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Taxonomic redescription of *Phagocata sibirica* and comparison with *Phagocata vivida* (Tricladida, Paludicola)

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ABSTRACT. Insufficient knowledge on the morphology and anatomy of the planarian flatworm *Phagocata sibirica* (Zabusov, 1903) has hampered adequate comparisons between species of *Phagocata* from the Far East and the assessment of biodiversity in this group of species. On the basis of an old sample of specimens, collected near the type locality in the vicinity of Lake Baikal by Russian workers who earlier had made important contributions to our knowledge on this group of flatworms, a redescription of the species is provided. The study of these specimens, together with information published by Russian workers, contributes to a much more detailed and comprehensive knowledge on the anatomy of *Ph. sibirica*. Furthermore, this new evaluation points to the fact that there is only one character in which the species *Phagocata fontinalis* (Zabusov, 1903) differs from *Ph. sibirica*. Previously, the species *Phagocata vivida* was sometimes considered to be conspecific with *Ph. sibirica.* On the basis of the examination of new material of *Ph. vivida* (Ijima & Kaburaki, 1916), collected from a new Siberian locality, together with information from the literature, it is concluded that *Ph. sibirica* and *Ph. vivida* cannot be considered as conspecific.

KEY WORDS: Platyhelminthes, Tricladida, Paludicola, *Phagocata sibirica*, *Phagocata vivida*, redescription, taxonomy, morphology

INTRODUCTION

Systematic biological revisions frequently are hampered not only by the complexity of nature itself but also by inadequate species accounts, according to modern standards, and by taxonomic descriptions in a language that prevents easy consultation by the world community of scientists. The Holarctic genus *Phagocata* Leidy, 1847 (Fig. 1) illustrates all of these complexities.

Recently, SLUYS et al. (1995) explored the phylogenetic systematics of the genus, as currently defined. Although it was clear that the current genus *Phagocata* subsumes a heterogeneous group of species, they found only few apomorphic characters suggesting some presumably monophyletic groups within *Phagocata* s.l.

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In a first preliminary, Russian and German account ZABUSOV (1903a) provided a superficial diagnosis of *Phagocata sibirica* (Zabusov, 1903) (olim *Planaria sibirica*) in that it lacks relevant anatomical and histological information. In a second preliminary report ZABUSOV (1903b) gives an equally short and non-informative description of a new variety, *Planaria sibirica* var. *fontinalis*, which is now usually considered to be a separate species, viz. *Phagocata fontinalis* (Zabusov, 1903). That *Ph. fontinalis* represents a separate species was for the first time suggested by LIVANOV & ZABUSOVA (1940), who redescribed the species and placed it into their new genus *Penecurva* Livanov & Zabusova, 1940; later, *Penecurva* was synonymized with *Phagocata* by KENK (1974). The same workers published a redescription (also in Russian) of *Ph. sibirica* under the generic name *Penecurva* (LIVANOV & ZABUSOVA, 1940). The only other more or less detailed, Russian accounts on *Ph. fontinalis* and *Ph. sibirica* are those of DYGANOVA & PORFIRJEVA (1990).

