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W. R. NICKLE

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## Observations on *Hexatylus viviparus* and *Neotylenchus abulbosus* (Neotylenchidae: Nematoda)

W. R. NICKLE<sup>1</sup>

T. Goodey (1926a) described *Hexatylus viviparus* from potato in England as a new genus and species. He also found it in diseased gladiolus corms, and later, T. Goodey (1926b) expanded the description. In 1931 Steiner proposed *Neotylenchus abulbosus* as a new genus and species for nematode specimens found associated with strawberry plants in California. He also stated that he collected it from strawberry plants in Wisconsin and Germany; from potatoes in ships stores from England, Holland, Norway, and New Brunswick, Canada; and from carrots in England and Sweden. In 1932 Steiner and Buhner described a single male specimen from carrots in Sweden as that of *N. abulbosus*. Both T. Goodey and Steiner accurately identified these nematodes, which lacked a valved median esophageal bulb, as not being the bulb and stem nematode, *Ditylenchus dipsaci* (Kühn), that required quarantine restrictions at that time.

Tylenchids lacking a valved median bulb have been known and studied for 42 years, and as a result of this study, the genus *Neotylenchus* has been designated as the type genus of the family Neotylenchidae. This family now includes about 75 nominal species.

A study of the esophageal morphology of the original specimens of Steiner's *N. abulbosus*, and *H. viviparus* of T. Goodey is basic to understanding the taxonomy of this large group of nematodes because various esophageal interpretations now appear in the literature (Fig. 1).

### Materials and Methods

Female specimens of *Neotylenchus abulbosus*, the original collection from strawberry in California, were obtained from the USDA Nematode Collection. The male from carrot in Sweden and some females from the same collection were also available. Other original specimens, labeled by Steiner and others as *Neotylenchus abulbosus*, were studied. These included nematodes from potato in England,

Holland, and Germany; from carrots in England; from sugarbeets in California; from iris in Holland; from turnip in Wales; from poppy in England; and from plantain in Oregon. D. J. Hooper of the Rothamsted Experiment Station kindly loaned me mounted syntype specimens of the original *Hexatylus viviparus* and *Neotylenchus consobrinus* (de Man, 1907) Filipjev, 1936, and a vial containing a mass collection of *H. viviparus* from potato in Ireland grown on a *Botrytis* culture. *Hexatylus viviparus* and other neotylenchids from the Thorne Collection also were thoroughly studied for relevant relationships. Paratype slides of *Hexatylus mulveyi* Das, 1964, were sent to me for study by R. H. Mulvey.

Steiner's slides of *Neotylenchus abulbosus* from strawberry in California were flooded with warm glycerine and remounted. Some specimens from the mass collection of *Hexatylus viviparus* were stained by the cottonblue-lactophenol technique, while others were stained in picric acid and mounted in dehydrated glycerine.

### Results and Discussion

Studies of the original syntype material of *Neotylenchus abulbosus* revealed that the stylet was surrounded by strengthening rings (Fig. 2C), similar in arrangement to those illustrated for *Hexatylus viviparus*. The stylet knobs of *N. abulbosus* were not in the form of outward-pointing curved processes as described by Steiner, 1931, but appeared slightly bifid (Fig. 2C). The posterior part of the esophagus of *N. abulbosus* did not have the definitely set-off posterior bulb, as expected from previous descriptions, but had dorsally overlapping glands. Syntype specimens and a mass collection of *H. viviparus* from Rothamsted also were studied and other similarities between the two species were noted. There was a prominent junction of the esophageal and intestinal lumena (Fig. 2A), just anterior to the nerve ring in both *N. abulbosus* and *H. viviparus*. This eliminates the possibility of a definitely set-off posterior bulb. Previous

<sup>1</sup> Nematologist, Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture, Beltsville, Maryland.

