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TETRAMERES (PETROWIMERES) STRIATA IN DUCKS

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ABSTRACT: *Tetrameres* (*Petrowimeres*) *striata* is an uncommon and incompletely described nematode from North American and Eurasian waterfowl. Specimens collected from mallards (*Anas platyrhynchos*) from the Playa Lakes Region (PLR) in western Texas (USA), the mottled duck (*A. platyrhynchos fulvigula*) in Florida (USA), the mallard in the Amur River Basin of eastern Russia and the blue-winged teal (*Anas discors*) from western Texas (USA) provide the basis for redescription of *T.* (*P.*) *striata*. This species is differentiated from the closely related *T.* (*P.*) *zakharowi* and *T.* (*P.*) *galericulata* by the size of the left spicule and the prominent cuff on the proximal end of the right spicule. In mallards from the PLR, one to several adult males and a single female occurred within distended mucosal glands or, more rarely, in cystic cavities in the submucosal tissue of the proventriculus; intensities ranged from one to seven nematodes per host ($\bar{x} \pm SE = 2.9 \pm 0.8$). Infected proventricular gland mucosae were compressed as a result of pressure atrophy by the large gravid females. In addition to nematodes, some lesions also contained necrotic debris with inflammatory cells and were surrounded by an intense inflammatory response of eosinophils, macrophages, lymphocytes, epithelioid cells and fibroblasts. Other lesions had little or no inflammatory response. Lesions in the submucosa were surrounded by a thin fibrous cyst with or without adjacent inflammatory cells.

Key words: *Anas platyrhynchos*, mallard, pathology, species redescription, *Tetrameres* (*Petrowimeres*) *striata*, tetrameriasis.

INTRODUCTION

Several species of *Tetrameres*, a markedly dimorphic genus of spirurid nematodes localized within the proventriculus of birds, are common parasites of waterfowl; McDonald (1974) found one or more species in 65% of all waterfowl collected in the western United States. However, species identifications were based only on male specimens, the taxonomy and systematics was confused by many incomplete species descriptions, females have not been adequately studied, and taxonomic keys such as those of McDonald (1974) are unworkable. The unpublished doctoral dissertation of Mollhagen (1976) provided an extensive taxonomic revision of males of the genus *Tetrameres* with redescriptions of subgenera, many species redescriptions and recombinations, and some new species descriptions. However, this does not constitute a valid taxonomic publication in accordance with Articles 8 and 9 of the rules of the International Code of Zoological Nomenclature (1985). Therefore, the names and information contained therein can not be applied as published information. Fortunately, all the paratype material for the above redescriptions is in the collection of one of the present authors (DBP) and remains available for further study.

In conjunction with other studies on the mallard (*Anas platyrhynchos*) population from the Playa Lakes Region (PLR) of Texas (USA), we had the opportunity to examine a large number of specimens for *Tetrameres* spp. This provided additional information on the epizootology, pathology and taxonomic relationships (including a redescription) of an uncommon and

incompletely described tetramerid from North American and Eurasian waterfowl, *Tetrameres (Petrowimeres) striata*.

MATERIALS AND METHODS

Mallards were collected by shooting in November 1988 to February 1989 from Castro County (34°25'N, 102°02'W) and surrounding counties in the PLR of western Texas (USA). The topography and ecology of this area was described by Godfrey et al. (1990).

The posterior esophagus, proventriculus, and gizzard of each host were removed and frozen or preserved in 10% buffered formalin. Nematodes were removed from the tissue, preserved in a mixture of 70% ethyl alcohol with 8% glycerin by volume, and examined in glycerine wet mounts following evaporation of the alcohol. Drawings and measurements were made with the aid of a Leitz drawing tube and Leitz ocular micrometer, respectively, attached to a Leitz bright field microscope (Ernst Leitz GmbH, Wetzlar, Germany). A pencil shading technique was used for illustration of the figures. Measured values are presented as a range which encompasses measurements reported in all previous studies as well as those recorded from specimens in the present study.

Pieces of tissue (1 cm^2) from 15 biopsied lesions with surrounding tissue and containing intact mature females (with and without males) of *T. (P.) striata* were excised and preserved in 10% buffered formalin for histologic studies. Paraffin embedded sections were cut at 4 to 6 μm and stained in hematoxylin and eosin, Giemsa, or Masson's trichrome stains (Lillie, 1965).