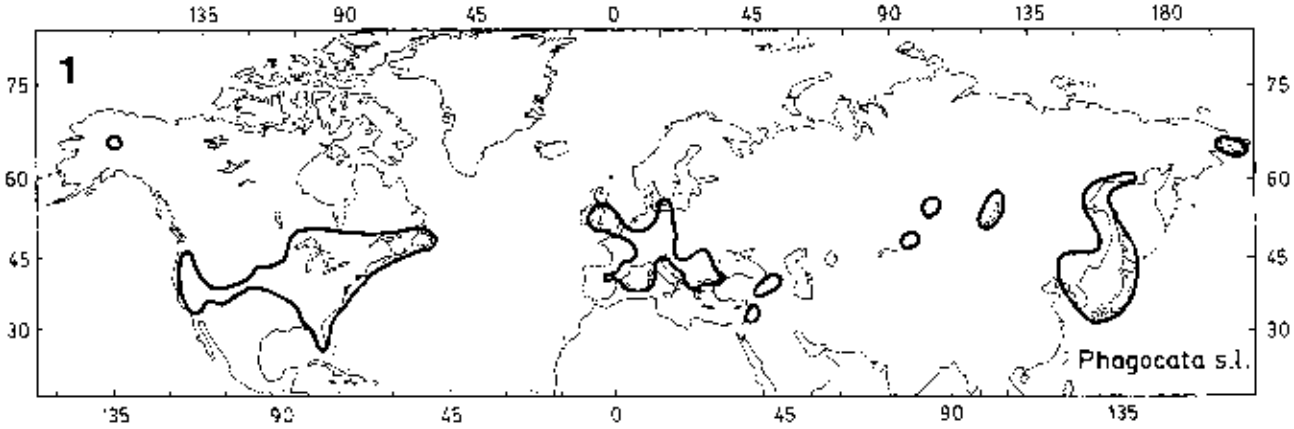


Fig. 1. – Generalized distribution map of the genus *Phagocata* sensu lato.

Present insufficient knowledge on *Ph. sibirica* has already hampered adequate comparisons between species of *Phagocata* from the Far East (KAWAKATSU et al., 1994, 1995), although this has not stopped several workers from assigning their laboratory organisms to the species *Ph. sibirica* (VYKHERESTYUK & KLOCHKOVA, 1984; CHELOMINA & PASHKOVA, 1991; BURENINA, 1993). Therefore, it is fortunate that the collections of the Museum für Naturkunde in Berlin (ZMB) house specimens presented by Livanov and identified as *Penecurva sibirica*. The present paper describes these specimens, thus contributing to a better understanding of the specific characteristics of *Phagocata sibirica*. Furthermore, the morphology of the species is compared with that of an Asian congener, *Phagocata vivida* (Ijima & Kaburaki, 1916), for which we describe specimens from a new Siberian locality that are now housed in the Zoological Museum Amsterdam (ZMA).

SYSTEMATIC SECTION

Order Tricladida Lang, 1884
Suborder Paludicola Hallez, 1892
Family Planariidae Stimpson, 1857
Genus *Phagocata* Leidy, 1847

Phagocata sibirica (Zabusov, 1903)

Material examined

ZMB 8074, Siberia, Baikal mountains, River Tscheremschan (= Cheremshanaya), preserved specimens. Two of the animals were sectioned at intervals of 6 µm and stained in Mallory-Heidenhain (Mallory-Cason): ZMB 8074-1, sagittal sections on 4 slides; ZMB 8074-2, sagittal sections on 6 slides.

