ANALYSES OF DISTRIBUTION AND FAUNAL RELATIONSHIP OF INLAND-WATER MICRODRILE OLIGOCHAETA (ANNELIDA) IN THE WORLD AND CHINA*

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Abstract

The relations of microdrile faunae of inland-waters were analyzed mainly by means of fuzzy clustering. In worldwide scale, the faunae of Britain, former Czechoslovakia, former Soviet Union, North America, China and Japan, all were chiefly parts of the ancient supercontinent Laurasia, are clustered together on the basis of the distribution data of the genera. However, the faunae of the regions mainly belonging to Gondwana, i.e. India, Africa, South America and Oceania, cannot be clustered into a group. The clustering of Chinese microdrile faunae reveals that there are some Holarctic taxa in Heilongjiang Basin and Xinjiang Uygur Autonomous Region, while those in Changjiang and Zhujiang Basins are more or less Oriental. A transition zone between south and north seems to be located in Huanghe Basin. Of the entire microdrile fauna, there are 1 genus and 14 species reported only from China.

Key words Microdrile oligochaetes, Inland-waters, Distribution, Faunal similarities, World, China

1 Introduction

Biogeographically speaking, zoologists paid attention to earthworms (megadrile oligochaetes) fairly early (e.g. Michaelsen, 1903, cited in Stephenson, 1930). Works in relation to aquatic oligochaetes were few so far, since they have long been regarded as highly dispersed animals without much importance for zoogeographical considerations (Stephenson, 1930). However, Chekanovskaya (1962) disagreed to this opinion. She pointed out that such a viewpoint "was based on inadequate study of the faunae outside Europe, and on inaccurate determination of species". She claimed that there should be no essential difference in geographic distribution patterns between terrestrial and aquatic oligochaetes. Later, Brinkhurst (Brinkhurst & Jamieson, 1971) examined the distribution materials of aquatic microdriles and concluded that "there does seem to be a genuine concentration of genera and species in the northern hemisphere". The geographical distribution of aquatic oligochaetes

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was also studied by Timm(1980). He pointed out that only 4.5% of the 709 known species are cosmopolitan, while 80% of them are restricted in a certain zoogeographical region and 42% in a single locality. Additionally, 42.6% of the taxa were reported only from the Holarctic. On the basis of his results, Timm divided the world into 6 biogeographical regions, viz. Holarctic, Baikal, Sino-Indian, Ethiopian, Neotropical and Antarctic regions. In China, studies on zoogeography of aquatic oligochaetes were few, only Chen(1940) simply dealt with this matter in his classical work.

Great advances in taxonomical studies of inland-water oligochaetes have been made since 1980. By using current data, the similarities of aquatic microdrile faunae of China and worldwide scale were analyzed and the results are given in the present paper. The family Enchytraeidae is excluded from this work, since it is still poorly known in most parts of the world.

2 Method

In fuzzy clustering, the similarity between any pair of taxa/regions(i, j) was calculated as:

$$S_{ij} = \sum_{k=1}^{n} x_{ik}x_{jk} / \left(\sum_{k=1}^{n} x_{ik}^2 \sum_{k=1}^{n} x_{jk}^2 \right)^{1/2} \qquad (i, j = 1, 2, 3, \cdots, m)$$

Regression analyses were performed using routine methods.

3 Distribution of Taxa

3.1 Distribution of genera in the world

Fig. 1 lists all 94 genera of inland-water microdriles hitherto known in the world. The matrix on the right of the figure demonstrates the occurrence(1 for presence and 0 for absence) of genera in Britain(a), former Soviet Union excluding Lake Baikal(b), former Czechoslovakia(c), Lake Baikal(d), China(e), India(f), Japan(g), North America mainly USA & Canada(h), South America(i), Africa(j) and Oceania(k)(Brinkhurst, 1971, 1986, 1988, 1989; Brinkhurst & Jamieson, 1971; Brinkhurst & Wetzel, 1984; Brinkhurst & Marchese, 1987; Chekanovskaya, 1962; Chen, 1940; Grimm, 1987; Hrabe, 1981; Marchese, 1987; Ohtaka, 1985; Persia, 1980; Snimschikova & Akinshina, 1994; Stephenson, 1923; Timm, 1987; Wang, 1995; Yamaguchi, 1953.). A cluster dendrogram is given on the left side. Roughly, the total microdrile genera may be separated into two major groups. The members of Group I are relatively widespread, comprising 54.3% of the total. Those of Group II are more limited in distribution, being 45.7%.

