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REDESCRIPTION, SYNONYMY, AND NEW RECORDS OF *VEXILLATA NOVIBERIAE* (DIKMANS, 1935) (NEMATODA: TRICHOSTRONGYLINA), A PARASITE OF RABBITS *SYLVILAGUS* SPP. (LEPORIDAE) IN THE UNITED STATES

María Celina Digiani, John M. Kinsella*, **Thomas B. Kass**†, **and Marie-Claude Durette-Desset**‡
División Zoología Invertebrados, Museo de La Plata, Paseo del Bosque s/n 1900 La Plata, Argentina, CONICET. *e-mail: mdigiani@fcnym.unlp.edu.ar*

ABSTRACT: *Vexillata noviberiae* (Dikmans, 1935) (Trichostrongylina: Heligmosomoidea), originally described as a parasite of *Sylvilagus floridanus* from Louisiana, is redescribed from material collected from *Sylvilagus palustris* in Florida and from *S. floridanus* in Kansas. New morphometric and morphological data are provided. *Stunkardionema halla* Arnold, 1941, described from *S. floridanus* from Kansas and New York, is proposed as a junior synonym of *V. noviberiae*. These findings confirm the occurrence of *V. noviberiae* as a parasite of rabbits and its wide distribution range in North America.

Species of *Vexillata* (Nematoda, Trichostrongylina) have usually been reported as parasites of geomyid and heteromyid rodents in North and South America (Guerrero, 1984; Durette-Desset and Digiani, 2005a; Falcón-Ordaz et al., 2006). Only 1 species, *Vexillata noviberiae* (Dikmans, 1935), has been reported as parasitic in lagomorphs (*Sylvilagus* spp.: Leporidae) from Louisiana. Originally described as *Longistriata noviberiae* Dikmans, 1935, it was transferred to *Vexillata* (Ornithostrongylidae) by Durette-Desset and Digiani (2005a) on the basis of type material from *Sylvilagus floridanus* (Allen, 1890). Further findings of specimens identified as *V. noviberiae* in *Sylvilagus palustris* (Bachman, 1837) from Florida and in *S. floridanus* from Kansas allow us to provide a redescription of the species and to confirm its wide distribution as a parasite of lagomorphs. *Stunkardionema halla* Arnold, 1941, a species described from *S. floridanus* from Kansas and New York, seems to correspond to *V. noviberiae* and is proposed as a junior synonym.

MATERIALS AND METHODS

Nematode specimens from *S. palustris* were collected by J.M.K. and those from *S. floridanus* by T.B.K. The material was deposited in the Helminthological Collections of the Muséum National d'Histoire Naturelle, Paris, France (MNHN) and the Museo de La Plata, La Plata, Argentina (CHMLP). The synlophe was studied following the method of Durette-Desset (1985). The nomenclature used for the study of the synlophe follows Durette-Desset and Digiani (2005b) and that of the caudal bursa Durette-Desset and Chabaud (1981). Cuticular ridges of the synlophe at midbody were numbered 1–6 from left to right for the dorsal ridges and as 1′–7′ from left to right for the ventral ridges. Measurements are given in micrometers except where stated otherwise. The parasite classification used above the family group level is that of Durette-Desset and Chabaud (1993) and the nomenclature of the hosts at the species level follows Wilson and Reeder (1993).

DESCRIPTION

***Vexillata noviberiae* (Dikmans, 1935)**
Durette-Desset and Digiani, 2005a

= *Longistriata noviberiae* Dikmans, 1935
= *Stunkardionema halla* Arnold, 1941
= *Heligmostrongylus hallus* (Arnold, 1941)
Durette-Desset, 1978
(Figs. 1–26)

General: Small nematodes, loosely coiled on ventral side following 2–4 (usually 3) spires in males and 4–6 in females. Excretory pore situated near esophagointestinal junction. Deirids at same level as excretory pore or slightly anterior or posterior (Fig. 1).

Head: Cephalic vesicle present. In apical view, triangular buccal opening surrounded by small ring. Presence of 2 amphids, 6 externolabial papillae, and 4 submedian cephalic papillae. Small dorsal tooth present (Figs. 5 and 6).