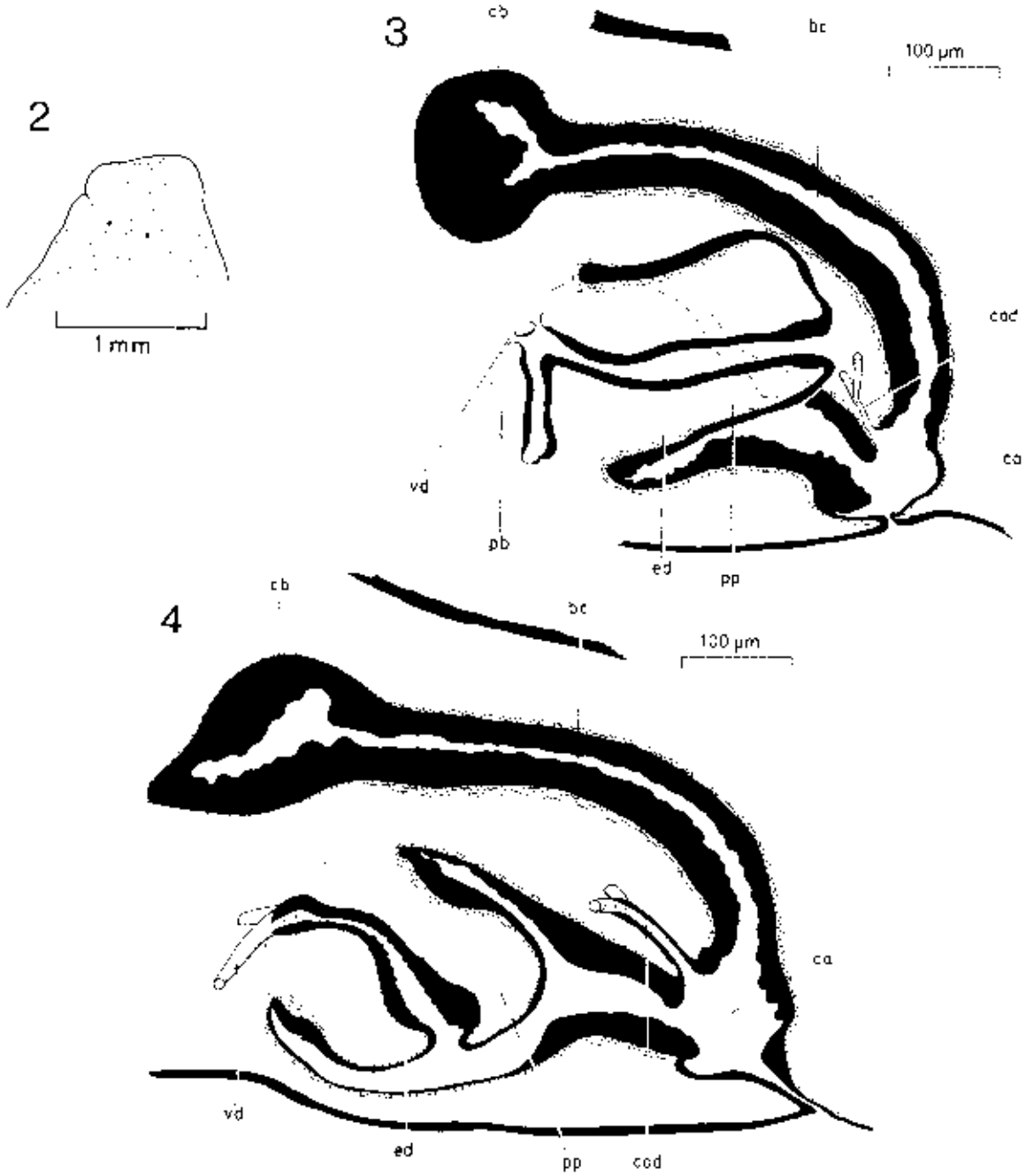
With respect to this sample the entry in the catalogue of the museum reads as follows: "Penecurva sibirica Sab., Sibirien, Baikalgebirge, Fluss Grosser Tscheremschan, 3. VI. 1931, N. Livanov Kasan ded., Frau Sa..... det., Eing. 1934". According to the late Dr. Hartwich (in litt.) of the museum, the name of the person who identified the material is hardly legible, but according to the length of the word and the number of letters it may be the name "Sabussov". According to Dr. Harwich the situation may be interpreted such that Livanov's co-author Zabusova (cf. LIVANOV & ZABUSOVA, 1940) identified this material (and probably also collected the sample) and that the specimens were presented as a gift to the museum by Livanov in 1934.

Redescription

The largest preserved specimen is about 11 mm long and 1.5 mm wide. The dorsal surface is brownish, the ventral surface is pale. The anterior end shows two unpigmented auricles (Fig. 2). In the preserved specimens, the pharynx measures about one-third of the body length. The mouth opening is situated at the posterior end of the pharyngeal cavity.

The numerous small testes are situated ventrally and extend from the level of the ovaries into the posterior end of the body. The paired ovaries are situated directly posterior to the brain; vitellarian follicles, located mainly in the ventral body region, occur throughout the body length.