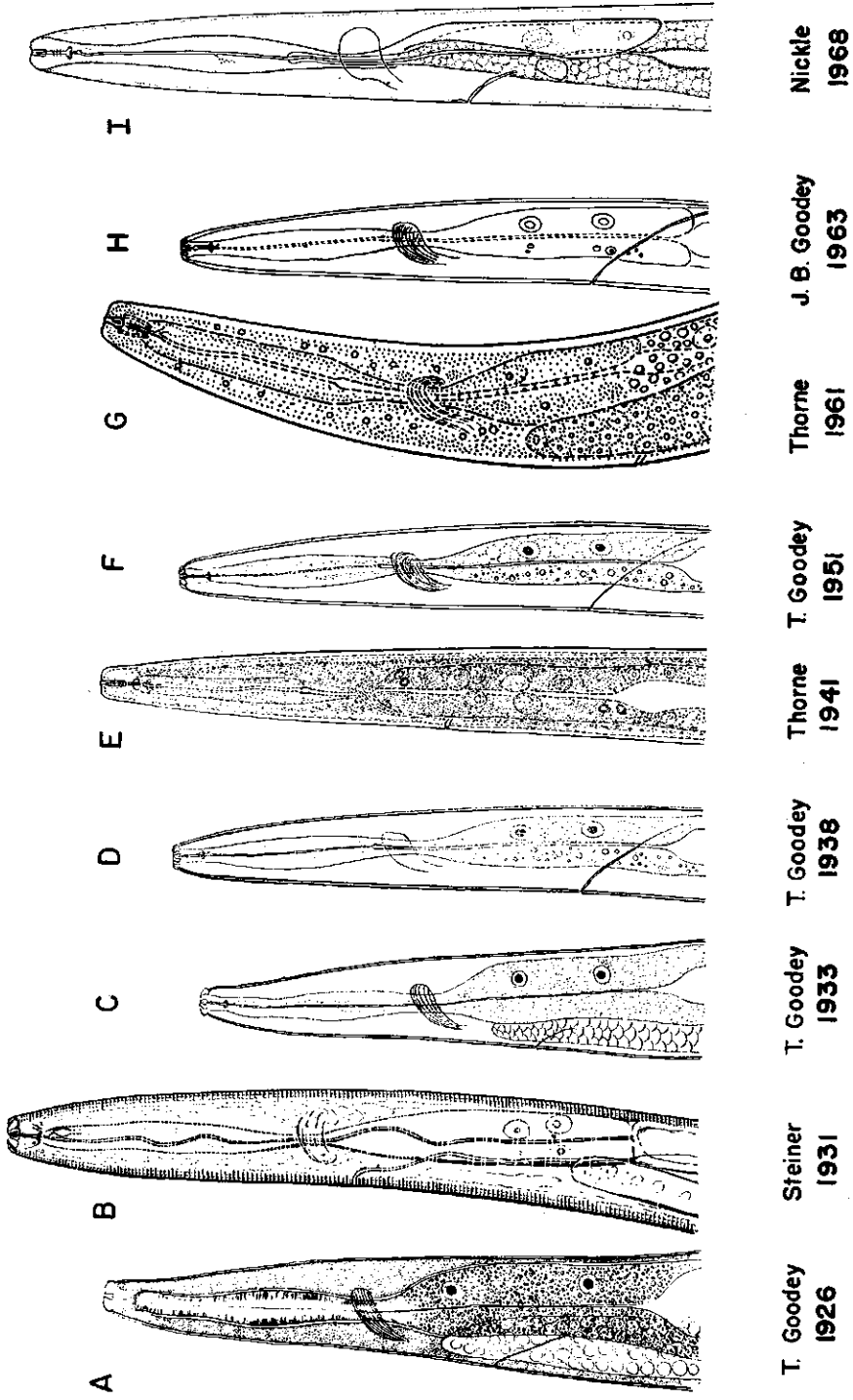


Figure 1. Drawings depicting the various interpretations of the esophageal area of *Hexatyphlus viviparus*.

workers considered the junction of the esophagus and intestine to be at the widening of the intestinal lumen at the level of the base of the overlapping esophageal glands (Fig. 1). The suggestion that the esophagus and intestine are fused, as stated in the diagnosis of the genus *Hexatylus*, was difficult to accept since fusion of two organ systems is not known to occur anywhere in the animal kingdom, and it would be unlikely to occur only in this nematode genus.

Both stained and glycerine mounted specimens of *H. viviparus* revealed that the esophageal glands overlap the intestine and lie dorsally in a diverticulum. Three esophageal gland nuclei and two large coelomocytes were present in the area (Fig. 2A). These coelomocytes may have been confused by earlier workers with the gland nuclei (Fig. 1). The overlapping esophageal glands were also observed in the original *N. abulbosus* and *H. viviparus* material. The posterior part of the esophagus did not vary from a posterior bulb to overlapping glands. Other differences previously thought to exist between *N. abulbosus* and *H. viviparus* were not found. Both nematodes were found to have the cephalic framework in eight sectors (Fig. 2B) as Steiner (1931) described and four lateral lines. The subventral gland orifices opened into the area where the median bulb would have been if it were present. The intestinal lumen widened broadly at a level just posterior to the base of the overlapping gland.