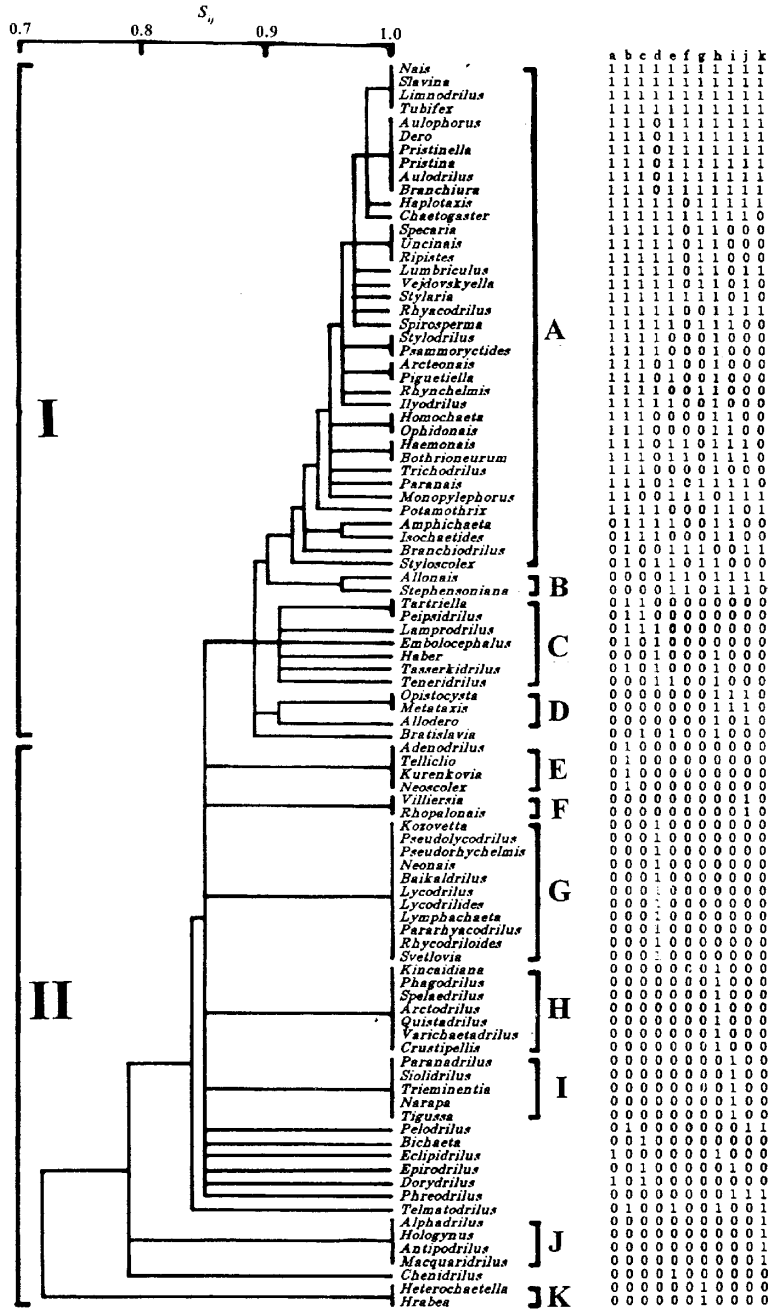

Fig. 1 Fuzzy cluster dendrogram of genera of inland-water microdriles in the world.

More detailedly, these genera may be further divided into 11 groups($\lambda = 0.91$):

Group A: Cosmopolitan forms in general;

Group B: Thermophilous forms, maily in tropical region;

Group C: In Holarctica including Lake Baikal;

Group D: In America and Africa;

Groups E-K: All endemic genera distributed respectively in: E, former Soviet Union; F, Africa; G, Lake Baikal; H, North America; I, South America; J, Oceania; K, Japan.