Synlophe (studied in 1 male, 1 female from S. floridanus and 1 male, 2 females from S. palustris): In both sexes, body bears continuous cuticular ridges, appearing at different levels mainly on right side, between cephalic vesicle and nerve ring (Figs. 12–14), and disappearing anterior to caudal bursa in male. In female, ventral ridges disappearing or fusing at different levels posterior to sphincter. Carene made up of 2 ridges, ventral one slightly more developed at midbody. Number of ridges at midbody: 13 (carene, 5 dorsal, 6 ventral). At midbody, double axis of orientation of ridges directed from right ventral quadrant to left dorsal quadrant. Right axis inclined at 80° on sagittal axis in male and 67–71° in female. Left axis subfrontal in both sexes (Figs. 2 and 3, 10 and 11). In females, synlophe modified at ovejector level, with disappearance or fusion of ridges, mainly on lateral and ventral sides (Figs. 17 and 18, 20–24). Two lateral ridges appear posterior to anus (Fig. 9).

Males (average and range of measurements of 9 specimens from S. palustris): Length 5.3 (4.3–6.3) mm and width 64 (50–80) at midbody; cephalic vesicle 61 (53–66) long and 30 (25–33) wide; nerve ring, excretory pore, and deirids at 185 (177–210), 306 (270–320) and 311 (270–330) from apex, respectively; esophagus 294 (265–315) long. Caudal bursa with pattern of type 2-2-1. Rays 2 and 3 in V-formation and of equivalent size. Rays 4 longer than rays 5. Rays 8 arising from basal third of dorsal ray. Dorsal ray divided into 2 branches at its half, each branch giving rise to 2 branches of equivalent length, rays 9 (external) and rays 10 (internal) (Fig. 7). Spicules 510 (460–670) long. Ratio spicule length/body length: 9.6 (8.0–10.9)%. Gubernaculum 23 (20–30) long and 14 (12–20) wide.

Females (average and range of measurements of 5 specimens from S. palustris): Length 7.6 (5.8–9.2) mm and width 60 (50–80); cephalic vesicle 58 (52–65) long and 33 (28–38) wide; nerve ring, excretory pore, and deirids situated at 190 (170–210), 350 (330–365), and 347 (330–365) from apex, respectively; esophagus 330 (300, 375) long. Vulva situated at 130 (120–140) from caudal extremity. Vagina vera 41 (40–45) long. Vestibule 141 (130–150) long, divided into 2 parts by a slight constriction, sphincter 37 (30–40) long and 44 (40–45) wide, infundibulum 133 (115–145) long (Fig. 8). Uterus 1.24 (1.13–1.47) mm long with 34 (24–56) eggs, 62 (40–72) long and 31 (25–38) wide. Ratio uterus length/body length 17 (15.7–19.7)%. Tail conical, 48 (38–55) long.

Females (average and range of measurements of 4 fragmented specimens from S. floridanus): Length (n = 2) 5.35–6.75, width 80 (75–90); cephalic vesicle (n = 3): 71 (52–80) long and 38 (30–45) wide; nerve ring, excretory pore, and deirids (n = 1) at 210, 365 and 365 from apex, respectively; esophagus (n = 2) 345–380 long. Vulva (n = 3) situated at 136 (130–142) from caudal extremity. Vagina vera (n = 3) 33 (30–40) long. Ovejector (n = 3) with bipartite vestibule 155 (140–165) long, sphincter 35 (30–45) long and 44 (38–50) wide, infundibulum 145 (135–160) long. Uterus (n = 3) 892 (585–1270) long with 34 (24–43) eggs, 49 (45–52) long and 28 (24–30) wide. Tail (n = 3) 45 (45–45) long.