Representative specimens of *T. (P.) striata* were deposited in the U.S. National Parasite Collection (Animal Parasitology Institute, USDA Building 1180 BARC-East, Beltsville, Maryland 20705, USA; accession numbers 82946 to 82948).

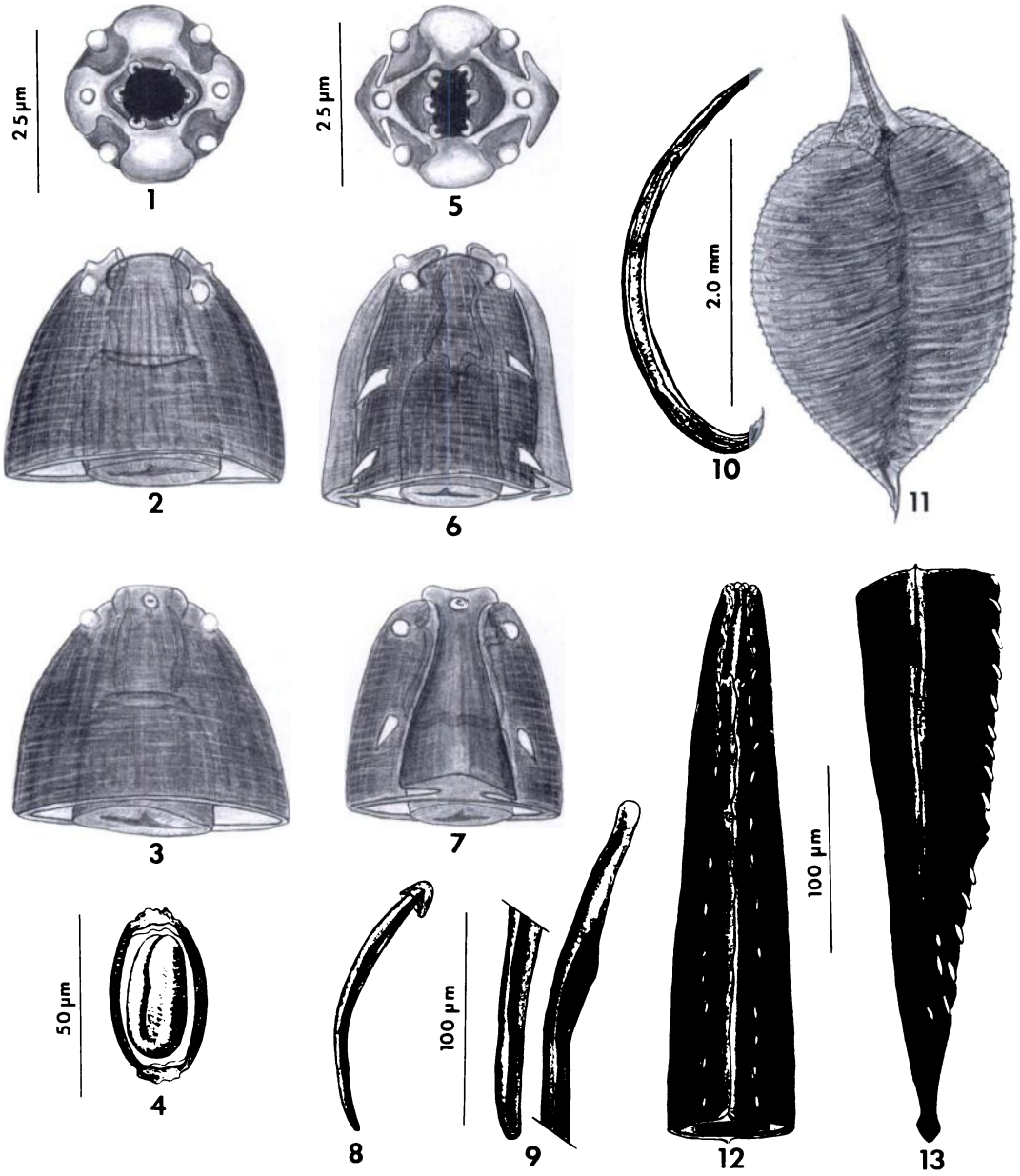
RESULTS AND DISCUSSION

Redescription of *T. (P.) striata*

The following redescription is based on the published data in the original description (Oshmarin, 1956), restudy and new measurements of the specimens examined by Mollhagen (1976) in an unpublished doctoral dissertation, and specimens collected in this and other recent studies of waterfowl helminths on the PLR. We examined three male *T. (P.) striata* collected from a single *A. platyrhynchos* in the Amur River Basin (Russia) by K. M. Ryzhikov in 1960; 19 male and 12 female specimens collected by J. M. Kinsella from five *A. platyrhynchos fulvigula* in Glades County, Florida (USA) in 1970 and 1971; one male and one female specimen from *A. discors* in Castro County, Texas by B. M. Wallace in 1984; 14 males and 8 females collected by P. N. Gray and C. A. Gray from *A. platyrhynchos* in Castro County, Texas in 1984; 20 males and 21 females from *A. platyrhynchos* in Castro County, Texas collected by J. F. Bergan and O. E. Rhodes, Jr., in the present study in 1988 and 1989, and four males and five female specimens collected by A. M. Fedynich and D. B. Pence from the same host and locality in 1990 and 1991.

Tetrameres (Petrowimeres) striata
Oshmarin, 1956
(Figs. 1 to 13)

Description of male: Larger, more robust nematodes than most male tetramerids, usually one or more specimens encapsulated with female in proventricular gland or fibrous cyst; 3.15 to 6.90 mm total length, 164 to 289 μm maximum width, body tapering to about ¼ maximum diameter at anterior extremity (Figs. 10, 12) and