 (2) | 8 (50/50) | 5 | 2-3 | 2.5 \pm 0.5 | 0.2 \pm 0.71 | 2.5 |
| | <i>Oxysomatium</i> sp. (10) | 40 (60/40) | 17 | 1-6 | 1.7 \pm 1.64 | 0.68 \pm 1.23 | 1 |
| | <i>R. ranae</i> (6) | 24 (66.6/33.3) | 15 | 2-5 | 2.5 \pm 1.22 | 0.6 \pm 1.22 | 2 |
| <i>H. annectens</i> (79) | <i>P. indicum</i> (7) | 8.86 (57.1/42.8) | 21 | 2-6 | 3 \pm 1.41 | 0.26 \pm 0.94 | 3 |
| | <i>B. baeri</i> (10) | 12.65 (40/60) | 12 | 1-2 | 1.2 \pm 0.42 | 0.15 \pm 0.43 | 1 |
| | <i>Oxysomatium</i> sp. (12) | 15.18 (58.3/41.6) | 36 | 1-7 | 3 \pm 1.83 | 0.45 \pm 1.3 | 2.5 |
| | <i>R. ranae</i> (20) | 25.31 (60/40) | 57 | 1-7 | 2.8 \pm 2.28 | 0.72 \pm 1.68 | 2 |
| <i>R. leibigii</i> (1) | <i>Cryptotropa</i> sp. (1) | - | 6 | 6 | 6 | - | - |

* M = male; F = female

prevalence of *Cosmocercella* sp. In Dimapur 25 hosts were examined and of these, 2 had infection with 1 species of helminth parasites, 4 with 2, 3 with 3, 3 with 4 and 1 with 5. In Kohima out of the 25 hosts, 4 had infection with 1, 4 with 2, 1 with 4 and 1 with 5 species, respectively. Out of 47 hosts examined in Mokokchung, 10 had infection with 1, 3 with 2, 3 with 4, 7 with 5 and 3 with 6 parasites species.

Hyla annectens, collected only from Kohima, had monogenean, cestode and nematode species constituting its parasitic spectrum. The monogenean and nematode parasites had more prevalence in male hosts than females, but the opposite was true for the cestode. Out of the 79 hosts examined 3 were infected with 1, 4 with 2, 7 with 3, 4 with 4 and 1 with 5 species.

R. liebigii, a single specimen of which could be examined from Kohima, harboured only 1 trematode species, *Cryptotropa* sp., a representative of Lecithodendriidae.

R. nagalandensis, also found to be occurring in Mokokchung alone, had only nematode infection by 2 species. Both the nematode species showed more prevalence in male hosts than in females. Out of the 18 hosts examined, 10 were found infected by at least 1 or more of the helminth parasites. Six hosts were found infected by 1 and 4, with 2 species.

R. khare, which was available only in Mokokchung had a representation of 5 helminth species that include 2 trematode and 3 nematode species. The male hosts had higher prevalence for *P. gastroporus* than females. Only 1 specimen of *Batrachotrema* sp. was recovered from a female host. The nematodes, *Oxysomatium* sp. and *R. ranae*, showed more prevalence in male as compared to the female host. Out of the 10 host

specimens examined, 2 were infected with only 1 species, 1 with 3, 2 with 2, 1 with 4 species of parasites and the remaining 4 hosts were uninfected.

A species of the genus *Rana* from Dimapur, designated herein as *Rana* sp., showed a wider parasite spectrum represented by all the helminth groups except Monogenea and included 2 trematode and 3 nematode species. The trematodes showed more preference for male hosts. Regarding the 3 nematode species, the female hosts showed a higher prevalence of *Aplectana* sp.1, while the infection of *Icosiella* sp.1 was more prevalent among the male hosts. A plerocercoid cestode larva and *Acanthocephalus bufonis* also parasitised *Rana* sp. Male hosts had more infection by plerocercoid cestode larva than the female; the opposite was true for *A. bufonis*. Out of the 43 hosts examined, 24 were found infected, of which 2 hosts had infection with 1, 9 with 2, 8 with 3, 4 with 4 and 1 with 5 parasite species.

Amolops afghanus, collected only from Mokokchung, harboured 7 helminth species, 3 trematode and 4 nematode. The trematodes showed more preference for male host. *Aplectana* sp.1 was equally shared between the male and female hosts. *R. ranae* had more prevalence for male, whereas *Ophidascaris* sp. and *Icosiella* sp.2 for female hosts. Of the 23 hosts examined, only 2 were found with only 1, 1 with 2, 2 with 3 and 1 with 4 species of parasites.

