

The millipede genus *Anaulaciulus* in Korea (Diplopoda, Julida, Julidae)

KORSOS Zoltan

Department of Zoology, Hungarian Natural History Museum, Baross u. 13., H-1088 Budapest, Hungary

Abstract: Six species of the East Asian millipede genus *Anaulaciulus* have hitherto been reported from the Korean Peninsula. All of them, i.e. *A. golovatchi*, *koreacolus*, *koreanus*, *longus*, *riedeli* and *tonggosanensis* are reviewed, together with a complete list of literature on their taxonomy and distribution. Their identity in the light of other similar member-species of the genus is discussed and a general pattern of their relationship is outlined.

Introduction

The genus *Anaulaciulus* consists of 44 nominal species (including 4 subspecies). The range of the genus is situated in the temperate zone of Eastern Asia: from Pakistan to Japan, through Nepal, northern India, Sikkim, Tibet, northeastern China and Korea, including the islands of Hong Kong and Taiwan. The species seem to be confined to the temperate zone or higher altitudes, and do not occur in tropical areas.

Anaulaciulus was originally described by POCOCK (1895). For a long time it has been replaced by *Fusiulus* ATTEMS, 1909, and only in 1966 did CAUSEY recognize the synonymy with a redescription of the two POCOCK's species (*paludicola* and *vallicola*).

Anaulaciulus belongs in the subfamily Brachyiulinae, tribe Brachyiulini. The characterization of the genus is given in details by KORSOS (in press a, b). The most important characters can be summarized according to the followings: Gonopods have a structure generally compressed in the antero-posterior direction. Promerites are characteristically flattened, scale-like, rudiments of telopodites and a well-developed flagellum are present. Posterior gonopods are rather simple, elongated, and have several longitudinal, slightly arched lamellae. In external view, the animals have no metazonal setae, cheek lobes are not expanded in the males,

opisthomerites in situ are always protruding from beneath protecting promerites. Penis is long, bifurcate in every member species of the genus.

The female vulval characters show also some peculiarities: they are slightly compressed in the antero-posterior direction, the well-separated operculum is always longer than bursa and apically provided with two lateral cusps (often also a median one). The median cleft on bursa is deep, the apodemetic tube without secondary branches, ampulla usually without an appendix.

Review of the Korean species of *Anaulaciulus*

The only complete list hitherto prepared for the millipedes of Korea (PAIK 1958) enumerates only the three forms of koreanus of the genus in question. In the followings, an annotated list of the species recorded from Korea is given, together with a name history and distributional data of every species. Illustrations wherever available are also referred to.

1. *Anaulaciulus golovatchi* MIKHAILOVA, 1982

Anaulaciulus golovatchi: MIKHAILOVA 1982 (Fig. 2)

Anaulaciulus golovatchi: ENGHOFF 1986

Anaulaciulus golovatchi: KORSOS in press b

Type material is deposited in the Zoological Museum of the Moscow State University, Moscow, Russia.

Distribution in Korea: North Korea (MIKHAILOVA 1993).

2. *Anaulaciulus koreacolus* JEDRYCZKOWSKI, 1982

Anaulaciulus koreacolus: JEDRYCZKOWSKI 1982 (Figs 28-36)

Anaulaciulus koreacolus: ENGHOFF 1986

Anaulaciulus koreacolus: KORSOS in press b

Type material deposited in the Institute of Zoology, Polish Academy of Sciences, Warsaw, Poland.

Distribution in Korea: Sunchon Prov., Josan-ri; and Hyangsan Prov., Mt. Myohyang-san, Manpok-tong and Hyangam-ri (JEDRYCZKOWSKI 1982).

Remarks: Judged only from a comparison of the gonopod illustration, this species is maybe synonymous with *A. longus* (TAKAKUWA, 1941). Opisthomerites of both species have a characteristic shoulder-like lateral lamella, and the tip of the opisthomerit is similarly simple. Unfortunately, no authentic material has been seen

from longus.