to a blunt tip at posterior end (Fig. 13). Cuticle thick with longitudinal and transverse striations from anterior to posterior extremities (Figs. 12, 13); triangular (cross section) anterior lateral flanges as part of lateral alae extend from base of pseudolabia to 30 to 70 μm from anterior end (Figs. 6, 7, 12), simple lateral somatic alae extend from anterior flanges ending typically between cloaca and midtail (Figs. 12, 13). Cuticular somatic spines in two rows dorsal and two rows ventral to each lateral alae (Figs. 6, 7, 12, 13); both rows start 20 to 50 μm from anterior end, dorsal rows end 1.35 to 3.40 mm anterior to cloaca, ventral rows extend to level of cloaca; anterior spines sharp-pointed, 8 to 15 μm long, spaced at intervals of 8 to 25 μm; mid-body somatic spines blunt-pointed, 10 to 15 μm long, spaced 40 to 320 μm apart; posterior spines near cloaca papilliform, 8 to 15 μm long, sep-



FIGURES 1 to 13. *Tetrameres* (*Petrowimeres*) *striata*. 1. En face view of female anterior. 2. Dorsal aspect of female anterior. 3. Lateral view of female anterior. 4. Egg. 5. En face view of male anterior. 6. Dorsal view of male anterior. 7. Lateral aspect of male anterior. 8. Right spicule. 9. Left spicule. 10. Complete male. 11. Complete female. 12. Anterior extremity of male. 13. Posterior extremity of male. Equivalent scale bars for Figs. 1, 2 and 3; 5, 6 and 7; 8 and 9; 10 and 11; 12 and 13.

arated by 8 to 35 µm. Caudal papillae (Fig. 13) digitiform, 10 to 20 µm long, spaced 10 to 25 µm apart; arranged in two subventral rows of five (rarely four) each, two sublateral rows of three (rarely two) each. Tail (Fig. 10, 13) 100 to 205 µm long, tip usually with a conical, papilliform or hemispherical bulb or simple blunt (rarely) tip. Dorsal and ventral labia and a pair of trilobed lateral pseudolabia surround