The penis papilla is a blunt, stubby structure lined with a nucleate epithelium, which is underlain with circular and longitudinal muscles, respectively; the penis bulb is moderately muscular (Figs. 3, 4). The animals are characterized by a slightly asymmetrical penial papilla, due to a ventrally displaced ejaculatory duct that opens at the tip of the papilla. Immediately after having penetrated the musculature of the penis bulb, the vasa deferentia open into the slightly expanded proximal section of the ejaculatory duct. From hereon, the ejaculatory duct narrows slightly before expanding again and opening at the tip of the penial papilla; the duct is lined with tall, nucleated cells. In specimen ZMB 8074-1 the proximal section of the ejaculatory duct gives rise to a, probably atypical, ventrally directed duct that seems to extend somewhat beyond the perimeter of the penial bulb.



Figs. 2-4. – *Phagocata sibirica*. (2) ZMB 8074, anterior end of preserved specimen; (3) ZMB 8074-1, sagittal reconstruction of the copulatory apparatus; (4) ZMB 8074-2, sagittal reconstruction of the copulatory apparatus. Abbreviations: bc, bursal canal; ca, common atrium; cb, copulatory bursa; cod, common oviduct; ed, ejaculatory duct; pb, penis bulb; pp, penial papilla; vd, vas deferens.

The male atrium that houses the stubby penial papilla narrows considerably before communicating with the common atrium; the female atrium is very small.

The common oviduct opens at the junction between male and common atrium. Shell glands could not be observed unequivocally, maybe due to the relatively weak staining of the preparations.

A small copulatory bursa is situated antero-dorsally to the penial bulb; there appeared to be no difference between the lining of the bursa and that of the bursal canal. The bursa communicates with a bursal canal that opens into the dorsal portion of the common atrium; the canal is lined with a tall, nucleated epithelium that is overlain with a well developed layer of intermingled longitudinal and circular muscles.

Phagocata vivida (Ijima & Kaburaki, 1916)

Material examined

ZMA: V.Pl. 914.1, Khor River, near Khabarovsk, Siberia, Russia, 4 September 1997, sagittal sections on 8 slides; V.Pl. 914.2, ibid., sagittal sections on 7 slides; V.Pl. 914.3, ibid., sagittal sections on 13 slides. Sections were made at intervals of 8 µm and were stained in Mallory-Heidenhain (=Mallory-Cason).

Description

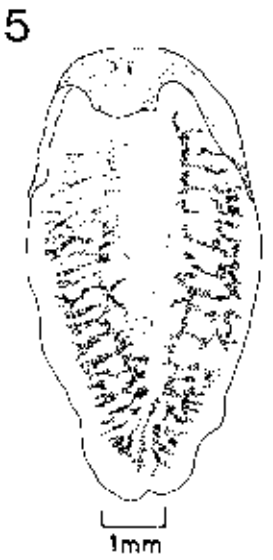
The largest preserved specimen measured about 10 x 3.5 mm. The dorsal surface is brown, the ventral body surface pale; the anterior end is provided with two unpigmented auricles (Fig. 5). The pharynx is located in the middle of the body and measures between one-fourth and one-fifth of the body length, in preserved specimens. The mouth opening is located at the posterior end of the pharyngeal cavity.