The male specimen from carrot in Sweden, described as the male of *N. abulbosus*, and some female nematodes from the same collection, were studied. These female nematodes were the same as *Hexatylus viviparus* as described in this paper. The male was not in good condition. It looked like it may have had a stylet, but the specimen gave the appearance of having decomposed before fixation rather than that of lacking a stylet as described by Steiner. *N. abulbosus* was described from female specimens taken from strawberry plants in California, and it appears unwise that the description of this male specimen from carrot in Sweden be given much credence in the taxonomy of *N. abulbosus*.

The esophageal area of *Hexatylus viviparus* has been illustrated differently nine times by

five nematologists in the last 42 years (Fig. 1). Because this area is difficult to see, we are confronted by illustrations that depict the esophagus as being fused with the intestine, as having a definitely set-off posterior bulb, and now as having overlapping glands. T. Goodey's original drawing (Fig. 1A) showed a fusion of the esophagus with the intestine and no esophageal gland orifices. Steiner's drawing (Fig. 1B) may have been a dorsal or ventral view of the overlapping gland which made it appear as a definitely set-off posterior bulb. In 1933 T. Goodey redrew this nematode (Fig. 1C), and though he maintained the fusion of the esophagus with the intestine, he added the dorsal and subventral gland orifices. He redrew the nematode again in 1938 (Fig. 1D) and added the important junction of the esophageal and intestinal lumina. He also still considered the esophagus and intestine to be fused, but he changed the pattern on the ventral side of the esophagus to appear more like an intestine. Thorne made a drawing (Fig. 1E) of this nematode in 1941 and decided that the esophagus was fused with the intestine. He pointed out the strengthening rings around the stylet but did not differentiate between the subventral gland orifices and the junction of the esophageal and intestinal lumina. T. Goodey redrew the nematode with minor changes for his textbook of 1951 (Fig. 1F). Thorne redrew the front end of this nematode for his textbook in 1961 (Fig. 1G). It was similar to his earlier drawing, and he still considered the esophagus to fuse with the intestine. In 1963 J. B. Goodey rounded off the base of the overlapping esophageal gland (Fig. 1H) and mentioned that further work might show that *H. viviparus* and *N. abulbosus* are indistinguishable. Figure 1I depicts the present author's interpretation of the esophageal intestinal area.

No differences could be found between syn-type specimens of *H. viviparus*, the type species of *Hexatylus*, and *N. abulbosus*, the type species of *Neotylenchus*. They thus become conspecific, requiring the synonymy of the genus *Neotylenchus* under the genus *Hexatylus*. This synonymy has been proposed in the past, or suggested by several workers (T. Goodey, 1933, 1938; Christie, 1938; Andrassy, 1952; Meyl, 1954; J. B. Goodey, 1963). How-

