ABSTRACT

During 1978-1986 oceanic squid *Sthenoteuthis oualaniensis* have been studied for parasitic helminths: 303 squid from open waters of the Indian Ocean and 146 squid from nerito-oceanic part of the East Pacific (2°N-12°S). Eleven species of parasitic helminths were recorded: 2 Trematoda species, 5 – Cestoda, 3 – Nematoda and 1 – Acantocephala. All these helminths occurred as larval stages. In each region nine species were found, seven of them being common. The total prevalence of infection was 98.4% in the Indian squids and 71.3% in the Pacific ones. But main helminths of the Indian Ocean had significantly higher infestation parameters (the prevalence 50-95%, the intensity tens and hundreds specimens) while in the Pacific Ocean these values were 20-32% and up to several dozen specimens. There were revealed geographic patterns of helminth fauna changes too. This squid is a member of the complicated and diverse tropho-parasite system that includes the most of ecosystem web at the consumer level. Thus, the revealed differences in parasite fauna and its infestation rates are a sensible indicator of the differences in both trophic and parasite structures in these two ecosystems.

Key words: purpleback squid, *Sthenoteuthis oualaniensis*, parasites as ecosystem indicator

INTRODUCTION

The animal parasites may be used as sensible indicators (= tags) for study the different hierarchic levels of the ecological processes – from cohort and population analyses of hosts till their role in the local ecosystems and macro-biocoenoses (Dogel, 1962; Rohde, 1987; Moser, 1991: Williams et al., 1992). The helminths of cephalopod hosts are a suitable for this aim also. There are many publications on using the parasites for different aspects of cephalopod biology studies (reviews: Hochberg, 1990; Pascual and Hochberg, 1996). However, there are only two papers on the
study of cephalopod parasites as tags of their biocoenotic relationships in different macro-ecosystems for oceanic ommastrephid squids *Ommastrephes bartrami* in North and South Atlantic (Gaevskaya and Nigmatullin, 1976) and *Dosidicus gigas* in Nicaraguan, Equatorial and Peruvian areas in the East Pacific (Shukhalter and Nigmatullin, 2001). The latitude aspect of the squid ecosystem relations variability was analyzed in both these investigations.

*Sthenoteuthis oualaniensis* is an abundant tropical Indo-Pacific oceanic nektonic squid. There are five intraspecific forms that are distinguished by size of adult animals, some morphological and ecological traits, and geographical distribution. The most numerous and widely distributed is the middle-sized late-maturing form with one year life cycle. Its range coincides with the species range. Mantle length (ML) of mature males of this form ranges 11-25 cm and mature females 15-34 cm (Zuev et al., 1985, 2001; Nigmatullin et al., 1991).

Squids of this form play the key-role in pelagic oceanic and nerito-oceanic ecosystems as consumers of II-IV orders, and they are the important transport hosts for some helminths between invertebrates, small teleosts and sharks, large fishes and mammals (Zuev et al., 2001). The composition of the helminth fauna of *Sthenoteuthis oualaniensis* and the helminths location in squid body are relatively well studied (reviews: Gaevskaya et al., 1983; Nigmatullin et al., 1985; Naidenova et al., 1985; Hochberg, 1990; Zuev et al., 1985, 2001; Shukhgalter, 1988, 1992). But the ecological aspects of its parasite-host relations are not investigated in deep.

The aim of the present paper is to provide the comparative study of helminth fauna and the values of its infection rates in the middle-sized late-maturing form of the ommastrephid squid *Sthenoteuthis oualaniensis* in the tropical zone of the Indian Ocean and East Pacific. The final aim of this study is to elaborate the parasite indication of the squid ecosystem relation peculiarities in these two tropical macro-ecosystems.

**MATERIALS AND METHODS**

The samples of squids were collected during 1978-1986. In the oceanic part of the Indian Ocean (8-15° S – 55-90° E) squid were caught in the cruise R/V “Professor Vodjanitsky” (Institute of Biology of the Southern Sea, Sevastopol) from May to August 1978 (Fig. 1). From the Indian Ocean 303 squid of ML 2-26 cm were studied.