3. *Anaulaciulus koreanus* (VERHOEFF, 1937)

Fusiulus koreanus: VERHOEFF 1937 (Figs 4-8)

Fusiulus koreanus koreanus VERHOEFF, 1937: PAIK 1976

Anaulaciulus koreanus: ENGHOFF 1986

Anaulaciulus koreanus koreanus: LIM 1988

Anaulaciulus koreanus: KORSOS in press b

Type material is deposited in the Zoologische Staatssammlung, München, Germany.

Distribution in Korea: Hoko (VERHOEFF 1937, TAKAKUWA 1941), Keisyo (TAKAKUWA 1941, PAIK 1976, LIM 1988).

Two subspecies have been introduced:

1. *Anaulaciulus koreanus boninensis* (VERHOEFF, 1939)

Fusiulus koreanus boninensis: VERHOEFF 1939a (Figs 16-17)

Anaulaciulus koreanus boninensis: GOLOVATCH 1980 (Figs 1-2)

Anaulaciulus koreanus boninensis: ENGHOFF 1986

Type material deposited in the Zoologische Staatssammlung, München, Germany.

Distribution in Korea: Keisyo (TAKAKUWA 1941, PAIK 1976, LIM 1988), Quelpart Island (PAIK 1961), Kangwon Prov., Mt. Kumgang-san (GOLOVATCH 1980).

Remarks: Originally described from Japan: Ogasawara Gunto (Bonin Islands) and the Ryukyus, it has been reported several times from Korea. In the samples collected by the zoological expeditions of the Hungarian Natural History Museum in North Korea this species is very abundant.

2. *Anaulaciulus koreanus tuberculatus* (TAKAKUWA, 1941)

Fusiulus koreanus tuberculatus: TAKAKUWA 1941 (Fig. 19)

Anaulaciulus koreanus tuberculatus: ENGHOFF 1986

Distribution in Korea: Hoko (TAKAKUWA 1941, PAIK 1976, LIM 1988).

Remarks: TAKAKUWA (1941), followed by PAIK (1958, 1976) and LIM (1988), mentioned *A. koreanus* VERH., *A. koreanus koreanus* VERH., *A. k. boninensis* VERH. and *A. k. tuberculatus* from Korea. Besides, PAIK (1958) considered VERHOEFF's original record from the Bonin Island as mislabelled. GOLOVATCH (1980) contributed with an excellent drawing to the knowledge of *boninensis*. Although I could only study an extensive sample from the subspecies *boninensis*,

based on the original descriptions and illustrations I believe that all forms are in fact the same and hence represent the species *A. koreanus* VERHOEFF 1937.

4. *Anaulaciulus longus* (TAKAKUWA, 1941)

Fusiulus longus: TAKAKUWA 1941 (Figs 6-7)

Anaulaciulus longus: ENGHOFF 1986

Anaulaciulus longus: KORSOS in press b

Type material is deposited in TAKAKUWA's collection, Japan.

Distribution in Korea: It is reported by PAIK (1963) from Mt. Sokkri but later identified as a new species (*A. tonggosanensis* PAIK, 1976). Second time the species is mentioned from Korea by LIM (1988), and it is not quite clear whether he is just repeating PAIK's first record. Gonopods of *A. longus*, however, show striking similarity to *A. koreacolus* JEDRYCZKOWSKI, 1982 (see Remarks there).

5. *Anaulaciulus riedeli* JEDRYCZKOWSKI, 1982

Anaulaciulus riedeli: JEDRYCZKOWSKI 1982 (Figs 19-27)

Anaulaciulus riedeli: ENGHOFF 1986

Anaulaciulus riedeli: KORSOS in press b

Type material is deposited in the Zoological Institute, Polish Academy of Sciences, Warsaw, Poland.