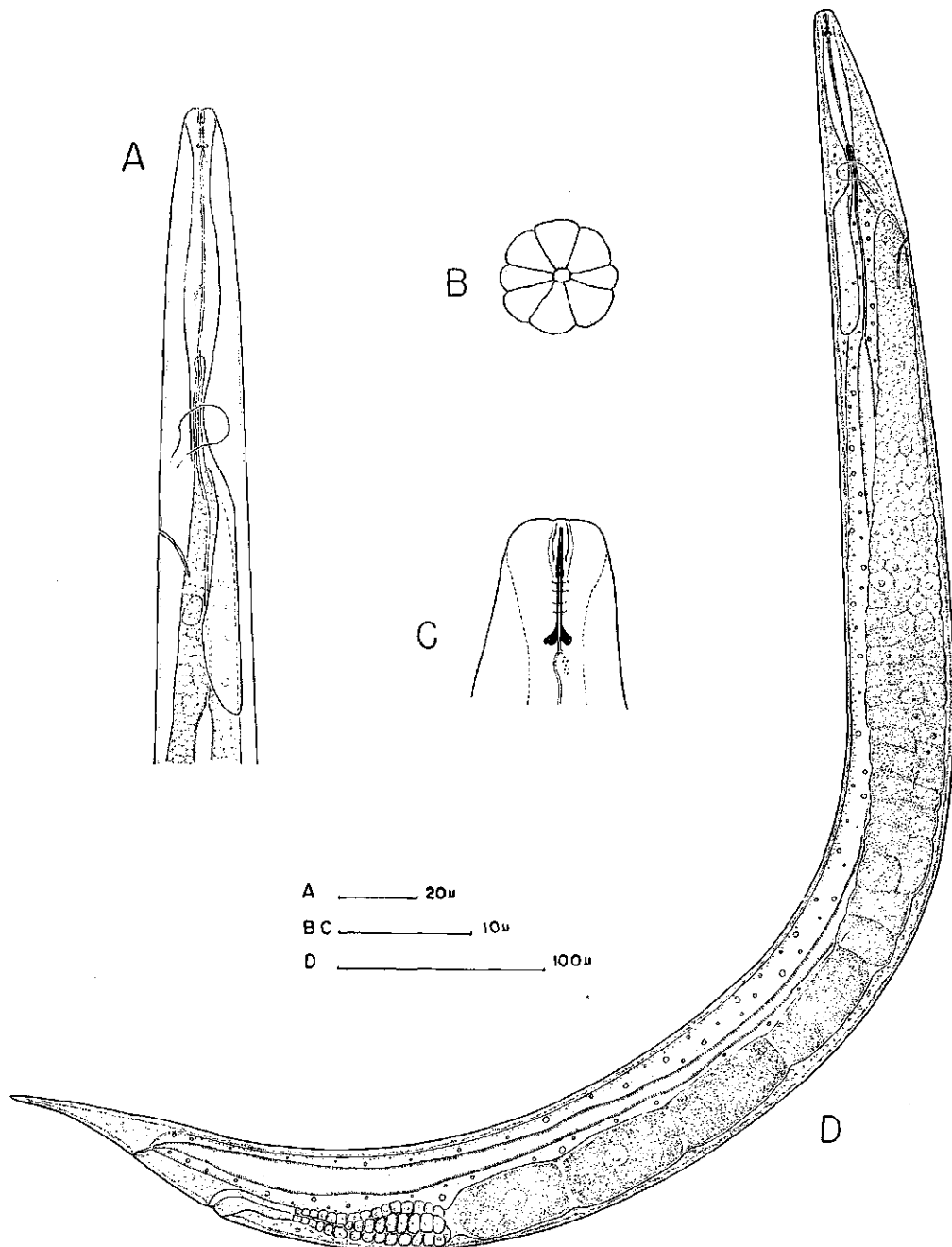


Figure 2. Drawings from *Hexatyclus viviparus* and the original *Neotylenchus abulbosus* material. A. Anterior end of *H. viviparus* from gladiolus corm. B. *En face* view, from original *N. abulbosus* slide. C. Head and stylet of original *N. abulbosus* specimen, showing bifid knobs and strengthening rings. D. Female from an original specimen of *N. abulbosus*.

ever, this action seems justified by the present studies of the original material of Steiner and T. Goodey.

The results of this study of syntype material of *N. abulbosus* and *H. viviparus* require certain adjustments in the Neotylenchidae, some of which are beyond the scope of this paper. As the type species of the genus *Neotylenchus* becomes a junior synonym of the type species of the genus *Hexatylus*, the former generic name can no longer be used. The family name Neotylenchidae and the subfamily name Neotylenchinae are retained. Studies of the available specimens and literature of the remaining species of the old genus *Neotylenchus* do not reveal a suitable type species to represent them as a group. My observations require the transfer of *N. consobrinus* (de Man, 1907) Filipjev, 1936, to another genus in the Neotylenchidae, namely, *Paurodontus* Thorne, 1941, because of the presence in T. Goodey's specimens of a long stemlike projection of esophageal tissue into the intestine. *N. linfordi* Hechler, 1962, has a short stemlike projection at the base of the esophagus and is also placed in the genus *Paurodontus*. In making these changes, I agree with J. B. Goodey (1963) in reducing the taxonomic value placed on the number of sectors in the cephalic framework of members of this family. After a study of excellently preserved syntype material, I have transferred *Neotylenchus arcuatus* Thorne, 1941, to the genus *Nothanguina* Whitehead, 1959. *Neotylenchus velatus* (Bütschli, 1873) Skarbilovich, 1952, *N. obtusicaudus* (Stek., 1941) Skarbilovich, 1952, and *N. zaeae* (Stek., 1941) Skarbilovich, 1952, are placed in *species inquirendae*. *N. acutus* Thorne, 1941; *N. beljaevae* (Atakhanov, 1959) Andrassy, 1961; *N. coprophagus* (T. Goodey, 1938) Thorne, 1941; *N. dendrophilus* Rühm, 1956; *N. intermedius* (Christie, 1938) Thorne, 1941; *N. latus* Thorne, 1935; *N. obesus* Thorne, 1934, and *N. serpens* Andrassy, 1961, require more study before they can be placed properly within the family Neotylenchidae. They are also considered as *species inquirendae*.