The above analysis indicates that inland-water microdriles are more or less regionally distributed. Relatively speaking, naidids tend to be cosmopolitan, while most of the other families are not so widespread. Concerning the endemics, the fauna of Lake Baikal is most special. In China, only one endemic genus was found, i.e. *Chenidrilus* Liang et Xie [type species: *Chenidrilus asiaticus* (Chen, 1940)] (Liang & Xie, 1997).

3.2 Generic diversity in relation to latitude and area

In addition to the distribution features, Fig. 1 also reveals that the number of genera varies greatly with regions. This difference might more or less arise from varying extent of previous investigations among regions, yet it is more likely that the richness of microdrile genera in a region is in connection with the geographical conditions there. In the present study, attempts have been made to relate generic diversity of microdriles with latitude and area of respective regions in the North Hemisphere. The results demonstrate that there is a significant positive correlation between generic number (G) and mean latitude(NL, °N).

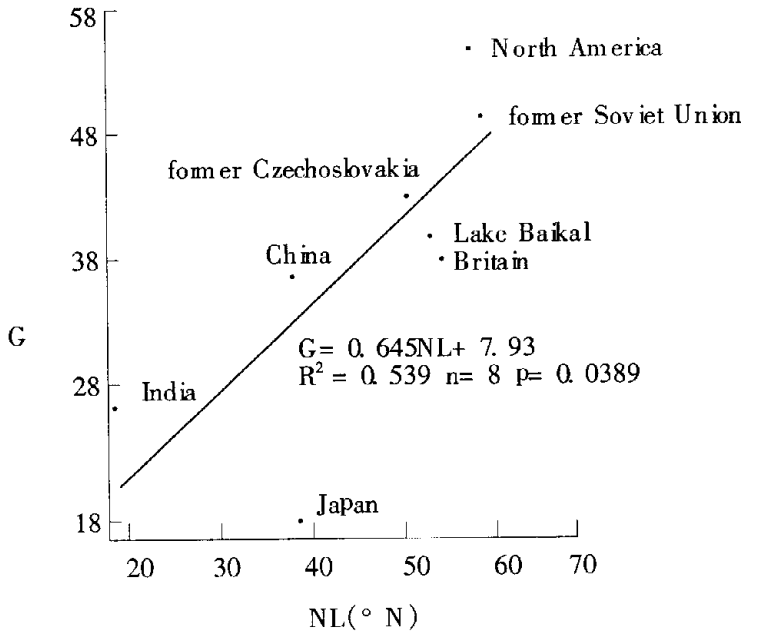

Fig. 2 Relationship between number(G) of microdrile genera and latitude(NL, °N) of Northern Hemisphere

The regression formula may be given as(Fig.2):

$$G = 0.645NL + 7.93 \qquad R^2 = 0.539 \quad n = 8 \quad p = 0.0389 \qquad (1)$$

The relationship between generic number and area (S, km^2) is also near the significant level(Fig. 3). Combining these three variables and calculated by means of forward stepwise regression, an even more significant relationship was obtained, which is expressed as:

$$G = 0.484NL + 6.34 \times 10^{-7} S + 10.9 \qquad R^2 = 0.757 \quad n = 8 \quad p = 0.0292 \qquad (2)$$