Distribution in Korea: Hyangsan Prov., Hyangam-ri, Munsu-tong; Kyongsong Prov., Onpo-ri; and Puryong Prov., Tomak-tong.

Remarks: Based on gonopod opisthomerit similarities, this species is very close to *A. paludicola* (POCOCK, 1895) originally described from China.

6. *Anaulaciulus tonggosanensis* PAIK, 1976

Fusiulus longus TAKAKUWA, 1941: sensu PAIK 1963

Fusiulus tonggosanensis: PAIK 1976 (Figs 1-11)

Anaulaciulus tonggosanensis: KORS^{LS} in press b

Type material is deposited in the collection of Kyungpook University, Taegu, Korea.

Distribution in Korea: Mt. Tonggo-san, Seu-myeon, Ulchin-gun, Mt. Sokkri-san (PAIK 1963, PAIK 1976, LIM 1988).

Remarks: This species, as also mentioned in the diagnosis (PAIK 1976) has a close resemblance to *A. longus*, and hence to *A. koreacolus* as well. It is possible that all the three forms are synonymous.

Several more forms of *Anaulaciulus* have been mentioned in different papers. These are listed in the followings, but more material is needed for their exact identification.

- *Fusiulus* (= *Anaulaciulus*) sp., 1 female, from Mt. Jiri (PAIK 1960)
- *Anaulaciulus* sp., 1 female, Sinryeong-gul Cave (MURAKAMI & PAIK 1968)
- *Anaulaciulus* sp., 1 female, Kyonggi Prov., Mt. Pagyon-san (GOLOVATCH 1980)
- *Anaulaciulus* "sp. 1.", *Anaulaciulus* "sp. 2", several males and females, several localities (LIM 1988)

Discussion

An attempt to describe the general pattern of the intrageneric relationships in all species of *Anaulaciulus* has been made earlier (KORSOS in press b). According to this presentation, based entirely on male gonopod structure similarity, the species hitherto reported from Korea can be pooled in two groups:

1. paludicola-group: *koreacolus*, *longus*, (*paludicola*), *riedeli*, (*simodanus*) and *tonggosanensis*
2. koreanus-group: *koreanus*, (*okinawaensis*), (*trapezoidus*)

Species in parentheses do not, according to our present knowledge, occur in Korea. The two groups listed above are connected to each other by the possible "bridge-species" of the Japanese *A. takakuwai* (KORSOS in press b).

The sixth Korean species, *A. golovatchi* originally described from the Russian Far East and subsequently also reported from North Korea, cannot be inserted in any of the species-groups hitherto outlined. The peculiar structure of its male gonopod opisthomerite may perhaps be an intermediate state on a complete reduction line from a "paludicola"-type gonopod to a simple "needle".

It is also the species *A. golovatchi*, for which it was shown for the first time (MIKHAILOVA 1982) that the shape of the scale-like promerit is vary variable in the populations and that it is not a reliable character for distinguishing species in *Anaulaciulus*.

Summarizing the different taxonomically useful characters, the structure of male gonopods should be mentioned first. However, the degree of the morphological variability of the opisthomerites is still to be defined, and a clarification may well be resulted in a number of synonymies in the species-groups of the genus.

Female (vulval) characters may also have taxonomic importance. The shape of the

ampulla and the apodematic tube, presence or absence of an appendix are to be observed here. In the Korean species a more-or-less spherical ampulla (it is strongly elongated in *riedeli*), a simple or slightly curved apodematic tube (more complicated in *golovatchi*), and the lack of an appendix (presence in *koreanus*) is mostly typical.

As it was shown by the analysis of the *inaequipes*-group (KORSOS in press a), external characters have usually an emphasized importance in distinguishing the members of *Anaulaciulus*. General body colouration (e. g., longitudinal middorsal stripe in *golovatchi*) is more characteristic in several species than the gonopod conformation, and may also be more useful in separating them.