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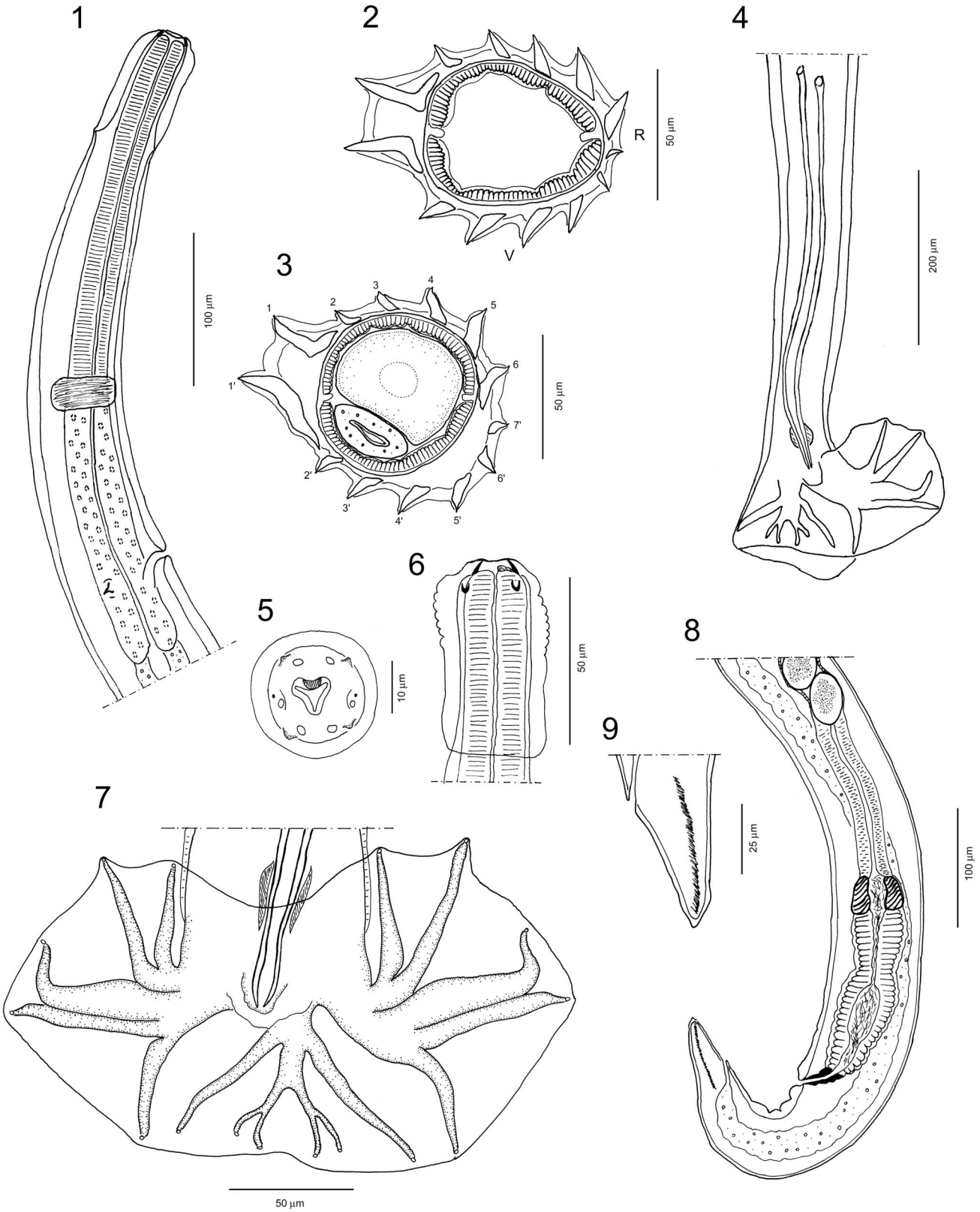
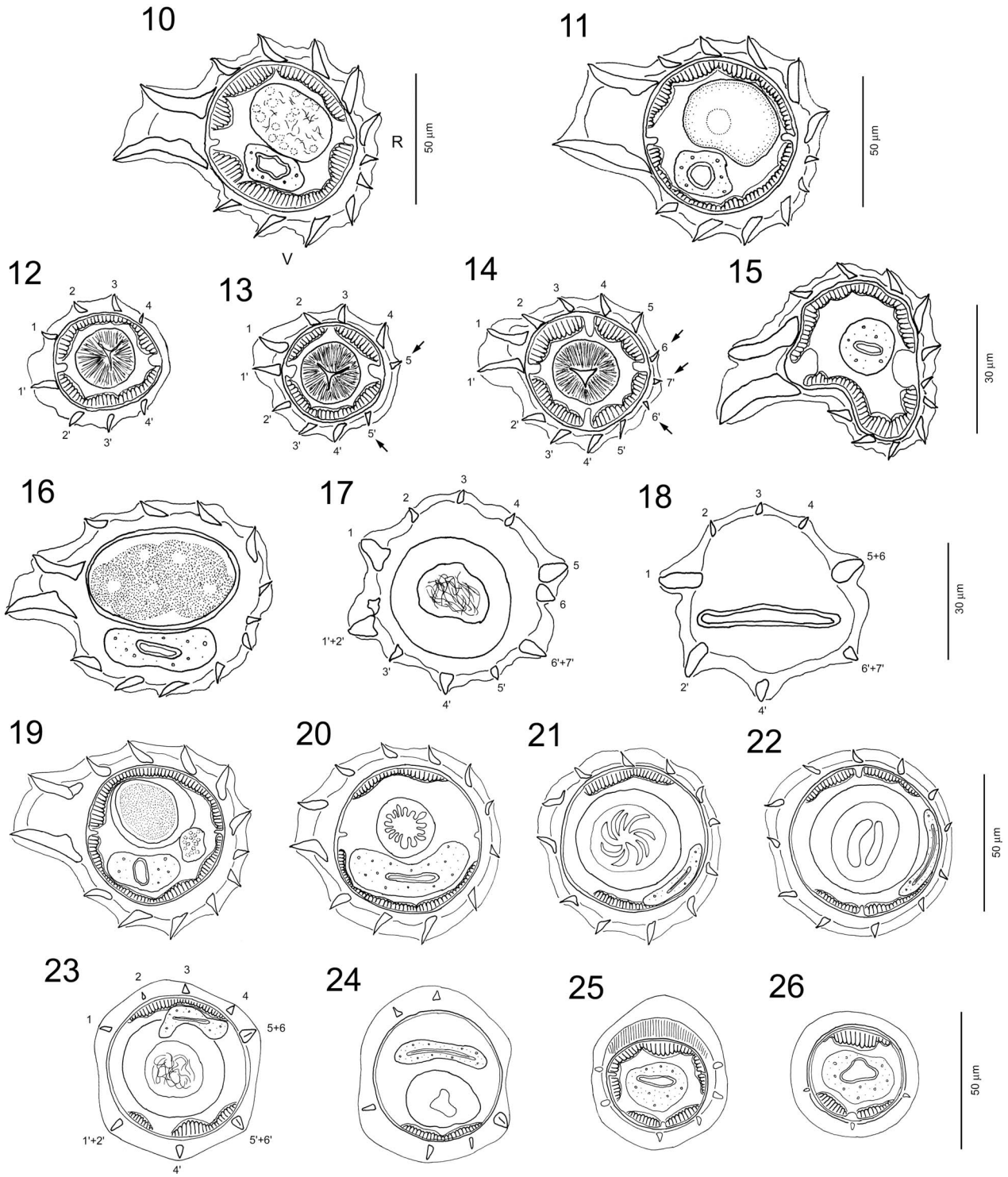
* 2108 Hilda Avenue, Missoula, Montana 59801.
† 1732 Highway 71, Wall Township, New Jersey 07719.
‡ Département de Systématique et Evolution, Muséum national d'Histoire naturelle, UMR 7138 associée au CNRS, CP 52, 61, rue Buffon 75231 Paris Cedex 05, France.