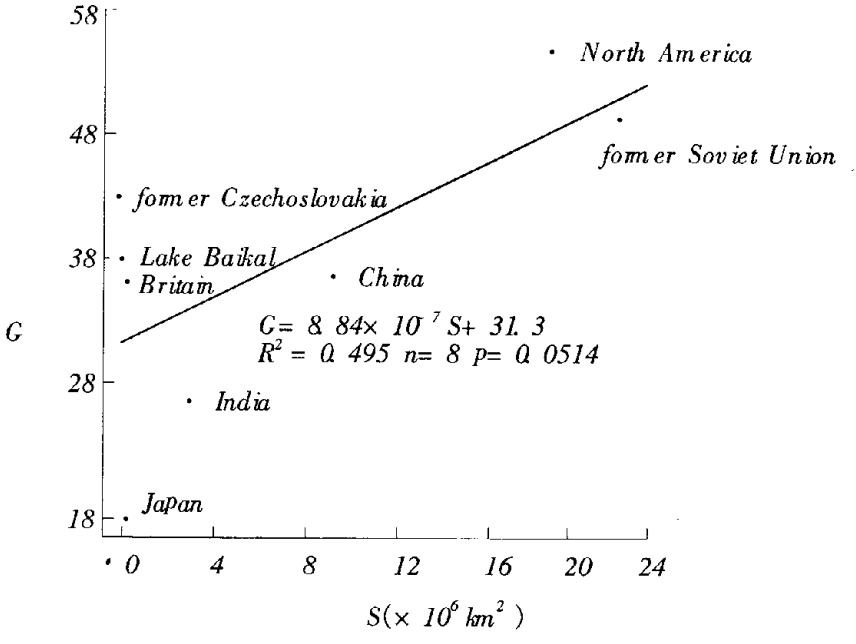

Fig.3 Relationship between number(G) of microdrile genera and area (S , km^2) of regions in Northern Hemisphere

The above results suggest that the generic diversity of aquatic Oligochaeta are affected by both latitude and areal dimension, but latitude element seems more important to their distribution or, in other words, microdrile worms prefer cooler environment to a certain extent.

3.3 Species distribution in China

88 microdrile species belonging to Haplotaxidae, Lumbriculidae, Naididae and Tubificidae(Wang, 1995) are hitherto recorded from China. With the exception of two very rare ones, Fig.4 shows the matrix of 86 species distributed in Xinjiang Uygure Autonomous Region(l), Heilongjiang Basin(m) of the Northeast, Huanghe(Yellow River) Basin(n), Changjiang (Yangtze River) Basin(o) and Zhujiang(Pearl River) Basin(p). At $\lambda = 0.93$, the dendrogram on the left is classified into 9 groups(Fig.4, A-I).