*Hexatylus mulveyi* Das, 1964, with six lines in the lateral field is retained as a valid species of the genus *Hexatylus*. The genus *Scytaleum* Andrassy, 1961, which he considered to be intermediate between the genus *Hexatylus* and

the genus *Neotylenchus*, is placed as a synonym of *Hexatylus*. *Scytaleum vigissi* (Skarbilovich, 1952) Andrassy, 1961, the type species of the genus *Scytaleum*, with a shorter stylet and the presence of males, is also considered a valid species of *Hexatylus*, as originally proposed by Skarbilovich. The three remaining species in the genus *Scytaleum*: *S. italicum* (Meyl, 1954) Andrassy, 1961; *S. skarbilowiczae* (Atakhanov, 1959) Andrassy, 1961; and *S. thornei* (Meyl, 1954) Andrassy, 1961, are placed in *species inquirendae*. Other *species inquirendae* include: *Hexatylus boettgeri* Meyl, 1954; *H. brevicaudatus* Meyl, 1954; and *H. dipapillatus* Meyl, 1954. Future work, especially on the esophageal area, will undoubtedly reveal their exact status.

The following changes are therefore proposed at this time:

*Hexatylus* T. Goodey, 1926.

Syn. *Neotylenchus* Steiner, 1931.

*Scytaleum* Andrassy, 1961.

*Hexatylus viviparus* T. Goodey, 1926.

Syn. *Neotylenchus abulbosus* Steiner, 1931.

*Hexatylus vigissi* Skarbilovich, 1952.

Syn. *Scytaleum vigissi* (Skarbilovich, 1952) Andrassy, 1961.

*Paurodontus linfordi* (Hechler, 1962)

n. comb.

Syn. *Neotylenchus linfordi* Hechler, 1962.

*Paurodontus consobrinus* (de Man, 1907)

n. comb.

Syn. *Neotylenchus consobrinus* (de Man, 1907) Filipjev, 1936.

*Nothanguina arcuatus* (Thorne, 1941)

n. comb.

Syn. *Neotylenchus arcuatus* Thorne, 1941.

#### *Species inquirendae*

The following species seem to belong in the Neotylenchidae but the details in their descriptions are inadequate for recognition by present-day standards. These species require more study, in the light of the basic changes imposed upon this group by the information presented in this paper.

*Neotylenchus acutus* Thorne, 1941.

*Neotylenchus beljaevae* (Atakhanov, 1959) Andrassy, 1961.

- Neotylenchus coprophagus* (T. Goodey, 1938) Thorne, 1941.  
*Neotylenchus dendrophilus* Rühm, 1956.  
*Neotylenchus intermedius* (Christie, 1938) Thorne, 1941.  
*Neotylenchus latus* Thorne, 1935.  
*Neotylenchus obesus* Thorne, 1934.  
*Neotylenchus obtusicaudus* (Stek., 1941) Skarbilovich, 1952.  
*Neotylenchus serpens* Andrassy, 1961.  
*Neotylenchus velatus* (Bütschli, 1873) Skarbilovich, 1952.  
*Neotylenchus zaeae* (Stek., 1941) Skarbilovich, 1952.  
*Hexatylus boettgeri* Meyl, 1954.  
*Hexatylus brevicaudatus* Meyl, 1954.  
*Hexatylus dipapillatus* Meyl, 1954.  
*Scytaleum italicum* (Meyl, 1954) Andrassy, 1961.  
*Scytaleum skarbilowiczae* (Atakhanov, 1959) Andrassy, 1961.  
*Scytaleum thornei* (Meyl, 1954) Andrassy, 1961.

Genus: *Hexatylus* T. Goodey, 1926.

Syn. *Neotylenchus* Steiner, 1931.

*Scytaleum* Andrassy, 1961.

DIAGNOSIS (Emended): Neotylenchinae. Cephalic framework octagonal. Stylet knobs slightly bifid. Pharynx slightly sclerotized, with several strengthening rings surrounding stylet. Dorsal esophageal gland orifice near base of stylet. Subventral gland orifices open in area where median bulb would have been if it were present. Lumen of esophagus joins lumen of intestine near base of corpus, in region of nerve ring. Lumen becomes wider at this junction and widens again markedly at level of base of overlapping esophageal glands. Esophageal glands overlap intestine dorsally in a diverticulum. Intestinal lumen with prominent villae. Gonad prodelphic, well-developed, extending into esophageal area; vulva posteriorly located; postuterine sac absent. Tail short, more or less acuminate. Males rare or absent.

