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Seasonal population dynamics of *Echinorhynchus gymnocyprii* (Acanthocephala: Echinorhynchidae) in the host *Gymnacypris przaewalskii przewalskii* in the Qinghai Lake *

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Abstract: Studies on seasonal population dynamics of the acanthocephalan *Echinorhynchus gymnocyprii* in its host *Gymnocypris przewalskii przewalskii* in Qinghai Lake, China, were carried out by four season's samples. Differences in mean abundance, mean intensity and prevalence are not statistically significant seasonally. This was related to the temperature dependent mortality of *E. gymnocyprii*, the seasonal dynamics of the intermediate host, *Gammarus* sp. and seasonal changes of host feeding. Distribution of *E. gymnocyprii* in its host population was over-dispersed in all seasons, which was believed to be related to the heterogeneity of the intermediate host in the lake and the feeding habit of the host *Gymnocypris przewalskii przewalskii*. Males were less than 11 mm and females between 5.0 and 24.3 mm. Recruitment into the infrapopulation in *G. przewalskii przewalskii* took place mainly in summer and autumn. Maturation and copulation of worms was deduced to happen in winter and mainly in spring. The sex ratio of females to males was almost 1.55 in spring and summer, 1.97 in autumn, and 2.24 in winter.

Keywords: *Echinorhynchus gymnocyprii*; seasonal population dynamics; *Gymnocypris przewalskii przewalskii*; Qinghai Lake

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Qinghai Lake, located in the Northwest Qingzang plateau (Qinghai Province and Tibet), is the largest inland brackish water lake in China, with an area of about 4 500 km^2 and with an altitude of 3 200 m. Its greatest depth is 32.8 m (mean 25 m). There are many inlet fresh water rivers into the lake but no outlets.

There are only two species of fish in the lake, *Gymnocypris przewalskii przewalskii* Kessler 1876 that is economically important, and *Nemachilus scleropterus* Herzenstein 1888 that is bound only to the edge of the lake and is of no economic value. The species and abundance of food organisms for these two fish species are also very poor in the lake[1].

Liu et al[2] reported two species of acanthocephalan from *G. przewalskii przewalskii* in the Qinghai Lake, *Echinorhynchus gymnocypriis* Liu et al 1982 and *Neoechinorhynchus qinghaiensis* Liu et al 1982. The mean abundance and mean intensity of *E. gymnocyprii* in *G. przewalskii przewalskii* increased with the increase of the host body length, which was related to the greater intestinal space and larger eating capacity of bigger fish[3]. For these two acanthocephalans in Qinghai lake no study on seasonality has been carried out to date although a large number of such studies have been carried out on acanthocephalans elsewhere[4]. For this reason the present study addresses on the seasonality.

1 Materials and Methods

In Qinghai Lake, spring lasts from April to June. Summer is from July to September. Autumn is

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between October and December. Winter runs from January to March.

Sampling was conducted in the Fishing Ground of Qinghai Lake. In spring, summer and autumn, fish were obtained from fishing boats that caught fish by deep trawlnets all around the lake. In winter the fish were netted under the ice that covered the lake. Sampled fish were arbitrarily chosen between 300 mm to 350 mm in body length in order to avoid any biased effect of host size on the results[3].

The fish sampled were taken to the field laboratory alive, measured, sexed, and dissected within 36 h of capture. The entire alimentary canal was removed and divided into ten segments based on percentages of the total length from the anterior end. Each segment was carefully checked for acanthocephalan worms. Worms were rinsed in cold physiological saline solution for about ten hours letting the proboscis protrude prior to being preserved in 70% ethanol solution. The number of *E. gymnocyprii* in each fish was recorded. The length of each worm was measured from the top of the proboscis to the end of the body at the Ichthyology Laboratory of Zhongshan University.

About 100 worms from each season's sample were taken randomly and stained by standard methods. To measure the development status of parasite, female worms were divided into 3 developmental stages: 1) those with immature ovaries not fragmented; 2) those with ovarian balls; and 3) those gravid with ovarian balls and eggs as well as those with eggs only[5]. Males with everted bursa were counted. Prevalence, mean intensity and mean abundance of parasites were used as defined by Bush et al[6]. The software SPSS (Statistic Package for Social Science) 6.0 for window was used to analyse data. The significance test for seasonal changes of mean abundance, mean intensity, mean length of the parasite and mean length of the fish dissected was one way ANOVA[7]. The method of calculating the index of patchiness (IP) was taken from Young et al[8]. Values of IP are less than, equal to, and greater than 1 correspond to underdispersion, randomness and overdispersion, respectively. Rising aggregation is reflected in increasing value of IP. The calculation of ecological niche width was after the method of Xu[9].