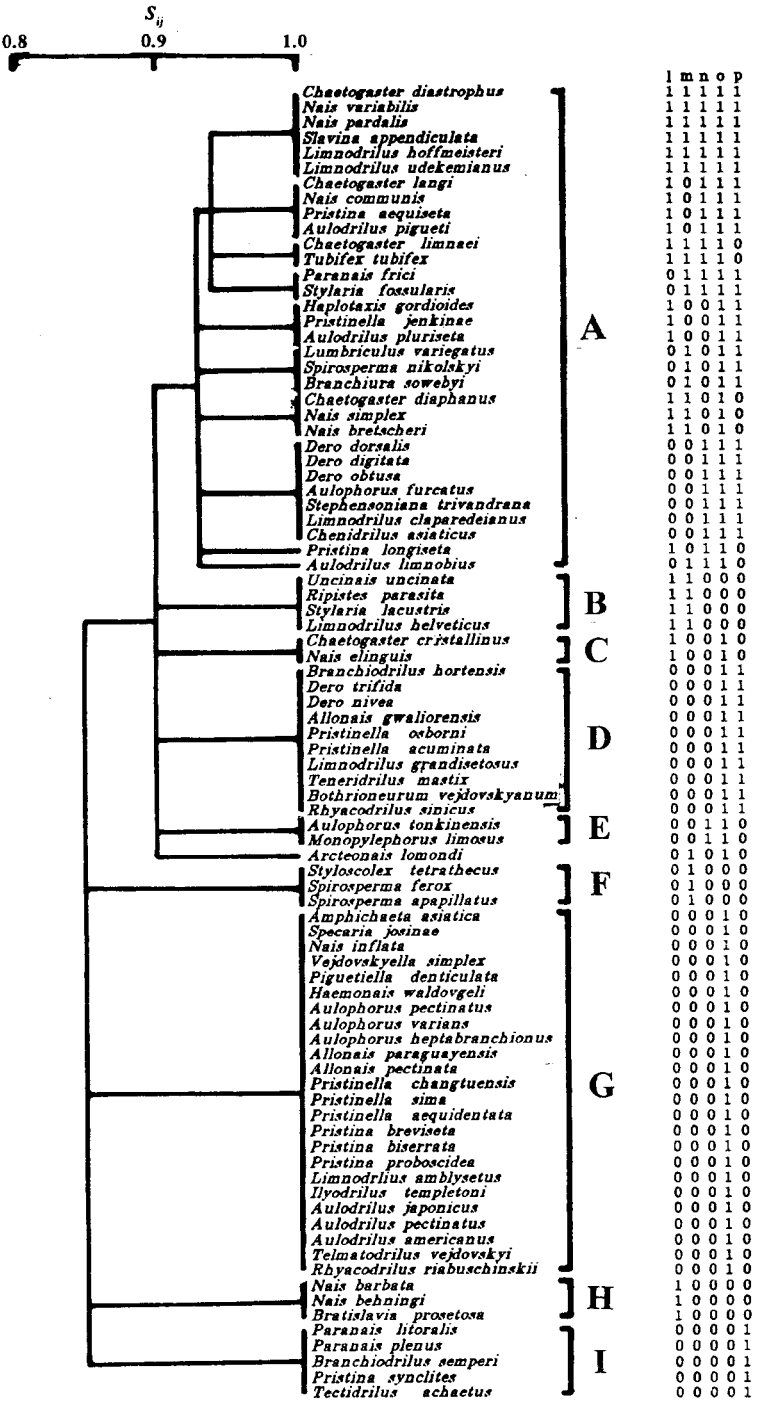

Fig.4 Fuzzy cluster dendrogram of species of inland-water microdriles in China

Group A contains 32 species, comprising 37.2% of the total. They might be regarded as widespread forms. Other groups(B-I) contain 54 species (62.8% of the total). They are generally regarded as having narrower distribution. It means that the microdriles in China are also regionally distributed. For the distribution characters of the other groups, they may be explained as:

Group B: In northern China(Heilongjiang Basin and Xinjiang);

Group C: In Xinjiang(north-western China) and Wuling Mountains area(parts of upper and middle Changjiang Basins);

Group D: In southern China(Changjiang and Zhujiang Basins);

Group E: In Huanghe and Changjiang Basins;

Group F: In Heilongjiang Basin;

Group G: In Changjiang Basin;

Group H: In Xinjiang;

Group I: In Zhujiang Basin.

For the other characters of the Chinese microdrile fauna, it is worthy of note that there are 14 species only reported from China, viz. *Amphichaeta asiatica*, *Paranais plenus*, *Nais inflata*, *Vejdovskyella simplex*, *Piguetiella denticulata* Liang et Xie, 1997, *Aulophorus varians*, *Aulophorus heptabranchionus*, *Bratislavia prosetosa*, *Pristinella aequidentata* Liang et Xie, 1997, *Pristinella changtuensis* (Liang)(Liang et al., in press), *Pristina biserrata*, *Limnodrlius amblysetus*, *Chenidrilus asiaticus* and *Tectidrilus achaetus*.

4 Faunal Analyses

4.1 Similarity of taxa in regions of the world

On the generic basis, Fig.5 shows faunal similarity of inland-water microdriles over the world. The fauna of Lake Baikal is much independent probably owing to its paleolimnological environment. The faunae of those regions mainly belonging to ancient supercontinent Laurasia, i.e. Britain, former Czechoslovakia, former Soviet Union, North America, China and Japan, are clustered together. However, the faunae of those chiefly belonging to Gondwana do not form a separate group. In that ancient supercontinent, the faunae of India and Africa are closely related, and they are rather more similar to the group of Laurasia than to that of South America and Oceania. The great difference among southern regions may be explained as follows: each continent of Gondwana (except Oceania and Antarctica) connects directly with one continent of Laurasia, and it enables the microdriles to migrate between both continents during the long historical period.

It is also shown by Fig. 5 that inland-water microdrile fauna of China is more similar to that of the Holarctic and Japan. It differs from the opinion of Chen. In 1940, Chen supposed

that the faunal relation of aquatic oligochaetes of China "is shown to be largely with the Indo-Malayan subregion and much less with Europe and America". Since Chen's data were insufficient, our conclusion is considered to be more realistic.