Hoplobatrachus tigerinus, collected from Dimapur only, exhibited a wide spectrum of parasites that included 4 trematode, 4 nematode and 1 acanthocephalan species beside the cestode plerocercoid larva. All the trematode species had more prevalence in female hosts than the male. Occurrence of yet another trematode, *Mehraorchis*

Table IV : Similarity index of parasite species among host species from Kohima

| Host species | E. cyanophlyctis | L. limnocharis | R. nigropalmatus | R. reinwardtii | P. leucomystax | H. annectens | R. liebigii |
|------------------|---------------------|-------------------|---------------------|-------------------|-------------------|-----------------|----------------|
| E. cyanophlyctis | | 0.33 | 0.15 | 0.17 | 0.27 | 0.28 | - |
| L. limnocharis | 0.33 | | 0.4 | - | 0.28 | 0.33 | - |
| R. nigropalmatus | 0.15 | 0.4 | | 0.4 | 0.5 | 0.86 | - |
| R. reinwardtii | 0.17 | - | 0.4 | | 0.28 | 0.33 | - |
| P. leucomystax | 0.27 | 0.28 | 0.5 | 0.28 | | 0.44 | - |
| H. annectens | 0.28 | 0.33 | 0.86 | 0.33 | 0.44 | | - |

Table V : Prevalence and intensity of helminth parasites in anuran hosts in Mokokchung (1000-1400 m ASL), Nagaland