In the nerito-oceanic part of the East Pacific (2° N-12° S – 82-100° W) 146 squids of ML 7-32 cm were collected during 1981-1986 in the cruises of AtlantNIRO research vessels (Fig. 1).

Both Indian and Pacific investigated squids include males and females in different stages of maturation, from juveniles and immature to mature. All squids were caught at the light drift stations
by handle net and mainly by jigs. For each studied squid mantle length (ML), sex and stage of maturity were recorded by Zuev et al. (1985).

Method of helminthological investigation of squids was a standard one (Zuev et al, 1985). All worms were collected from fresh or frozen squids. As plerocercoids of Pelichnibothrium speciosum were very numerous, intensity of plerocercoids encysted in the rectum wall was taken by multiplication of the mean number of cysts in 1mm² of rectum wall surface. These plerocercoids very similar to P.speciosum were not assessed quantitatively in the Indian Ocean squids, but some of investigated squids were infested by them.

The rates of infection for main and secondary helminths in the equal-sized males and females were quasi-similar. Therefore for the comparative analysis data on helminth fauna of equal sized specimens of different sex are combined.

The following ecological terms – prevalence, intensity and mean dintensity were used in accordance with the recommendations by Margolis et al. (1982). The definitions of these terms are followings. Prevalence is the number of individuals of a host species infected with a particular or all parasite species and it is expressed as a percentage of number of infected hosts to number of all hosts examined in the sample. Intensity is the number of individuals of a particular parasite species in each infected host in the sample. Mean intensity (= density) is the mean number of individuals of a particular parasite species per infected host in the sample.

RESULTS AND DISCUSSION

In total, twelve species of the parasitic helminths were revealed: Trematoda (2 species), Cestoda (5), Nematoda (3) and Acanthocephala (2) (Table 1). But it’s necessary to say that in the stomachs of two adult squids from the Indian Ocean were found 12-18 specimens of not unidentified Acanthocephala in bad digested condition. Therefore this helminth must not be considered as the true parasite of these squids, and there are eleven species of true parasitic helminths. All these helminths occurred as larval stages.

In each region nine species were found, seven of them being common (Table 1). The differences of the helminth species composition are mainly due to rare species. It is characteristic especially for Pacific squid fauna. The species that absent in Indian squid fauna are represented here another species of given genus Nybelinia and Anisakis. Long worms with length 10-20 cm (probably primitive Acanthocephala) from pericardial coelomic cavity were discovered in both Sthenoteuthis species in Tropical Atlantic and Indian Ocean only (Naidenova, Zuev, 1978; Naidonova et al., 1995). During intensive study on the parasitic helminths of Dosidicus gigas and another species of ommastrephid squids in same area of the East Pacific there were not found these worms (Gaevskaya
et al., 1983; Schukhalter, 1988; Shukhalter and Nigmatullin, 2001).

Thus, in general the helminth faunas compositions of *Sthenoteuthis oualaniensis* in these two regions are similar. The most common and wide distributed representatives of the fauna are metacercaria of didymozoids, the larvae of nematode Anisakis sp., Porrocaecum sp., and the cestodes Nybelinia sp., Phyllobotrium sp. and Pelichnibotrium-like plerocercoids. These helminths are typical for all oceanic nektonic ommastrephid squids of the World Ocean (Gaevskaya and Nigmatullin, 1976, 1981; Naidenova and Zuev, 1978; Gaevskaya et al., 1983; Hochberg, 1990; Shukhgalter and Nigmatullin, 2001).