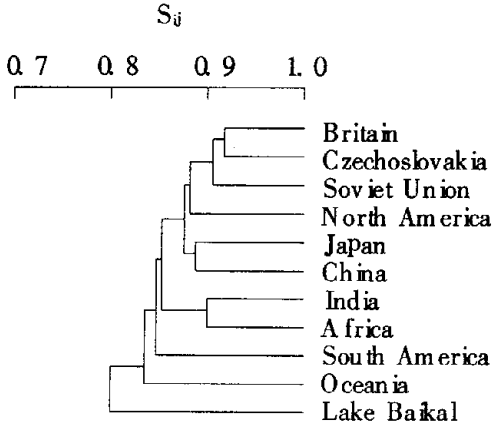

Fig.5 Faunal similarity of microdriles in different regions of the world

4.2 Similarity of taxa in regions in China

On the basis of species, the similarity of regional faunae in basins of four major rivers and Xinjiang Uygure Autonomous Region of China was analyzed. Fig.6A shows that the faunae of Xinjiang Uygure Autonomous Region and Heilongjiang Basin form a northern group, those of Zhujiang and Changjiang Basins form a southern group, while that of

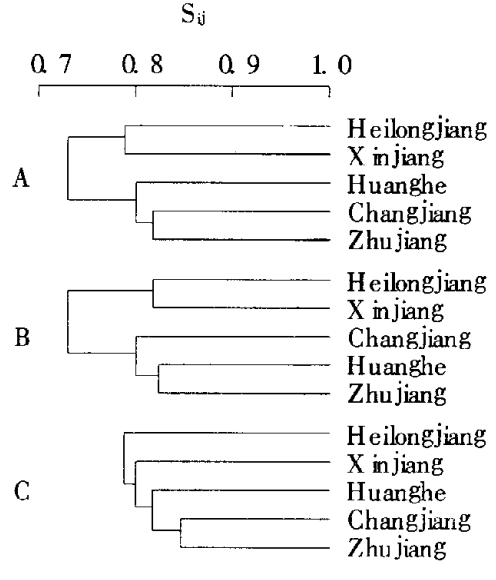

Fig.6 Similarity of species composition of microdriles of different regions in China
A. Entire fauna, B. Naididae, C. Tubificidae

Huanghe Basin appear to be transitional but closer to the North. Considering that Naididae and Tubificidae are main parts of inland-water microdriles, clustering was performed on the basis of 57 naidid species (Fig. 6B) and 27 tubificid species (Fig. 6C) respectively. As a rule, Fig. 6B is of the same shape as Fig. 6A, except the reversed position between Changjiang and Huanghe. It seems that the transition zone of naidids is situated somewhat southward, though most of the species are rather widespread. Fig. 6C shows that tubificid faunae among regions do not form conspicuous groups. It means that the distribution area of different tubificids is relatively limited.

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References

Brinkhurst, R.O., 1971. A guide for the identification of British aquatic Oligochaeta. Freshwater Biological Association, Scientific Publication, 22: 1 - 55.

Brinkhurst, R.O., 1986. Guide to the freshwater aquatic microdrile oligochaetes of North America. *Can. Spec. Publ. Fish. Aquat. Sci.* 84: 1 - 259.

Brinkhurst, R.O., 1988. A taxonomic analysis of the Haplotaxidae (Annelida, Oligochaeta). *Can. J. Zool.* 66: 2243 - 2252.

Brinkhurst, R.O., 1989. A phylogenetic analysis of the Lumbriculidae (Annelida, Oligochaeta). *Can. J. Zool.* 67: 2731 - 2739.

Brinkhurst, R.O., B.G.M. Jamieson, 1971. Aquatic Oligochaeta of the world. Oliver and Boyd, Edinburgh.

Brinkhurst, R.O., M. Marchese, 1987. A contribution to the taxonomy of the aquatic Oligochaeta (Haplotaxidae, Phreodrilidae, Tubificidae) of South America. *Can. J. Zool.* 65: 3154 - 3165.

Brinkhurst, R.O., M.J. Wetzel, 1984. Aquatic Oligochaeta of the world: supplement. A catalogue of new freshwater species, descriptions, and revisions. *Can. Tech. Rep. Hydrogr. Ocean Sci.* 44: 1 - 101.