Type species: *Hexatylus viviparus* T. Goodey, 1926.

Syn. *Anguillulina* (*Hexatylus*) *vivipara* (T. Goodey, 1926) W. Schneider, 1939.

*Iotonchium viviparum* (T. Goodey, 1926) Filipjev and Stek., 1941.

- Neotylenchus abulbosus* Steiner, 1931.  
*Hexatylus abulbosus* (Steiner, 1931) T. Goodey, 1933.  
*Anguillulina* (*Neotylenchus*) *abulbosa* (Steiner, 1931) W. Schneider, 1939.  
*Iotonchium abulbosum* (Steiner, 1931) Filipjev and Stek., 1941.

MALE: Unknown.

FEMALE: Length 0.67–1.5 mm; width 0.037–0.057 mm; a = 15–35; b = 13–16; c = 10–20; V% = 81–89; stylet = 9–11  $\mu$ .

Females with great variation in length and width between those not yet producing eggs and senile forms. Cuticle striated. Lateral field with four lines. Phasmids and deirids not observed. Cephalic framework slightly sclerotized. Stylet 9–11  $\mu$ . Excretory pore posterior to nerve ring. Hemizonid just anterior to excretory pore. Overlapping esophageal glands located dorsally in a diverticulum, later more degenerate, and pushed to side by developing ovary.

*Bionomics.* This species has worldwide distribution and has been found in various situations in which rotting plant material was present. It has been successfully cultured on fungal plates.

Other species:

*Hexatylus mulveyi* Das, 1964.

*Hexatylus vigissi* Skarbilovich, 1952.

Syn. *Scytaleum vigissi* (Skarbilovich, 1952) Andrassy, 1961.

I believe that members of the genus *Hexatylus* should be limited to those nematodes having the strengthening rings surrounding the stylet, bifid stylet knobs, the prominent junction of the esophageal and intestinal lumina, and overlapping esophageal glands.

### Summary

Studies of syntype specimens of *Neotylenchus abulbosus* Steiner, 1931, and *Hexatylus viviparus* T. Goodey, 1926, revealed that they were conspecific. Because *N. abulbosus*, the type species of *Neotylenchus*, is now a junior synonym of the type species of the older genus *Hexatylus*, the genus *Neotylenchus* becomes unavailable.

The esophagus of *Hexatylus viviparus* was found to have dorsally overlapping esophageal glands instead of a fusion of the esophagus with the intestine. The descriptions of the

genus *Hexatylus* and its type species *H. viviparus* are emended. Illustrations of *H. viviparus* are presented.

*Neotylenchus consobrinus* (de Man, 1907) Filipjev, 1936, and *Neotylenchus linfordi* Hechler, 1962, are transferred to the genus *Paurodontus* Thorne, 1941. *Neotylenchus arcuatus* Thorne, 1941, is transferred to the genus *Nothanguina* Whitehead, 1959, and the genera *Scytaleum* Andrassy, 1961, and *Neotylenchus* Steiner, 1931, are considered to be synonyms of the genus *Hexatylus* T. Goodey, 1926. The following species are placed in *species inquirendae*: *Neotylenchus acutus* Thorne, 1941; *N. beljaevae* (Atakhanov, 1959) Andrassy, 1961; *N. coprophagus* (T. Goodey, 1938) Thorne, 1941; *N. dendrophilus* Rühm, 1956; *N. intermedius* (Christie, 1938) Thorne, 1941; *N. latus* Thorne, 1935; *N. obesus* Thorne, 1934; *N. obtusicaudus* (Stek., 1941) Skarbilovich, 1952; *N. serpens* Andrassy, 1961; *N. velatus* (Bütschli, 1873) Skarbilovich, 1952; *N. zaeae* (Stek., 1941) Skarbilovich, 1952; *Hexatylus boettgeri* Meyl, 1954; *H. brevicaudatus* Meyl, 1954; *H. dipapillatus* Meyl, 1954; *Scytaleum italicum* (Meyl, 1954) Andrassy, 1961; *S. skarbilowiczae* (Atakhanov, 1959) Andrassy, 1961; *S. thornei* (Meyl, 1954) Andrassy, 1961.

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