| Host (no. examined) | Parasite (no. of host infected) | prevalence (% M/F) | Total no. of parasites recovered | Intensity | Mean Intensity \pm S.D. | Abundance \pm S.D. | Median value for Frequency | |
|-------------------------------|---------------------------------|-----------------------------|----------------------------------|-----------|---------------------------|----------------------|----------------------------|-----|
| <i>E. cyanophlyctis</i> (50) | <i>G. tigrinum</i> (10) | 20(20/80) | 27 | 1-7 | 2.7 \pm 2.36 | 0.54 \pm 1.49 | 1.5 | |
| | <i>H. almorai</i> (30) | 60(33.3/66.6) | 102 | 1-22 | 3.4 \pm 4.16 | 2.04 \pm 3.58 | 2 | |
| | Pterocercoid (3) | 6(0/100) | 7 | 2-3 | 2.3 \pm 0.58 | 0.14 \pm 0.57 | 2 | |
| | <i>Aplectana</i> sp. 1(4) | 8(50/50) | 20 | 2-6 | 5 \pm 2 | 0.4 \pm 1.46 | 6 | |
| | <i>Oxysomatium</i> sp. (12) | 24(0/100) | 33 | 1-12 | 2.7 \pm 3.14 | 0.66 \pm 1.9 | 2 | |
| <i>A. bufonis</i> (1) | 2(100/0) | 1 | 1 | 1 | 0.02 \pm 0.14 | - | | |
| <i>L. limnocharis</i> (15) | <i>G. tigrinum</i> (3) | 20(33.3/66.6) | 10 | 2-4 | 3.33 \pm 1.15 | 0.66 \pm 1.45 | 4 | |
| | <i>Oxysomatium</i> sp. (5) | 33.3(33.3/66.6) | 17 | 2-5 | 3.5 \pm 1.82 | 1.13 \pm 1.19 | 4 | |
| <i>L. mawphalangensis</i> (2) | <i>Aplectana</i> sp. 1(1) | 50(100/0) | 6 | 6 | 6 | 3 \pm 3 | - | |
| | <i>Oxysomatium</i> sp. (1) | 50(100/0) | 7 | 7 | 7 | 3.5 \pm 3.5 | - | |
| <i>R. nigropalmatus</i> (40) | <i>P. indicum</i> (10) | 25(70/30) | 30 | 2-6 | 3 \pm 0.84 | 0.75 \pm 1.38 | 2 | |
| | <i>D. amphichirus</i> (6) | 15(66.6/33.3) | 22 | 2-7 | 3.66 \pm 2.58 | 0.55 \pm 1.62 | 2 | |
| | Pterocercoid (3) | 7.5(66.6/33.3) | 11 | 2-6 | 3.66 \pm 2.08 | 0.27 \pm 1.08 | 3 | |
| | <i>Aplectana</i> sp. 1(7) | 17.5(71.4/28.5) | 19 | 1-7 | 2.7 \pm 2.63 | 0.47 \pm 1.47 | 1 | |
| | <i>Aplectana</i> sp. 2 (5) | 12.5(60/40) | 10 | 1-4 | 2 \pm 1.22 | 0.25 \pm 0.82 | 2 | |
| | <i>Oxysomatium</i> sp. (5) | 12.5(60/40) | 9 | 1-3 | 1.8 \pm 0.84 | 0.22 \pm 0.66 | 2 | |
| | <i>Cosmocercella</i> sp. (4) | 10.0(50/50) | 16 | 1-5 | 4 \pm 2 | 0.4 \pm 1.34 | 5 | |
| | <i>R. ranae</i> (11) | 27.5(63.6/36.3) | 22 | 1-4 | 2 \pm 1.18 | 0.55 \pm 1.08 | 2 | |
| | <i>P. leucomystax</i> (47) | <i>P. indicum</i> (4) | 8.5(50/50) | 13 | 2-6 | 3.25 \pm 1.89 | 0.27 \pm 1.04 | 2.5 |
| | | <i>D. amphichirus</i> (6) | 12.7(83.3/16.6) | 16 | 1-5 | 2.68 \pm 1.97 | 0.22 \pm 1.11 | 2 |
| <i>M. monas</i> (4) | | 8.5(75/25) | 6 | 1-3 | 1.5 \pm 1 | 0.08 \pm 0.49 | 1 | |
| <i>G. tigrinum</i> (7) | | 14.8(71.4/28.5) | 22 | 2-6 | 3.14 \pm 1.34 | 0.46 \pm 1.23 | 3 | |
| Pterocercoid (23) | | 48.9(56.5/43.4) | 89 | 2-18 | 3.86 \pm 3.87 | 1.89 \pm 3.32 | 2 | |
| <i>Aplectana</i> sp. 1(10) | | 21.2(70/30) | 35 | 1-11 | 3.5 \pm 2.95 | 0.74 \pm 1.95 | 2.5 | |
| <i>Aplectana</i> sp. 2(7) | | 14.8(42.8/57.1) | 20 | 1-6 | 2.8 \pm 1.86 | 0.42 \pm 1.23 | 2 | |
| <i>Cosmocercella</i> sp. (4) | | 8.5(50/50) | 12 | 2-6 | 3.0 \pm 2 | 0.25 \pm 0.98 | 2 | |
| <i>R. ranae</i> (13) | | 27.8(63.6/36.3) | 35 | 1-6 | 2.6 \pm 1.79 | 0.74 \pm 1.52 | 2 | |
| <i>R. nagalandensis</i> (18) | | <i>Aplectana</i> sp. 1(4) | 22.2(75/25) | 13 | 2-6 | 3.25 \pm 1.89 | 0.72 \pm 1.60 | 2.5 |
| | | <i>Oxysomatium</i> sp. (10) | 55.5(60/40) | 25 | 1-5 | 2.5 \pm 1.43 | 0.88 \pm 1.64 | 2 |
| <i>R. khare</i> (10) | <i>P. gastroporus</i> (3) | 30(66.6/33.3) | 9 | 2-5 | 3 \pm 1.73 | 0.9 \pm 1.66 | 2 | |
| | <i>Batrachotrema</i> sp. (1) | 10(0/100) | 1 | 1 | 1 | 0.1 \pm 0.32 | - | |
| | <i>Aplectana</i> sp. 1(3) | 30(33.3/66.6) | 8 | 1-5 | 2.66 \pm 2.08 | 0.8 \pm 1.62 | 2 | |
| | <i>Oxysomatium</i> (3) | 30(66.6/33.3) | 13 | 2-6 | 4.3 \pm 2.08 | 1.3 \pm 2.31 | 5 | |
| | <i>R. ranae</i> (4) | 40(75/25) | 9 | 1-3 | 2.25 \pm 0.96 | 0.9 \pm 1.29 | 2.5 | |
| <i>Amolops afghanus</i> (23) | <i>Cryptotropa</i> sp. (3) | 13(66.6/33.3) | 21 | 1-18 | 7 \pm 9.54 | 0.91 \pm 3.75 | 2 | |
| | <i>P. gastroporus</i> (5) | 21(60/40) | 8 | 1-3 | 1.6 \pm 0.89 | 0.34 \pm 0.78 | 1 | |
| | <i>Batrachotrema</i> sp. (3) | 13(66.6/33.3) | 7 | 1-4 | 2.33 \pm 1.53 | 0.03 \pm 0.93 | 2 | |
| | <i>Aplectana</i> sp. 1(4) | 17.3(50/50) | 11 | 2-3 | 2.7 \pm 0.50 | 0.47 \pm 1.12 | 3 | |
| | <i>R. ranae</i> (6) | 26(66.6/33.3) | 9 | 1-4 | 1.5 \pm 1.22 | 0.39 \pm 0.78 | 1 | |
| | <i>Ophidascaris</i> (3) | 13(66.6/33.3) | 7 | 1-3 | 2.3 \pm 1.15 | 0.3 \pm 0.87 | 3 | |
| | <i>Icosiella</i> sp. 2 (6) | 26(33.3/66.6) | 12 | 1-3 | 2.0 \pm 0.63 | 0.34 \pm 0.95 | 2 | |