Chekanovskaya, O.V., 1962. Aquatic Oligochaeta of the USSR. *Opred Faune SSSR* 78(3): 1 - 513. (English translation 1981 Amerind. Publ. to New Delhi).

Chen, Y.,1940. Taxonomy and faunal relations of the limnitic Oligochaeta of China. *Contr. Biol. Lab. Sci. Soc. China*, zool. 14: 1 - 132.

Grimm, R., 1987. Contributions towards the taxonomy of the African Naididae(Oligochaeta). Ⅳ. Zoogeographical and taxonomical consideration on African Naididae. *Hydrobiologia* 155: 27 - 37.

Hrabe, S., 1981. The freshwater Oligochaeta (Annelida) of Czechoslovakia. *Acta Univ. Carolinae-Biologica* 1979:1 - 167.

Liang, Y. L., Z. C. Xie, 1997. Aquatic Oligochaeta from Wuling Mountains area. In: D.X. Song(ed.), Invertebrates of Wuling Mountains area, Southwestern China. Beijing: Science Press, 383 - 394. (in Chinese with English abstract)

Liang, Y.L., H.Z. Wang, Z. C. Xie, in press. Studies on the aquatic Oligochaeta of China. IV. Diagnoses

of new records and rare species of Naididae and Tubificidae. *Acta Hydrobiol. Sin.* (in Chinese with English abstract)

Marchese, M. R., 1987. The ecology of some benthic Oligochaeta from the Parana River. *Hydrobiologia* 155: 209 - 214.

Ohtaka, A., 1985. Taxonomical studies of the Japanese Naididae (Annelida, Oligochaeta). 1. Four unrecorded species in small genera. *Jour. Fac. Sci. Hokkaido Univ.* ser. Ⅵ, zool. 24(2): 113 - 121.

Persia, D. H. D., 1980. The aquatic Oligochaeta of Argentina: current status of knwledge. In: R. O. Brinkhurst and D.G. Cook(eds.), Aquatic oligochaete biology. 79 - 113.

Snimschikova, N.L., T.W. Akinshina, 1994. Oligochaeta fauna of Lake Baikal. *Hydrobiologia* 278: 27 - 34.

Stephenson, J., 1923. Oligochaeta. The fauna of British India. London.

Stephenson, J., 1930. The Oligochaeta. Oxford University Press.

Timm, T., 1980. Distribution of aquatic oligochaetes. In: R.O. Brinkhurst and D.G. Cook(eds.), Aquatic oligochaete biology. 55 - 77.

Timm, T., 1987. Aquatic Oligochaeta of the northwestern part of the USSR. Valgus, Tarlin. (in Russian with English summary).

Wang, H. Z., 1995. Studies on taxonomy, distribution and ecology of microdrile oligochaetes of China, with descriptions of two new species from the vicinity of the Great Wall Station of China, Antarctica. D.Sc. thesis. Institute of Hydrobiology, Chinese Academy of Sciences, Wuhan, China. (in Chinese with English summary)

Yamaguchi, H., 1953. Studies on the aquatic Oligochaeta of Japan. Ⅵ. A systematic report, with some remarks on the classification and phylogeny of the Oligochaeta. *Jour. Fac. Sci. Hokkaido Univ.*, ser. Ⅵ, zool. 11: 277 - 342.

世界和中国内陆水体小蚓类的分布与区系分析

提　要

本文主要用 Fuzzy 聚类方法分析了世界不同地区内陆水体小蚓类的区系相似性。结果显示，主要属于劳亚古陆的英国、前捷克斯洛伐克、前苏联、北美洲、中国和日本归为一大类，但主要属于冈瓦纳古陆的印度、非洲、南美洲、大洋洲却未能单独聚为一类。就中国而言，小蚓类在黑龙江水系和新疆有较多全北区的成分，而在长江和珠江等水系有较多的东洋区种类，南北间的过渡地带大体在黄河流域一带。到目前为止，小蚓类中计有 1 属 14 种仅在中国有过报道。

关键词　小蚓类，内陆水体，分布，区系相似性，世界，中国