mouth (Figs. 5, 6, 7); pseudolabia each with three pairs small blunt teeth extending into buccal cavity with middle pairs of teeth sometimes larger than adjacent dorsal and ventral pairs, amphids in depression at base of pseudolabia just ahead of origin to the anterior flange of lateral alae; labia simple with one large sessile papilla at each postlateral margin. Buccal capsule (Figs. 5, 6, 7) circular, triangular, or laterally compressed at different levels in transverse section, cylindrical in longitudinal section; 20 to 35 μm long, 5 to 20 μm wide. Deirids (Fig. 12) in form of sessile papillae bearing a posteriorly curved sharp-tipped spine located just anterior to lateral somatic alae 125 to 175 μm from anterior extremity. Nerve ring 140 to 220 μm from anterior end. Excretory pore 190 to 230 μm from anterior end. Muscular esophagus 260 to 345 μm long, glandular esophagus 615 to 725 μm long. Spicules (Figs. 8, 9) very unequal, dissimilar; right spicule shorter, 100 to 165 μm long, shaft curved, distal end blunt-tipped, proximal end usually with prominent cuff (Fig. 8); left spicule 500 to 675 μm long, divided into anterior 65 to 115 μm long hilt that broadly tapers to bluntly rounded proximal end and posterior 425 to 550 μm long straight shaft region of uniform width ending in truncate to blunt distal tip (Fig. 9); gubernaculum not seen.

Description of female: Large globular- to saccular-shaped red nematodes localized within proventricular glands or fibrous capsules with or without one or more males; 4.25 to 7.0 mm total length; 2.30 to 4.85 mm maximum width, body grossly distended from between base of glandular esophagus to level of cloaca with large saccular black blood-filled intestine and highly coiled uterus distended with eggs (Fig. 11); anterior and posterior regions similar to male in appearance. Cuticle with transverse and longitudinal striations; anterior lateral flanges, lateral somatic alae, deirids, caudal papillae, or rows of cuticular somatic spines not seen. Mouth surrounded by simple dorsal and ventral labia and simple unlobed lateral pair of pseudolabia each with three small bifid teeth on inner margins projecting into the buccal cavity (Fig. 1), subposterior sessile labial papillae and pseudolabial amphids similar to those of male (Figs. 1, 2, 3); buccal capsule 20 to 40 μm long, 10 to 20 μm wide, similar to the male's in structure. Nerve ring 175 to 210 μm from anterior extremity. Excretory pore 185 to 220 μm from anterior end. Muscular esophagus 335 to 350 μm long, glandular esophagus 590 to 635 μm long. Vulva not seen. Tail 80 to 160 μm long, conical, blunt-tipped. Eggs elongate, thick-shelled, embryonated, 45 to 55 μm long, 20 to 25 μm wide (Fig. 4).

Localities and hosts: Oshmarin (1956) described *T. (P.) striata* from *Anas* sp. (type host) near Chuguyevka (44.11°N, 133.53°E) in the Primorsk Kray Region in the extreme southwestern part of Russia (type locality). Subsequently, Chuan (1962) found *T. (P.) striata* in the falciated teal (*Anas falcata*) and mallard in the Amur River basin on the border of southwestern Russia and northeastern People's Republic of China. Ryzhikov (1963) reported this species from the northern pintail (*Anas acuta*) in the Dal'nego Vostoka in western Russia. Herein, we report a new host and locality record of *T. striata* from the mottled duck (*Anas fulvigula* = *A. platyrhynchos fulvigula*) collected by J. M. Kinsella in 1970 and 1971 near Palmdale, Glades County, Florida (USA) and previously reported as an undescribed *Tetrameres* sp. by Kinsella and Forrester (1972). A new host and locality record is established for *T. (P.) striata* from the blue-winged teal (*Anas discors*) collected near Hart, Castro County, Texas in 1984 by B. M. Wallace; this species was reported previously by Wallace and Pence (1986) as an unidentified species (believed to be a new species) of the genus *Tetrameres* encysted on the serosal surface of the proventriculus in a single host. A new locality record previously was established for *T. (P.) striata* from mallards collected by Gray et al. (1989) in the same area of the PLR.

Site of infection: Adult male and female *T. (P.) striata* usually occur as pairs within the greatly distended proventricular glands. More than one male may occur with a single female. Rarely, pairs of the nematodes may occur outside the proventricular glands within cystic cavities in the submucosal connective tissue of the proventriculus or in the esophageal band just anterior to the proventriculus.

Etymology: The specific epithet is derived from the characteristic longitudinal cuticular striations seen in this species. However, these are not unique to *T. (P.) striata* as they occur in most other species of the genus.