Table VI : Similarity index of parasite species among host species from Mokokchung

| Host species | <i>E. cyanophlyctis</i> | <i>L. limnocharis</i> | <i>L. mawphlangensis</i> | <i>R. nigropalmatus</i> | <i>P. leucomystax</i> | <i>H. annectens</i> | <i>R. liebighii</i> | <i>A. afghanus</i> |
|--------------------------|-------------------------|-----------------------|--------------------------|-------------------------|-----------------------|---------------------|---------------------|--------------------|
| <i>E. cyanophlyctis</i> | - | 0.5 | 0.5 | 0.43 | 0.4 | 0.5 | 0.36 | 0.15 |
| <i>L. limnocharis</i> | 0.5 | - | 0.5 | 0.2 | 0.18 | 0.5 | 0.28 | - |
| <i>L. mawphlangensis</i> | 0.5 | 0.5 | - | 0.4 | 0.18 | 1 | 0.28 | 0.22 |
| <i>R. nigropalmatus</i> | 0.43 | 0.2 | 0.4 | - | 0.82 | 0.4 | 0.46 | 0.27 |
| <i>P. leucomystax</i> | 0.4 | 0.18 | 0.18 | 0.82 | - | 0.18 | 0.28 | 0.25 |
| <i>R. nagalandensis</i> | 0.5 | 0.5 | 1 | 0.4 | 0.18 | - | 0.57 | 0.22 |
| <i>R. khare</i> | 0.36 | 0.28 | 0.28 | 0.46 | 0.28 | 0.57 | - | 0.67 |
| <i>A. afghanus</i> | 0.15 | - | 0.22 | 0.27 | 0.25 | 0.25 | 0.67 | - |

Table VII : Prevalence and intensity of helminth parasites in anuran hosts in Dimapur (195-260 m ASL), Nagaland