2 Results

2.1 Seasonal changes of infection parameters of *E. gymnocyprii* in its host

A total of 4 147 individuals of *E. gymnocyprii* were collected from 249 individuals of *G. przewalskii przewalskii* for seasonality analysis of the acanthocephalan population. Prevalence levels were high and did not fluctuate significantly (F ratio = 0.364 1, P = 0.780 9) in the four seasons, nor did the mean intensity (F ratio = 0.288 8, P = 0.833 5) or the mean abundance (F ratio = 0.242 1, P = 0.866 9). The values of the sex ratio were stable (1.54 or 1.55) in spring and summer, but rose to 1.97 in autumn and 2.24 in winter.

2.2 The frequency distribution of *E. gymnocyprii* in its host population

Values of IP and of the variance to mean ratio (Table 1) illustrated the seasonal changes of frequency distribution of *E. gymnocyprii*. Over-dispersed distributions of *E. gymnocyprii* in the host populationin four seasons were observed because values of variance to mean ratio and IP were all much greater than 1.0. The aggregation of *E. gymnocyprii* population in the host was highest in spring and lowest in summer.

2.3 The size composition of *E. gymnocyprii* population in different seasons

The length range of female *E. gymnocyprii* in its host *G. przewalskii przewalskii* was between 5.0 mm and 24.3 mm and that of males was from 5.0 mm to 11.0 mm (Figure 1). The proportion of female less than 12 mm in length (generally immature) was zero in spring, increased from summer (4.2%) through autumn (19.7%) to winter (21.3%). The proportion of smaller male less than 6 mm in length was also zero in spring, increased through summer (3.2%) and autumn (6.5%) to winter (8.0%). It is also observed that there was a considerable loss of males longer than 10 mm

Tab.1 The seasons parameters of *E. gymnocyprii* population in its host *G. przewalskii przewalskii* population and of the fish sampled[1)]

	Spring	Summer	Autumn	Winter
No. of fish sampled	58	63	62	66
Length of fish/mm	332 ± 2.1	320 ± 2.5	306 ± 2.7	301 ± 1.7
Prevalence/%	69	73	77	73
Mean intensity	21.5 ± 5.2	25.6 ± 3.5	20.5 ± 3.9	23.2 ± 3.9
Intensity	1 ~ 146	1 ~ 74	1 ~ 121	1 ~ 116
Mean abundance	14.9 ± 3.8	18.7 ± 3.0	15.9 ± 3.2	16.8 ± 3.2
Variance/mean	57.4	29.8	40.8	38.9
Index of Patchiness(IP)	4.8	2.5	3.5	3.3
Sex ratio (♀/♂)	1.54	1.55	1.97	2.24
Length of female/mm	18.2 ± 0.3	15.3 ± 0.3	15.1 ± 0.3	14.3 ± 0.3
Length of male/mm	9.5 ± 0.1	7.9 ± 0.2	7.7 ± 0.2	7.8 ± 0.1
Width of niche	0.59	0.41	0.63	0.72
Mean position in theintestine of host/%	42.67	48.32	45.87	44.78

1) The value is mean ± standard error

(from 43.2% to 3.2%) and of females longer than 19 mm (from 21.1% to 4.2%) from spring to summer. Male loss continued from summer (22.6% of male longer than 9.0 mm) to autumn (9.7%). The results of t-test for the parasite mean lengths in different seasons demonstrated that both males and females in spring (males of 9.5 mm and females of 18.2 mm) were significantly bigger than those in other seasons.

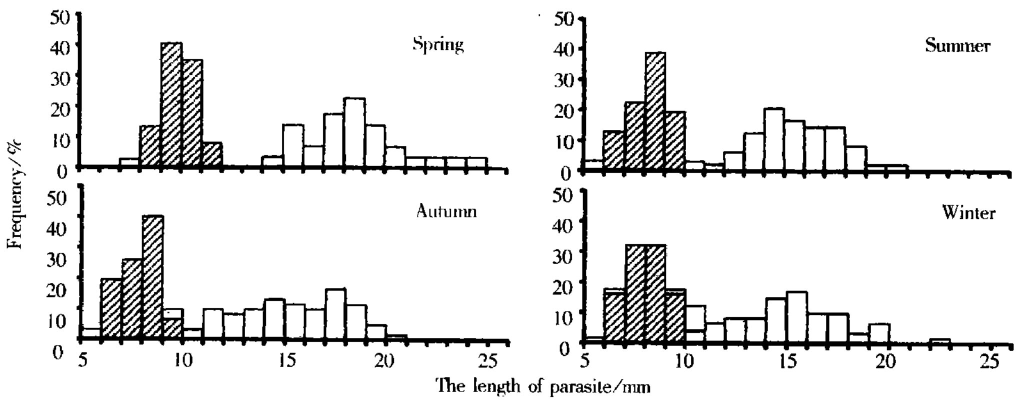

Fig.1 The length composition of *E. gymnocyprii* population in the host *G. przewalskii przewalskii* in defferent seasons. (Bar hatched represents males and the vacant bars females)

2.4 The development of the *E. gymnocyprii* in different seasons

Figure 2 shows the developmental status of *E. gymnocyprii* in different seasons. Male worms with everted bursa were observed in winter and predominantly in spring. Immature female and those with ovarian ball were present in all seasons. The proportion of gravid females did not significantly vary in different seasons. The proportion of males in the population decreased from summer through autumn to winter.