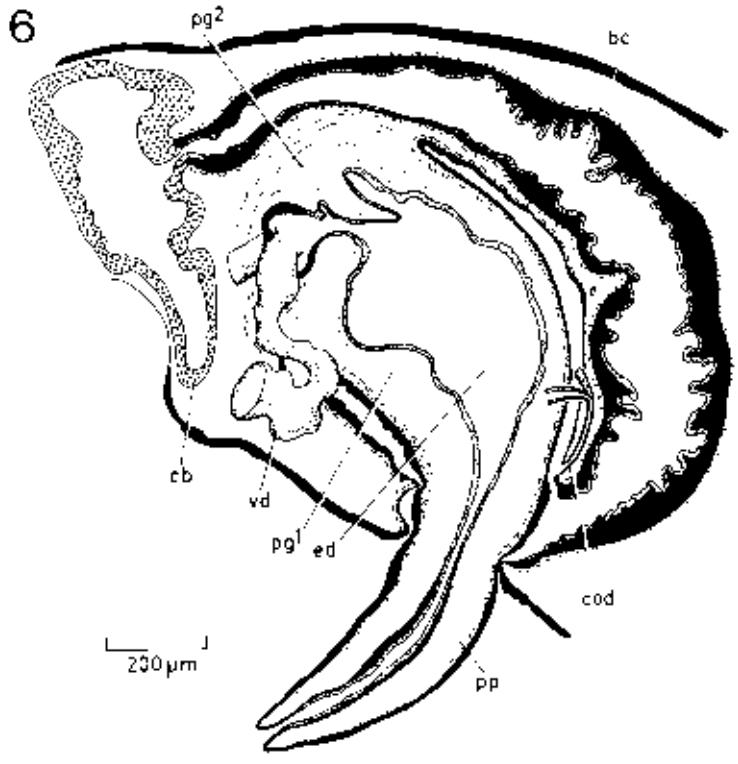
The testis follicles occupy most of the dorso-ventral space and are distributed throughout the body length. The ovaries are located at a short distance (approx. 300 µm) behind the brain. Vitellarian follicles are well developed, occupying the entire dorso-ventral space and extending throughout the body.

In all three of the specimens examined the penial papilla extends through the gonopore (cf. Fig. 6), most likely as a result of the fixation in 70% ethanol. In these specimens the penial papilla is an elongated cone, covered with a nucleated epithelium, which is underlain with a well developed layer of circular muscle, followed by a layer of longitudinal muscle.

At the level of the copulatory apparatus the vasa deferentia expand to form large spermiducal vesicles. Subsequently, the ducts narrow and recurve before penetrating the penis bulb. Once within the bulb, the vasa deferentia expand again before separately opening into the intrabulbar seminal vesicle; the intrabulbar, expanded section of the vasa deferentia is surrounded by a coat of mostly circular muscle fibres. The seminal vesicle, which is lined with a nucleated epithelium, communicates with the highly expanded proximal section of the ejaculatory duct. It may well be that in animals with a more contracted penis papilla this expanded proximal portion of the ejaculatory duct is located within the penial bulb and then represents a sort of bulbar cavity. In the present specimens this presumed bulbar cavity gradually narrows to form the ejaculatory duct, which traverses the penis to open at the tip of the penial papilla; the ejaculatory duct is lined with a cuboidal to tall, nucleated epithelium.

The presumed bulbar cavity and the interconnecting duct between the cavity and the seminal vesicle receive the secretion of abundant eosinophilic glands. Another type of penis gland is also highly developed and discharges a more granular erythrophilic secretion into the





Figs 5-6. – *Phagocata vivida* (5) ZMA: V.Pl. 914, ventral view of preserved specimen; (6) ZMA: V.Pl. 914.1, sagittal reconstruction of the copulatory apparatus. Abbreviations: bc, bursal canal; cb, copulatory bursa; cod, common oviduct; ed, ejaculatory duct; od, oviduct; pg^1, first type of penial gland; pg^2, second type of penial gland; pp, penial papilla; sg, shell gland; spe, spermatophore; sv, seminal vesicle; vd, vas deferens.

ejaculatory duct; most of the glands open into the proximal section of the duct, whereas the distal part of the ejaculatory duct receives much less secretion.

Before uniting to form the common oviduct, the distal sections of the separate oviducts receive the secretion of erythrophilic shell glands; the glands do not open into the common oviduct. Oviducts and common oviduct are lined with a cuboidal, nucleated epithelium. The common oviduct opens through the roof of the most distal (posterior) section of the male atrium, i.e. at the junction of the male and common atrium (a separate female atrium practically being absent); the male atrium is lined with a cuboidal, nucleated epithelium.

A relatively large copulatory bursa is located directly anterior to the hemispherical penis bulb; the bursa of specimen V.Pl. 914.2 contains the distinct remains of a spermatophore. A broad bursal canal connects the bursa with the common atrium. The bursal canal is lined with a nucleated, glandular epithelium, the secretion accumulating in the apical sections of the cells; the canal is covered with a subepithelial layer of circular muscle, followed by a layer of longitudinal muscle.