| Host (no. examined) | Parasite (no. of host infected) | Prevalence % (M/F) | Total no. of parasites recovered | Intensity | Mean Intensity \pm S.D. | Abundance \pm S.D. | Median value for Frequency |
|-------------------------------|---------------------------------|--------------------|----------------------------------|-----------|---------------------------|----------------------|----------------------------|
| <i>E. cyanophlyctis</i> (108) | <i>G. ellipticum</i> (3) | 2.7(33.3/66.6) | 5 | 1-2 | 1.66 \pm 0.58 | 0.04 \pm 0.28 | 2 |
| | <i>D. mehrai</i> (7) | 6.4(42.5/57.1) | 31 | 1-8 | 4.42 \pm 2.51 | 0.02 \pm 1.24 | 5 |
| | <i>H. mehransis</i> (2) | 1.8(0/100) | 5 | 2-3 | 2.5 \pm 0.5 | 0.46 \pm 0.34 | 2.5 |
| | <i>G. tigrinum</i> (13) | 12(38.4/61.5) | 53 | 2-8 | 4.07 \pm 2.25 | 0.49 \pm 1.53 | 3 |
| | <i>H. almorai</i> (30) | 27.7(33.3/66.6) | 72 | 1-8 | 2.4 \pm 1.54 | 0.66 \pm 1.33 | 2 |
| | <i>Proalarioides sp.</i> (5) | 4.6(20/80) | 20 | 1-7 | 4 \pm 2.23 | 0.18 \pm 0.95 | 4 |
| | Plerocercoid larva (8) | 7.4(37.5/62.5) | 11 | 1-3 | 1.25 \pm 0.74 | 0.1 \pm 0.41 | 1 |
| | <i>Aplectana sp.</i> 1(10) | 9.2(50/50) | 23 | 1-5 | 2.3 \pm 1.57 | 0.21 \pm 0.81 | 2 |
| | <i>Oxysomatium sp.</i> (15) | 13.8(20/80) | 45 | 1-7 | 3 \pm 2 | 0.41 \pm 1.27 | 3 |
| | <i>Icosiella sp.</i> 1(3) | 2.7(33.3/66.6) | 8 | 2-4 | 2.6 \pm 1.15 | 0.07 \pm 0.47 | 2 |
| | <i>Kalicephalus sp.</i> (5) | 4.6(20/80) | 22 | 2-8 | 4.4 \pm 2.3 | 0.2 \pm 1.03 | 4 |
| | <i>A. bufonis</i> (6) | 5.5(50/50) | 10 | 1-3 | 1.66 \pm 0.82 | 0.04 \pm 0.42 | 1.5 |
| <i>L. limnocharis</i> (5) | <i>G. tigrinum</i> (2) | 40(100/0) | 5 | 2-3 | 2.5 \pm 0.5 | 1 \pm 1.41 | 2.5 |
| | <i>Oxysomatium sp.</i> (3) | 60(66.6/33.3) | 15 | 1-7 | 5 \pm 2.64 | 3 \pm 3.31 | 6 |
| <i>P. leucomystax</i> (25) | <i>G. tigrinum</i> (2) | 8(100/0) | 6 | 2-4 | 3 \pm 1 | 0.29 \pm 0.88 | 3 |
| | Plerocercoid (12) | 48(75/25) | 19 | 1-7 | 1.5 \pm 1.73 | 0.17 \pm 1.45 | 1 |
| | <i>Oxysomatium sp.</i> (5) | 28(71.4/28.5) | 17 | 1-4 | 2.4 \pm 0.98 | 0.68 \pm 1.22 | 2 |
| | <i>R. ranae</i> (3) | 12(66.6/33.3) | 14 | 2-6 | 4.6 \pm 2.31 | 0.56 \pm 1.68 | 6 |
| | <i>Icosiella sp.</i> 1(2) | 8(100/0) | 8 | 4 | 4 | 0.32 \pm 1.11 | 4 |
| | <i>Kalicephalus sp.</i> (4) | 16(75/25) | 12 | 2-4 | 3 \pm 0.82 | 0.48 \pm 1.16 | 3 |
| <i>Rana sp.</i> (43) | <i>A. bufonis</i> (6) | 24(66.6/33.3) | 19 | 2-6 | 3.16 \pm 1.60 | 0.76 \pm 1.56 | 2.5 |
| | <i>G. tigrinum</i> (21) | 48.8(52.3/47.6) | 92 | 1-11 | 4.38 \pm 2.65 | 2.13 \pm 2.87 | 4 |
| | <i>H. almorai</i> (10) | 23.2(60/40) | 25 | 1-6 | 2.5 \pm 1.78 | 0.58 \pm 1.34 | 2 |
| | Plerocercoid (7) | 16.2(71.4/28.5) | 10 | 1-2 | 1.42 \pm 0.53 | 0.23 \pm 0.57 | 1 |
| | <i>Aplectana sp.</i> 1(5) | 11.6(40/60) | 19 | 2-8 | 3.5 \pm 2.68 | 0.44 \pm 1.48 | 2 |
| | <i>Oxysomatium sp.</i> (8) | 18.6(50/50) | 21 | 1-3 | 2.6 \pm 0.74 | 0.48 \pm 1.08 | 3 |
| | <i>Icosiella sp.</i> 1(7) | 16.2(57.1/42.8) | 15 | 1-3 | 2.1 \pm 0.69 | 0.34 \pm 0.84 | 2 |
| <i>H. tigerinus</i> (23) | <i>A. bufonis</i> (15) | 34.8(46.6/53.3) | 25 | 1-8 | 1.68 \pm 1.29 | 0.58 \pm 1.31 | 1 |
| | <i>G. tigrinum</i> (10) | 43.4(20/80) | 23 | 1-8 | 2.3 \pm 2.26 | 1 \pm 1.86 | 1 |
| | <i>H. almorai</i> (7) | 30.4 (28.5/71.4) | 17 | 1-6 | 2.42 \pm 2.43 | 0.13 \pm 1.56 | 2 |
| | <i>P. gastroporus</i> (3) | 13(33.3/66.6) | 11 | 3-4 | 3.6 \pm 0.58 | 0.41 \pm 1.27 | 4 |
| | Plerocercoid (13) | 56.5(53.8/46.2) | 20 | 1-6 | 1.53 \pm 1.39 | 0.18 \pm 1.29 | 1 |
| | <i>Aplectana sp.</i> 1(5) | 21.7 (40/60) | 10 | 1-3 | 2.0 \pm 0.71 | 0.43 \pm 0.89 | 2 |
| | <i>Oxysomatium sp.</i> (7) | 30.4(57.2/42.5) | 18 | 1-4 | 2.5 \pm 1.13 | 0.18 \pm 1.35 | 2 |
| | <i>R. ranae</i> (4) | 17.3(50/50) | 14 | 2-6 | 3.5 \pm 1.91 | 0.60 \pm 1.53 | 3 |
| | <i>Amplicaecum sp.</i> (1) | 4.3(0/100) | 2 | 2 | 2 | 0.08 \pm 0.42 | - |
| | <i>A. bufonis</i> (3) | 13(33.3/66.6) | 8 | 2-3 | 2.6 \pm 0.58 | 0.34 \pm 0.93 | 3 |