3 Discussion

No significant seasonal changes in the prevalence and mean abundance of *E. gymnocyprii* were observed, although seasonal periodicity in recruitment was deduced from observed changes in the size

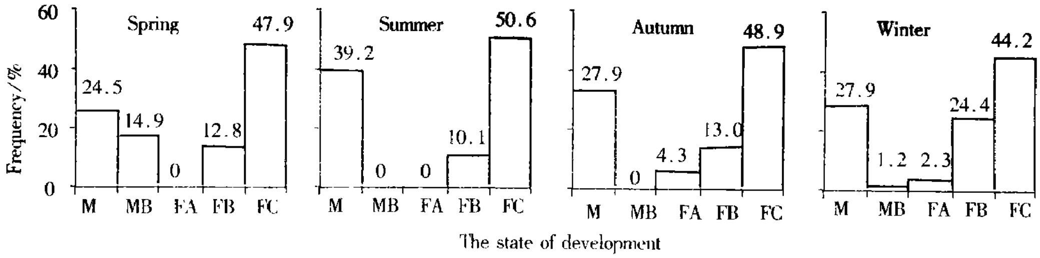

Fig.2 The state of development of *E. gymnicyprii* in its host *G. przewalskii przewalskii* in defferent seasons M: male without everted bursa; MB: male with everted bursa; FA: immature female; FB: ovrian ball female; FC: gravid female

composition. This indicates that there was no prolonged period when mortality exceeded recruitment, or vice versa. This 'stability' might be explained, in part, if the increasing establishment was offset by the loss of worms from spring to autumn, and in winter the decreasing losses of worms was contracted by the decreased host feeding activity. Changes in parasite size composition revealed that periods of both greater recruitment and of worm loss were in warmer seasons. During the colder seasons reverse factors to the decreased loss of worms were the reduction of host feeding activity, indicated by the gut Plumpness Index($PI = 10\,000 \times$ weight of food/body weight of fish) of *G. przewalskii przewalskii* and the scarceness of the intermediate host, *Gammarus* sp.[1]. Aho et al sugested that long-term consistency of seasonal patterns of parasites in aquatic systems could often be the result of ecosystem stability, rather than of other factors such as density-dependent regulation or premunition[10]. This is especiallytrue of parasites that complete their entire life cycle within the aquatic system. This explanation is helpful for understanding the stability of *E. gymnocyprii* in Qinghai Lake since it is relatively stable environmentally. It has been reported that the establishment, development and expulsion of *E. truttae* was temperature dependent[11]. The seasonal changes of *E. gymnocyprii* recruitment could be attributed to the seasonal dynamics of *Gammarus* sp. population in the Lake[1] just as *E. truttae* in the intermediate host *Gammarus pulex*[12].

Over-dispersed distribution of the *E. gymnocyprii* population in its host *G. przewalskii przewalskii* was observed in the four seasons. This is a very common distribution pattern of parasites in their host population[13]. The distribution pattern described herein is probably primarily determined by density independent factors such as heterogeneity in temporal and spatial distribution of the infection source, *Gammarus* sp., and the change of feeding behaviour and food selectivity of host *G. przewalskii przewalskii* in such a big lake. Three groups of fish with completely different food types (herbivorous, carnivorous and omnivorous) have clearly been observed in the lake[1].

For dioecious parasites, the sex ratio and mating system (monogamous or polygamous) have a profound impact on the fecundity and the relationship between host and parasite[14]. Sex ratio has been studied from many theoretical and empirical perspectives. The sex ratio of *E. gymnocyprii* in Qinghai Lake remained around 1.54 in spring and summer and rose to 2.44 in winter. This meant that female *E. gymnocyprii* occurred in significantly larger numbers than males in all seasons. Similar results were reported for *Echinorhynchus clavula*[15], *E. truttae*[12] and *Acanthocephalus parksidei*[16]. This may result from the loss of short-lived males. Additionally, Eure(1976) observed the drastic loss of males of the acanthocephalan, *Neoechinorhynchus cylindratus*, during the summer, when copulation had finished[17]. The high proportion of females in the population in autumn and winter was due to the continuous loss of males.

References:

[1] Biology Institute of Qinghai Province. The biology of *Gymnocypris przewalskii przewalskii* and the fish fauna in the

area of the Qinghai Lake[M]. Beijing: Science Press of China, 1974.