COMPARATIVE DISCUSSION

Phagocata sibirica

When the anatomy of the specimens from the River Cheremshanaya is compared with the descriptions of *Ph. sibirica* provided by Zabusov (1903a) and Livanov & Zabusova (1940), it is important to note that the gross morphology of the reproductive apparatus of the specimens examined suggests that they are not fully mature. Notably their small copulatory bursae, densely packed with small cells, and the apparent absence of shell glands seem to indicate that the animals are not in a state of full maturity. However, the same appears to have been the case with some of the animals studied by Zabusov (1903a) and Livanov & Zabusova (1940). The latter mentioned that the majority of their specimens, collected in 1931, and some collected by Zabusov (1903a, b) have evidently no mature genital organs. Furthermore, Livanov & Zabusova (1940) provide a description of specimens that are not completely mature but also give an account of the anatomy of animals that are in a state of full maturity. It is to be expected that the animals from the River Cheremshanaya will resemble the not fully mature specimens described by Livanov & Zabusova (1940) since they probably stem from the same sample taken in 1931.

According to Zabusov (1903a), *Ph. sibirica* is characterized by a male atrium that via a kind of channel communicates with the common genital atrium. Although Livanov & Zabusova (1940) interpreted this feature to be an artefact, it does hold true also for the Cheremshanaya specimens, in which the male atrium narrows considerably before communicating with the common genital atrium.

Zabusov (1903a) and Livanov & Zabusova (1940) described for *Ph. sibirica* an acentral, ventrally displaced ejaculatory duct running through a short and blunt penial papilla, representing features that are present also in the Cheremshanaya animals. Livanov & Zabusova also mentioned that in fully mature animals the ejaculatory duct receives the secretion of shell glands; another type of secretion would be discharged into the small seminal vesicle at the proximal end of the ejaculatory duct.

As is the case with the material examined, Livanov & Zabusova (1940) were also unable to discern shell glands opening into the oviducts and/or common oviduct of their not completely mature specimens; Zabusov does not mention the shell glands, but his drawing (Zabusov, 1903a, fig. 14) suggests that they open into the common oviduct. Livanov & Zabusova observed that in their fully mature animals shell glands open into the distal sections of the oviducts and into the proximal part of the common oviduct.

Zabusov (1903a) did not say anything about the testes, but Livanov & Zabusova (1940) mentioned that the follicles extend to the dorsal body surface when they are fully developed. This implies, in our opinion, that the testes are ventral in less mature specimens, such as the Cheremshanaya animals.

According to Livanov & Zabusova (1940) the copulatory bursa occupies only the dorsal half of the body in less mature specimens, as we observed in the Cheremshanaya animals, but that the bursa occupies the entire dorso-ventral space in fully mature specimens. Livanov & Zabusova described the musculature of the bursal canal as consisting of intermingled layers of longitudinal and circular muscle fibres, both in fully mature and less mature specimens; an intermingled muscle coat was observed also in the Cheremshanaya animals.

One last, and less important, feature in which the material examined agrees with the accounts of Livanov & Zabusova (1940) and Zabusova-Zhdanova (1962) on *Ph. sibirica* is that the pharynx measures about one-third of the body length.

On the basis of the comparisons discussed above, we have concluded that the Cheremshanaya specimens indeed concern representatives of the species *Ph. sibirica*, albeit in a not fully mature state.

When the characteristics of *Ph. sibirica* are compared with those of *Ph. fontinalis*, as described by Zabusov (1903b) and Livanov & Zabusova (1940), there is actually very little that might be considered supportive of the presumed specific status of the last-mentioned species. Initially, the species was merely recognized as a variety of the species *Ph. sibirica* on the basis of a slightly different configuration of the intestinal branches: *Ph. sibirica* var. *fontinalis*. However, according to Livanov & Zabusova

(1940) *Ph. fontinalis* also differs from *Ph. sibirica* in details of its copulatory apparatus. Although LIVANOV & ZABUSOVA (1940) gave a comprehensive description of *Ph. fontinalis* there is actually only one character that seems to be really different between the two species, i.e. the presence of a non-intermingled coat of circular and longitudinal muscle on the bursal canal of *Ph. fontinalis*, thus contrasting with the coat of intermingled muscle in *Ph. sibirica* .