ranarum was also recorded from *H. tigerinus*, but data regarding its prevalence could not be tabulated. The nematode, *Aplectana* sp.1, infected more females than males and *Oxysomatium* sp., more males than females; the prevalence of *R. ranae* was somewhat the same in male and female hosts. Out of the 23 hosts examined, 5 had infection with 1, 2 with 2, 1 with 3, 4 with 4, and 1 with 5 species of parasites and the remaining 10 hosts did not show any infection.

In overall estimation, the trematode and nematode groups emerged as more prevalent among the female hosts in comparison to the male. In all the localities more predilection for female hosts was shown by trematode parasites. However, with regard to plerocercoid infection, prevalence in male and female host did not show a uniform trend; while females in Dimapur had higher prevalence, those in the other two localities had lower than the males.

Of the frog species surveyed, *L. limnocharis*, *E. cyanophlyctis* and *P. leucomystax* were common to all the three localities explored. *E. cyanophlyctis* from Mokokchung showed the highest prevalence of over all helminth infection, and the lowest, in Dimapur area. This frog in Kohima maintained a considerably high prevalence of infection. However, while a higher rate of infection occurred in *L. limnocharis* in Dimapur, a much less prevalence occurred in Mokokchung. The prevalence of helminth parasites in *P. leucomystax* ranged between 40% in Kohima and 62% in Dimapur.

In general, the intensity of infection in all the host species was somewhat low, the range being between 1 and less than 10; only *Haematoloechus almorai*, *G. tigrinum* and plerocercoid larva showed relatively higher range, their maximum number being 22, 11 and 18, respectively recovered from a single host. The mean intensity in respect of all the parasite species was also low.

DISCUSSION

Of the 28 helminth species reported in the present study, 6 trematodes (4 adult and 2 metacercariae) and 5 nematodes are among the 17 species that have hitherto been reported from Amphibia in Meghalaya by Diengdoh (1989). The trematode species, representing the genera *Cryptotropa* and *Batrachotrema* are not reported earlier and this is the first report of their

presence in the Indian sub-continent. In the present study the trematodes and nematodes emerged as the most prevalent helminth groups, followed by cestodes, acanthocephala and monogenea, in the receding order.

The highest prevalence of helminth infection occurred in frogs of Mokokchung (49.26%), followed by Dimapur (41.66 %) and Kohima (35.95%). The topographical and climatic conditions of Mokokchung area might have contributed toward the occurrence of diverse amphibian fauna and their sustained helminth parasitic fauna and also provided congenial environment for the existence of their intermediate hosts (molluscs, insects etc.) in the region. Dimapur, being like any other tropical plain, exhibits the prevalence of the host and parasite species, some of which have a commonality with those occurring in other regions of the study area. The higher altitude with mild to cold climate and high rainfall conditions of Kohima region are perhaps suited to a few amphibian host species and their parasitic fauna.

Of the 13 host species surveyed, 9 represent the family Ranidae, out of which 4 are lentic or still-water-dwelling species. Two of these, *L. limnocharis* and *E. cyanophlyctis* were shared by all the three localities, whereas *H. tigerinus* and *Rana* sp. were restricted to only Dimapur region. *L. limnocharis* from all the sites sustained only two parasite species, one trematode and one nematode both of which showed a higher prevalence in Dimapur region. *E. cyanophlyctis* revealed the highest species composition with 14 helminth species out of the 28 prevalent. Again, this frog species from Dimapur showed the richest parasitic fauna dominated by trematodes, with the nematode, cestode and acanthocephalan groups following in receding order. In *H. tigerinus* both trematode and nematode groups emerged as equally dominant. However, in *Rana* sp. the nematode component predominated over the trematode. The trematode *G. tigrinum* and the nematode *Oxysomatium* sp. were shared by all the lentic ranid hosts. The lung fluke, *H. almorai* and *Aplectana* sp.1 were shared by three host species and *Icosiella* sp.1 was hosted by both *Rana* sp. and *E. cyanophlyctis*. The latter showed a very low species composition in Mokokchung sites. Whereas in Dimapur collections of this host were made from ponds that were not inhabited by any fish, those in Mokokchung were made in two fishery ponds.