FIGURES 1–9. *Vexillata noviberiae* (Dikmans, 1935). Material from *Sylvilagus floridanus* (Kansas). (**1**) Female, anterior extremity, right lateral view. Transverse sections at midbody; (**2**) male, (**3**) female. (**4**) Male posterior extremity, right laterodorsal view. Material from *Sylvilagus palustris* (Florida). Female head; (**5**) apical view, (**6**) left lateral view. (**7**) Male caudal bursa, ventral view. (**8**) Female posterior extremity, left lateral view. (**9**) Female tail, right lateral view. Abbreviations: R, right side; V, ventral side. All sections orientated as in Figure 2.



FIGURES 10–26. *Vexillata noviberiae* (Dikmans, 1935) from *Sylvilagus palustris* (Florida). Transverse body sections; (**10** and **11**) at midbody, (**10**) male, (**11**) female. Female; (**12**) just posterior to cephalic vesicle, (**13**) at 40 µm posterior to cephalic vesicle, (**14**) at 80 µm posterior to cephalic vesicle, (**15**) at esophagointestinal junction, (**16**) at 2 mm from posterior extremity, (**17**) at level of proximal vestibule, (**18**) at level of vagina vera. Another female; (**19**) at midlength of uterus. At different levels of ovejector; (**20**) proximal sphincter, (**21**) distal sphincter, (**22**) proximal vestibule, (**23**) distal vestibule, (**24**) at level of vulva, (**25**) posterior to vulva, (**26**) between vulva and anus. Abbreviations: R, right side; V, ventral side. All sections orientated as in Figure 10. Arrows indicate the appearance of ridges.