The total prevalence of infection is 98.4% in the Indian squids and 74.0% in the Pacific ones. The more low level of infection in the East Pacific is due to the differences in the prevalence values in small squids of ML 7-16 cm (0-68%) from Pacific and of ML 2-16 cm (80-100%) in Indian ones. In general samples main helminths of the Indian Ocean had significantly higher infestation parameters (the prevalence 46-95%, the intensity tens and hundreds specimens) while in the Pacific Ocean these values were 20-38.4% and from few specimens up to several dozen (Table 1).

The same situation was observed in the equal-sized adult squid (Table 1). The total prevalence of infection of Indian squid was 1.3 times more than in Pacific ones. Most of helminth species in Indian squid has both the prevalence and density values 3-10 times more than Pacific ones. But there was the solely exception of *Anisakis sp*.: its prevalence value was higher at 4.5 time for Pacific squid.

The ontogenetic variations in the helminths infestation data on five squids’ size groups in these two regions were compared (Fig. 2, 3). Bearing in mind monocyclia and one year life of the middle-sized late-maturing form of *Sthenoteuthis oualaniensis* in both areas (Nigmatullin et al., 1991; Zuev et al., 2001) these series nearly completely (with exception of larvae and frys) cover their life cycle. In both areas parameters of infection rates by all helminths are more or less increasing during ontogenesis of squid. There is the except for metacercaria of didymozoids in Pacific squid. Their prevalence value has tendency to decrease, and intensity value is quasi-stable.

There were found significant differences in ontogenetic infection dynamic of squids from Indian and East Pacific regions (Fig. 2, 3). Some helminths begin infect squids of the different sizes (3 species). Curves describing infection dynamics are different for 5 species. In 5 species these curves move on the different levels and have differences in prevalence of 30-50% and up to 70-80%.

**CONCLUSION**

All revealed helminths (except for long acantocephala-like worms) have very broad
specificity. They use various planktonic invertebrates, small fishes and squids at same stages of their life cycles. Infection of *Sthenoteuthis oualaniensis* occurs when they eat infected preys, which are the second or paratenic intermediate hosts for these helminths. This squid is the transport (paratenic) host. Transfer of these helminths to definitive hosts (sharks, tunas, xiphoid fishes and mammals) occurs when they consume infected squids. The life cycles of these helminths are realized by trophic chains of the pelagic communities (Nigmatullin, 1987; Hochberg, 1990). Thus, *Sthenoteuthis oualaniensis* and its helminths are members of the complicated, diverse and synchronized tropho-parasite system that includes the most part of epi-mesopelagic oceanic ecosystem members at the consumer level till top-predators. This is why the helminth data of this squid may be the important ecosystem-condition indicator.

In general for both western and eastern borders of species range, the similarity of the helminth fauna composition is characteristic. This similarity testifies the proximity of the main traits of the ecological niches of these two geographical squid populations, and spatial stability of middle-sized form *Sthenoteuthis oualaniensis’* position in trophic-parasite web of pelagic ecosystems in range limits.

But there were revealed the significant differences in the infestation levels, and geographical patterns of helminth fauna ontogenetic changes. These data suggest earlier and more mass infestation of squids and accordingly squid participation in helminths life cycles in the Indian Ocean than in East Pacific. In general in the life cycle of Indian squid population the prevalence and intensity parameters of parasitic helminths were increased synchronously, and as the result of that the adult part of squid population had maximal values of infested squids and maximal numbers of helminth larvae in hosts. In East Pacific squid population this tendency is less expressed, and the significant accumulation of helminth specimens in hosts does not occur.

These two types ontogenetic infestation exist due to the differences in the infestation rates of squid preys in these areas. But ultimately this is due to the differences in the infestation rates of final hosts of these helminths (high in Indian Ocean and low in East Pacific). Another version is following: probably this is due to the features of quantitative distribution in these areas of the final hosts. But in both cases this leads to differences of infection of planktonic crustacea and small fish that are preys of the squid, and accordingly to differences in infection of *Sthenoteuthis oualaniensis*.