Table VIII : Similarity index of parasite species among host species from Dimapur

| Host species | <i>E. cyanophlyctis</i> | <i>L. limnocharis</i> | <i>P. leucomystax</i> | <i>Rana sp.</i> | <i>H. tigerinus</i> |
|-------------------------|-------------------------|-----------------------|-----------------------|-----------------|---------------------|
| <i>E. cyanophlyctis</i> | - | 0.28 | 0.63 | 0.74 | 0.5 |
| <i>L. limnocharis</i> | 0.28 | - | 0.44 | 0.44 | 0.4 |
| <i>P. leucomystax</i> | 0.63 | 0.44 | - | 0.71 | 0.53 |
| <i>Rana sp.</i> | 0.74 | 0.44 | 0.71 | - | 0.67 |
| <i>H. tigerinus</i> | 0.5 | 0.4 | 0.53 | 0.67 | - |

Exclusion of predators increases the abundance of the intermediate hosts for frog species (Morin, 1984). Various ecological factors, both biotic and abiotic, are well known to play an important role in influencing the host-parasite relationship (Kennedy, 1975). *E. cyanophlyctis*, essentially an aquatic species, is an opportunistic and unselective feeder, preying on arthropods and also exhibits cannibalistic habit (Kumar, 1982). Thus, feeding habit may contribute to a richer species composition in *E. cyanophlyctis*. Further, in the present survey the larger *E. cyanophlyctis* were always the adult females (which holds true for many invertebrates and vertebrate animals) and had more species richness. Muzzal (1991a, b), in a study on newts, also observed that the helminth infracommunities become more diverge with increase in length or size of the host, suggestedly resulting from the larger number and wider range of intermediate hosts eaten by larger newts in comparison with smaller ones. The island-size hypothesis of Holmes and Price (1986) also predicts that larger hosts support a richer helminth fauna than smaller ones. The tropical climatic conditions prevailing in Dimapur provide optimum conditions for the propagation of invertebrate host fauna and thus, indirectly for helminth parasites. Hence, not only *E. cyanophlyctis* but also *H. tigerinus* and *Rana sp.* showed a relatively rich species composition. The host species collected from the same water body site did not share all the helminth species. The parasite species composition may also be determined by a predilection for a particular host species, as exemplified by many parasitic species of Amphibia (Waitz, 1959, del Fosse and Whittaker, 1971; Frandsen, 1974).

The ranid frogs viz., *R. khare*, *R. liebighii*, *R. nagalandensis*, *L. mawphalangensis* and *A. afghanus* are known to dwell in lotic system. Except for *R. liebighii*, which was collected from Kohima, the

remaining four species were all from Mokokchung. Their habit and habitat seem to reflect on their parasitic faunal composition. *R. khare*, serving a host for only 2 trematode and 3 nematode species, inhabits strong current water bodies and co-occurs with a variety of fish in the river. Strong water currents may hinder helminth transmission, as a low diversity of helminths was seen in the case of the newt, *Leurognathus marmorata* that inhabits strong current (Aho, 1990). The poor species composition of infection exhibited in *R. nagalandensis* and *L. mawphalangensis* needs to be studied further with a larger sample size. *A. afghanus* had a more diverse helminth fauna including 3 trematode and 4 nematode species. This host was collected from various sites viz., rivers, riverbanks, cliffs, rocks and waterfalls. With adoption to so many habitats, and with more chances of feeding on aerial, terrestrial and aquatic organisms, this host is likely to be exposing itself to a variety of parasites and emerge as harbouring a richer helminth infracommunity among the ranid frogs of the lotic system (Muzzal, 1991a, b).

The hyloid, *H. annectens* and the three rhacophorids represent the arboreal anuran species. Among them the prevalence of infection was more in males than females, perhaps because the males spend more time in or near the water body in the process of making mating calls and thus have more exposure to the infective stages of the parasites. *H. annectens* and *R. nigropalmatus* from Kohima shared 1 monogenean and 2 nematode parasites and harboured no trematode infection. *R. reinwardtii*, also collected from Kohima, but from comparatively higher altitude sites, exhibited a poor infection. *R. nigropalmatus* from Mokokchung, which is warmer than Kohima, showed comparatively higher species composition. *P. leucomystax*, collected from all the localities revealed a high species composition (with 9 helminths) in Dimapur, which