Taxonomic summary

Hosts: Sylvilagus floridanus (Allen, 1890) (Leporidae) and *S. palustris* (Bachman, 1837) (Leporidae).

Site: Small intestine.

Geographic origin: Kansas and Florida.

Material studied: One male (posterior extremity), 4 females MNHN 341 MC; 3 males, 2 females CHMLP 5638; and 6 males, 3 females MNHN 407 MQ.

Remarks

By the characters of the synlophe, caudal bursa, and female ovejector, the specimens studied here correspond undoubtedly to *V. noviberiae* as described by Dikmans (1935) and Durette-Desset and Digiani (2005a) in *S. floridanus* from Louisiana (types). Only the body measurements show slight differences, these specimens being larger compared to the type material. Rays 9 of the caudal bursa, described as shorter than rays 10 by Durette-Desset and Digiani (2005a) were observed as having equivalent length in these specimens, corresponding to the first observations by Dikmans (1935) (Fig. 7). In the females from both hosts, 2 lateral ridges were observed on the tail (Fig. 9), which were probably overlooked in the examination of the type material. The synlophe at ovejector level is also described for the first time.

Stunkardionema Arnold, 1941, and its only species *Stunkardionema halla* Arnold, 1941, were described for a nematode parasitic in the cottontail *S. floridanus* from Kansas and New York (Arnold, 1941). The type material of this species was studied by Durette-Desset (1978), who provided a description of the female ovejector and some observations on the synlophe. This latter could not be properly studied because the material was mounted on slides (the only specimens of *S. halla* in the U.S. National Parasite Collection, type and paratype, are both on slides [P. Pilitt, pers. comm.]). Durette-Desset (1978) described the synlophe of *S. halla* as having 2 left ridges forming a carene, 5 dorsal and 5 ventral ridges, all continuous, and proposed transferring the species to *Heligmostrongylus* (Heligmonellidae: Pudicinae).

The original description and figures by Arnold (1941), as well as the redescription given by Durette-Desset (1978), seem to correspond well to the specimens studied by Dikmans (1935), Durette-Desset and Digiani (2005a), and in this article. Moreover, part of the material studied in this article (MNHN 341 MC) comes from the same host species and geographical area as the type material of *S. halla*. Similarities are evident for the body measurements, female ovejector, and caudal bursa. The only slight difference is in the number of ridges, described by Durette-Desset (1978) as 12. However, it must be taken into account that the type specimen was mounted and illustrated in median view. In this position, the right ridges 6′ and 7′ (Figs. 2 and 3) overlap and cannot be differentiated from each other, and then they were probably counted as 1. It is very likely that the species described by Arnold (1941) as *S. halla* and that described by Dikmans (1935) as *Longistriata noviberiae*, refer to the same taxon. *Stunkardionema halla* (=*Heligmostrongylus hallus*) is thus proposed as a junior synonym of *V. noviberiae*.

DISCUSSION

The known distribution range of *V. noviberiae* is enlarged with these findings to include Kansas, New York, and southern Florida, and it seems that the species is a typical parasite of rabbits. Its range is apparently coincident with the geographical ranges of *S. palustris* and *S. floridanus* in the United States. *Sylvilagus floridanus*, the eastern cottontail, is the North American species of *Sylvilagus* with the largest geographical range and is probably the most frequently captured species (Wilson and Reeder, 1993). It will be interesting to confirm whether *V. noviberiae* can be found in the rest of the geographical range of *S. floridanus*, which reaches the northern part of South America, and, especially, in other species of *Sylvilagus* with a more restricted distribution but with populations still common or abundant, such as those inhabiting the western part of the United States (*Sylvilagus audubonii*, *Sylvilagus nuttallii*) (Wilson and Reeder, 1993). Parasitological studies cannot be foreseen in several endemic species of *Sylvilagus* from Mexico, whose populations are endangered (*Sylvilagus graysoni*, *Sylvilagus insonus*) (Chapman and Flux, 1990).

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