Phagocata vivida

Our conclusion that the Khabarovsk specimens belong to the species *Ph. vivida* has been reached after detailed comparison of their features with other, congeneric species. Notably, for only a few species of *Phagocata* sensu stricto (cf. SLUYS et al., 1995) have testes been reported that occupy most of the dorso-ventral space and extend throughout most of the body: *Ph. kawakatsui* Okugawa, 1956 (from Shikoku, Chûgoku, Kinki, and Chûbu Regions in Honshû, central Japan), *Ph. suginoi* Kawakatsu, 1974 (from Hokuriku Region in Honshû, central Japan), *Ph. tenella* Ichikawa & Kawakatsu, 1963 (from Hokkaidô, northern Japan), *Ph. teshirogii* Ichikawa & Kawakatsu, 1962 (from Tôhoku Region in Honshû, northern Japan), *Ph. vivida* (from Kyûshû, Shikoku, Honshû, and Hokkaidô, Japan; also distributed in the Korean Peninsula and northeastern China). However, the Khabarovsk specimens do not exhibit a sphincter on the bursal canal (as in *Ph. kawakatsui*), an expanded common oviduct (as in *Ph. suginoi*), an expanded and tall epithelium at the distal, vaginal end of the bursal canal (as in *Ph. tenella*), or the enlarged, intrabulbar parts of the vasa deferentia opening into the equally sized bursal cavity (as in *Ph. teshirogii*). The copulatory apparatus of the Khabarovsk animals, however, conforms to the situation described for *Ph. vivida*. Particularly noteworthy in *Ph. vivida* are the expanded intrabulbar parts of the vasa deferentia, opening into a small seminal vesicle that, via a constriction, communicates with the bulbar lumen, the latter tapering to form the ejaculatory duct (cf. KAWAKATSU et al., 1982, 1994); these are all features that also occur in the Khabarovsk specimens. Furthermore, *Ph. vivida* has been described with well developed penial glands opening into the bulbar lumen and the ejaculatory duct, and with a highly glandular epithelium of the bursal canal (KAWAKATSU et al., 1982, 1994), being features that are present also in the specimens from Khabarovsk. The only difference between previous accounts of *Ph. vivida* and the present material concerns the presence of a much more developed muscle coat on the distal section of the bursal canal, consisting of a thin inner layer of longitudinal muscle, a thick layer of circular muscle, followed by a well-developed layer of longitudinal muscle. This thick coat of muscle contrasts with the thin and simple musculature covering the bursal canal of the Khabarovsk animals.

Confusion and distribution

In the past there has been some confusion about the identity of *Ph. sibirica* and *Ph. vivida*, which were sometimes considered as conspecific (cf. TU, 1939). However, on the basis of the descriptions provided above it can be concluded that they are separate species, each characterized by several distinct features.

Ph. vivida occurs both in Japan and on the mainland in the Far East (cf. KAWAKATSU et al., 1995, fig. 2). *Ph. sibirica* was first described from near Lake Baikal and since then has been found at several localities in the vicinity of the lake. Furthermore, the last-mentioned species has been reported also from near Lake Belove and from localities in Primorskiy Kray and Khabarovsk Kray (cf. KAWAKATSU et al., 1995, fig. 2); in addition, findings have been reported also for the Zabaykalsk (DYGANOVA & PORFIRJEVA, 1990) and Krasnoyarskiy territories (ZABUSOVA-ZHDANOVA,1962). In view of the better understanding that we now have of the anatomy of *Ph. sibirica* it is desirable that records far from the type locality and the environs of Lake Baikal are substantiated by new findings and by voucher material.

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