represents the warmest of the three localities under the present study. The low prevalence of helminth infection in this host species from Kohima can be explained by the nature of the collection site; in Kohima *P. leucomystax* was collected from terrace fields, which show a seasonal accumulation of water only during summer, thus affecting the survival of aquatic intermediate hosts of parasites. Even though it is arboreal in habit, *P. leucomystax* from Dimapur shared some parasitic species with *Rana* sp. and *E. cyanophlyctis*. All the helminth species recovered from *R. nigropalmatus* of Mokokchung were shared with *P. leucomystax* of the same locality except for *G. tigrinum* and *M. monas* which were restricted to the latter host species. The polystomatid monogenean was recovered from the rhacophorid hosts of Kohima and Mokokchung only. Though in the present study *R. reinwardtii* did not reveal the presence of *P. indicum*, the juvenile stages of this monogenean have previously been reported from this host by Dutta (1997). The reason for the occurrence of more nematode species in all the arboreal host species can be attributed to their habit, i. e., spending more time in dry land and trees than in water. The present study revealed that the 2 dominant helminth groups are trematode and nematode, which showed an overall higher prevalence among female hosts, though no definite pattern could be seen emerging for cestode parasites. Though several earlier studies indicate towards a positive relationship between the host sex and prevalence of infection (Plasota, 1969), in other studies no such relationship is inferable (Dronen, 1977; Tinsley,

1977). The present study also revealed that the most widely distributed helminth parasites in the anuran host group are the nematodes, present in 12 host species and the trematodes, parasitising 10 hosts; following in the sequence is the plerocercoid larva that utilises as many as 6 species of frogs as paratenic host, whereas the adult cestode, *B. baeri* is prevalent only in two host types; the monogenean representative is exclusively restricted to arboreal species of Rhacophoridae and Hylidae. A high degree of host specificity and restricted geographical distribution exhibited among the polystomatid monogeneans is well documented (Combes and Knoepffler, 1997; Combes and Channing, 1979). Frogs from mainly dry areas would have a predominantly nematode fauna, whereas those from aquatic habitats would have a higher trematode infection (Smyth and Smyth, 1980; Vojtkova, 1982, 1989).

The present study revealed newer host and/or locality records for several helminth species. However, many species (of the genera *Phyllodistomum*, *Prosotochus*, *Megalotriotrema*, *Pleurogenes* and *Laxogenes*) that have been reported from Amphibia in the Indian subcontinent were hitherto not represented in the same hosts in Nagaland.

Of the various components of the parasitic spectrum recorded herein, plerocercoid larva (= sparganum) emerged as the only parasite with a plausible zoonotic potential. Amphibia are implicated as one of the many paratenic hosts for *Spirometra* spp, adults of which are common parasites of feline and canid mammals

Table IX : Helminth species richness of anuran amphibian hosts in Nagaland

| Name of species | Kohima | Mokochung | Dimapur |
|--------------------------|-----------|-----------|-----------|
| <i>E. cyanophlyctis</i> | 1.45±1.91 | 2.32±1.57 | 0.81±1.52 |
| <i>L. limnocharis</i> | 2.65±3.33 | 0.4±0.74 | 1±1 |
| <i>R. mawphlangensis</i> | - | 1±1 | - |
| <i>R. nigropalmatus</i> | 1.75±0.96 | 1.3±2.01 | - |
| <i>R. reinwardtii</i> | 0.37±0.74 | - | - |
| <i>P. leucomystax</i> | 0.84±1.34 | 1.72±2.15 | 1.44±1.66 |
| <i>H. annectens</i> | 0.67±1.32 | - | - |
| <i>R. liebigii</i> | 1 | - | - |
| <i>R. nagalandensis</i> | - | 0.78±0.81 | - |
| <i>R. khare</i> | - | 1.3±1.42 | - |
| <i>Rana</i> sp. | - | - | 1.51±1.55 |
| <i>Amolops afghanus</i> | - | 0.61±1.19 | - |
| <i>H. tigrinus</i> | - | - | 1.43±1.7 |

(Miyazaki, 1991). The present study recorded considerably high intensity and prevalence of plerocercoid larvae in as many as 6 amphibian host species, all of which have a use in traditional medicine or local cuisine among the natives of Nagaland. Highly endemic foci of Amphibia-borne zoonoses, sparganosis in particular, are known to occur among populations in the neighbouring South-east Asian and Far-Eastern countries where similar practices are customary (Mastura et al., 1995). Dissemination of this zoonotic infection among the native population of Nagaland needs to be ascertained.

In view of the endemicity of the amphibian fauna in Northeast India, a further study of hitherto unexploited eastern zone of Nagaland would provide still more information about the diversity of helminth fauna among the anuran hosts of the region.

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