These revealed differences suggested that the parasite-host systems, population parameters of helminths and probably the quantitative aspects of the trophic relations in the Indian Ocean and East Pacific are not similar. The real bases of this are the different types of oceanographic conditions and communities. In Indian Ocean the studied squid inhabits the typical oceanic ecosystems, and in East Pacific – typical nerito-oceanic (intermediate between neritic and oceanic) ecosystem. They have very significant differences in water masses circulation, predictability of the environmental traits,
level of productivity, complexity of trophic structure and so on (Beklemishev, 1969; Vinogradov and Sushkina, 1987).

Thus, the revealed differences in helminth fauna and its infestation rates are the sensible indicator of the similarity and differences in both trophic and parasite structures in these two macro-ecosystems.

ACKNOWLEDGEMENTS

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REFERENCES


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<th>I</th>
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<th>MI</th>
<th></th>
<th>P</th>
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<td>+</td>
<td>+</td>
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<td>1011.1</td>
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<td>43.1 (32.4-53.9)</td>
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<td>1-28</td>
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<td>(long worms)</td>
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* CL - confidence limits

Table 1. Data on prevalence (P, %), intensity (I, spec.) and mean intensity (MI, spec.) of infections in squid from Indian Ocean and East Pacific
Fig. 1 The range of squid Stenoteuthis oualaniensis (1) and the position of sampling stations (2)
Fig. 2 Data on prevalence of infections in ontogeny of squid from Indian Ocean and East Pacific

1. **Didymozoida indet.**
   - P, %
   - ML, cm; N (Indian squid/Pacific squid)
   - Indian Ocean vs. Pacific Ocean

2. **Nybelinia lingualis l.**
   - P, %
   - ML, cm; N (Indian squid/Pacific squid)
   - Indian Ocean vs. Pacific Ocean

3. **Pelichnibothrium speciosum l.**
   - P, %
   - ML, cm; N (Indian squid/Pacific squid)
   - Indian Ocean vs. Pacific Ocean

4. **Anisakis simplex l.**
   - P, %
   - ML, cm; N (Indian squid/Pacific squid)
   - Indian Ocean vs. Pacific Ocean

5. **Phyllobothrium sp.l.**
   - P, %
   - ML, cm; N (Indian squid/Pacific squid)
   - Indian Ocean vs. Pacific Ocean

6. **Anisakis physeteris l.**
   - P, %
   - ML, cm; N (Indian squid/Pacific squid)
   - Indian Ocean vs. Pacific Ocean

7. **Tentacularia coryphaenae l.**
   - P, %
   - ML, cm; N (Indian squid/Pacific squid)
   - Indian Ocean vs. Pacific Ocean

8. **Porrocaecum sp.l.**
   - P, %
   - ML, cm; N (Indian squid/Pacific squid)
   - Indian Ocean vs. Pacific Ocean

9. **Nybelinia yamagutii l.**
   - P, %
   - ML, cm; N (Indian squid/Pacific squid)
   - Indian Ocean vs. Pacific Ocean

10. **Acanthocephala indet. (long worms)**
    - P, %
    - ML, cm; N (Indian squid/Pacific squid)
    - Indian Ocean vs. Pacific Ocean
Fig. 3. Data on mean intensity of infections in ontogeny of squid from Indian Ocean and East Pacific:

- **Didymozoidae indet.**
  - LM (cm), N (Indian Ocean/Pacific Ocean)
  - Didymozoidae indet.
  
- **Nybelinia lingualis l.**
  - LM (cm), N (Indian Ocean/Pacific Ocean)
  - Nybelinia lingualis l.

- **Pelichnibothrium speciosum l.**

- **Anisakis simplex l.**

- **Phyllobothrium sp.l.**

- **Anisakis physeteris l.**

- **Tentacularia coryphaenae l.**

- **Porrocaecum sp.l.**

- **Nybelinia yamaguiti l.**

- **Acanthocephala indet. (long worms)**

Legend:
- Blue bars represent Indian Ocean
- Black bars represent Pacific Ocean