The shape of the epiproct may also help in distinguishing the species. While *koreanus* has a preanal project short, straight and pointed, an upward turned epiproct characterizes some other species (e.g., *golovatchi*, *koreacolus*, *riedeli*).

References

- Causey, N. B. (1966): Redescriptions of two Chinese species of *Anaulaciulus* (Diplopoda, Julidae, Nemasomatidae), a genus known also in Taiwan, Korea, and Japan. - Proc. Louisiana Acad. Sci., 29: 63-66.
- Enghoff, H. (1986): Leg polymorphism in a julid millipede, *Anaulaciulus inaequipes* n. sp. With a list of congeneric species (Diplopoda, Julida, Julidae). - Steenstrupia, 12: 117-125.
- Golovatch, S. I. (1980): A contribution to the millipede fauna of Korea (Diplopoda). - Folia ent. hung., 41: 49-58.
- Jedryczkowski, W. (1982): New and rare millipedes (Diplopoda, Julida) from North Korea. - Annls Zool. PAN, 36: 375-384.
- Korsos, Z. (in press a): Another Himalayan group of julid millipedes: Towards the clarification of the genus *Anaulaciulus* Pocock, 1895 (Diplopoda: Julida). - Senckenbergiana biol.
- Korsos, Z. (in press b): An approach to the revision of the East Asian millipede genus *Anaulaciulus*. - Bull. Mus. Nat. d'Hist. Nat. Paris
- Lim, K.-Y. (1988): Taxonomical studies on Class Diplopoda from Korea. - M. Ed. Thesis, Wonkwang Univ., 34 p.
- Mikhajlova, E. V. (1982): New millipedes of the family Julidae (Diplopoda) from the Soviet Far East. - Zool. Zhur., 61: 210-216.
- Mikhajlova, E. V. (1993): The millipedes (Diplopoda) of Siberia and the Far East of Russia. - Arthropoda Selecta, 2: 3-36.
- Murakami, Y. & Paik, K. Y. (1968): Results of the speleological survey in South Korea 1966 XI. Cave-dwelling myriapods from the southern part of Korea. - Bull. Natn. Sci. Mus. Tokyo, 11: 363-384.
- Paik, K. Y. (1958): A list of Chilopoda, Symphyla and Diplopoda from Korea. - Kyongpook

- Univ. Theses Coll., 2: 351-369.
- Paik, K. Y. (1960): On the myriapods of Mt. Jiri. - J. Applied Zool., 3: 5-13.
- Paik, K. Y. (1961): The myriapeds fauna of Quelpart Island, Korea. - Kyungpook Univ. Theses Coll., 5: 75-88.
- Paik, K. Y. (1963): Survey of the myriapods of Mt. Sökkri, Chungcheung-pookto, Korea. - Kyungpook Univ. Theses Coll., 7: 33-42.
- Paik, K. Y. (1976): A new myriapod of the genus *Fusiulus* (Julidae: Diplopoda). - Theses Coll. of Graduate School Education (Kyungpook Nat. Univ.), 6/7: 157-160.
- Pocock, R. I. (1895): Report upon the Chilopoda and Diplopoda obtained by P. W. Basset-Smith, Esq., Surgeon R. N., and J. J. Walker, Esq., R. N., during the cruise in the Chinese Seas of H. M. S. 'Penguin', Commander W. U. Moore commanding. - Ann. Mag. Nat. Hist., Ser. 6., 15: 346-372.
- Takakuwa, Y. (1941): Die *Fusiulus*-Arten (Diplopoda). - Trans. Sapporo Nat. Hist. Soc., 16: 218-226.
- Verhoeff, K. W. (1937): Zur Kenntnis ostasiatischer Diplopoden. II. - Zool. Anz., 119: 33-40.
- Verhoeff, K. W. (1939a): Zur Kenntnis ostasiatischer Diplopoden. IV. - Zool. Anz., 127: 273-285.