[2] LIU L Q, WANG B Z, YANG T B. Study on the acanthocephalans in the *Gymnocypris przewalskii przewalskii* in the Qinghai Lake[J]. J Fishery, 1982, 5: 295 ~ 299.

[3] YANG T B. Population biology of *Echinorhynchus gymnocyprii* in *Gymnocypris przewalskii przewalskii* in the Qinghai Lake[J]. Transactions of Researches on Fish Diseases, 1995(2): 169 ~ 174.

[4] CHUBB J C. Seasonal occurrence of helminths in freshwater fishes: Part Ⅳ. Adult cestoda, Nematoda and Acanthcephala[J]. Adv Parasitol, 1982, 20: 1 ~ 292.

[5] MUZZALL P M. Ecology and seasonal abundance of three acanthocephalan species infecting white suckers in SE New Hampshire[J]. J Parasitol. 1980, 66: 127 ~ 133.

[6] BUSH A O, LAFFERTY K D, LOTZ J M, et al. Parasitology meets ecology on its own terms: Margolis et al. revisited[J]. J Parasitol, 1997, 83(4): 575 ~ 583.

[7] BRYMAN A, DUNCAN C. Quantitative data analysis with SPSS for Windows[M]. London and New York: Routledge, 1997.

[8] YOUNG L J, YOUNG J H. Statistical ecology, a population perspective[M]. Kluwer Academic Publishers, 1998.

[9] XU R M. Population ecology of insect[M]. Beijing: Press of Beijing Nonnal University, 1985.

[10] AHO J M, CAMP J W, ESCH G W. Long-term studies on the population biology of *Diplostomulum scheuringi* in a thermally altered reservoir[J]. J Parasitol, 1982, 68: 695 ~ 708.

[11] AWACHIE J B E. Experimental studies on some host-parasite relationships of the Acanthocephala. Effects of primary heavy infection and superimposed infection of *Salmo trutta* L. by *Echinorhynchus truttae* Schrank, 1788 [J]. Acta Parasiltologica Polonica, 1972, 20: 375 ~ 382.

[12] AWACHIE J B E. The ecology of *Echinohynchus truttae* Schrank, 1788 (Acanthocephala) in a trout stream in North Wales[J]. Parasitology, 1965 55: 747 ~ 762.

[13] GORDON D M, RAU M E. Possible evidence for mortality induced by the parasite *Apatemon gracilis* in a population of brook sticklebacks[J]. Parasitology, 1982, 84: 41 ~ 47.

[14] MORAND S, RIVAULT C. Infection dynamics of blatticola-blattae graeffe (Nematoda, Thelastomatidae), A parasite of *Blattella germanica* L (Dictyoptera, Blattellidae)[J]. Int J Parasitol, 1992, 22: 983 ~ 989.

[15] CHUBB J C. Occurrence of *Echinorhynchus clavula* (Dujardin, 1845) nec Haman, 1892 (Acanthocephala) in the fish of Llyn Tegid (Bala Lake) Merionethshire[J]. J Parasitol, 1964, 50: 52 ~ 59.

[16] AMIO O M. Host and seasonal association of *Acanthocephalaus parksidei* Amin 1974 (Acanthocephala: Echinorhynchidae) in Wisconsin fishes[J]. J Parasitol, 1975, 61: 318 ~ 329.

[17] EURE H. Seasonal abundance of *Neoechinorhynchus cylindratus* taken from largemouth bass (Micropterus salmoides) in a heated reservoir[J]. Parasitology, 1976, 73: 355 ~ 370.

青海湖裸鲤寄生湟鱼棘头虫的种群季节动态研究

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摘　要：以在青海湖收集的寄生于青海湖裸鲤的湟鱼棘头虫（*Echinorhynchus gymnocyprii*）4个季节的样本研究湟鱼棘头虫种群的季节动态．结果表明：种群的平均丰度，感染强度和感染率都没有明显季节变化．这与湟鱼棘头虫温度依赖性死亡、中间宿主的季节数量动态、宿主食性的季节改变有关．湟鱼棘头虫种群在宿主种群的分布在各季度中都是聚集性的．这与宿主食性的分化及第一中间宿主（钩虾）的分布不均匀性有关．雄虫体长小于11 mm，雌虫在5.0与24.3 mm之间．湟鱼棘头虫感染青海湖裸鲤（*Gymnocypris przewalskii przewalskii*）主要发生在夏天和秋天．成熟和交配则主要发生在冬天和春天．湟鱼棘头虫在春夏秋冬的性比（雌/雄）分别为1.55，1.55，1.97和2.24．

关键词：湟鱼棘头虫（*Echinorhynchus gymnocyprii*）；种群季节动态；青海湖裸鲤（*Gymnocypris przewalskii przewalskii*）；青海湖

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