Taxonomic remarks: The three subgenera recognized in the genus *Tetrameres* are *Tetrameres* (Creplin, 1846), *Gynaecophila* (Gubanov, 1950) and *Petrowimeres* (Chertkova, 1953). The mouth of species in the subgenera *Gynaecophila* and *Petrowimeres* has prominent lateral pseudolabia and simple dorsal and ventral labia; pseudolabia are reduced and there are no labia in species of the subgenus *Tetrameres*. Species in the subgenus *Petrowimeres* have a distinctive anterior flange originating from the base of the pseudolabia and attached at the midline of the lateral somatic alae; this structure is absent from species in the subgenera *Gynaecophila* and *Tetrameres*. Thus, the anterior flange is a unique feature of the subgenus *Petrowimeres* (Pence et al., 1975). Clearly, *T. striata* is representative of species in the subgenus *Petrowimeres* because of its well-developed oral appendages and presence of an anterior flange.

Three closely related species of the subgenus *Petrowimeres* from waterfowl (Anatidae) share the characteristics of body spines arranged in four distinct rows with the dorsal rows extending no further than the midbody and the ventral rows extending to near the cloaca, and having left spicules ≤1.0 mm long and of uniform diameter throughout without any proximal expansion near the hilt. These three species are *T. (P.) striata* from dabbling ducks (Anatini) mostly of the genus *Anas; T. (P.) zakharowi* described from geese and swans (Anserini) in Russia by Petrov (1926); and *T. (P.) galericulata* described from the surface-feeding mandarin duck (*Aix galericulata*) by Oshmarin (1956), and also reported from the wood duck (*Aix sponsa*) in North America (Thul et al., 1985). Additionally, Mollhagen (1976) in an unpublished doctoral dissertation described a fourth species, *Tetrameres (P.) sponsae*, from the wood duck in Florida and Louisiana (USA) which is very close to *T. (P.) galericulata;* however, this remains as an invalid taxon, despite the fact that the name *T. (P.) sponsae* was published in Thul et al. (1985). The length of the left spicule of *T. (P.) striata* is shorter (500 to 575 μm) than that reported (775 to 1130 μm) for *T. (P.) zakharowi* by Zaskind (1963) and Ryzhikov (1959), but larger than the measurements (440 to 490 μm) given for *T. (P.) galericulata* by Oshmarin (1956), and those (383 to 413 μm and 234 to 322 μm) presented by Mollhagen (1976) for specimens identified as *T. (P.) galericulata* and *T. (P.) sponsae*, respectively. The single morphological characteristic that distinguishes *T. (P.) striata* from these species is the usually prominent cuff on the proximal end of the right spicule. Based on present data, we believe that *T. (P.) striata* can be differentiated as a distinct species. However, all or part of these closely related species may eventually be combined as a single highly variable species in the Anatini.

Many of the mallards we examined also were infected with *T. (P.) ryjikovi*, a very prevalent and abundant species in dabbling ducks. The mature females of *T. (P.) striata* are more than twice the size of those of *T. (P.) ryjikovi*. Thus, the mature females of the two species could be distinguished easily *in situ* without dissecting them from the tissue; this allowed the histopathologic studies described below. However, the smaller immature females of *T. (P.) striata* could not be differenti-

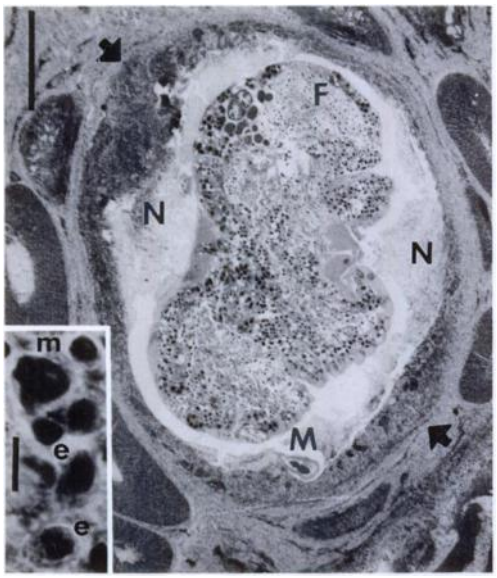


FIGURE 14. Pressure atrophy and necrosis of mucosa in a proventricular gland of a mallard infected with a male (M) and female (F) *Tetrameres* (*Petrowimeres*) *striata*. Note the necrotic debris (N) surrounding the nematodes and areas of pronounced inflammatory response (arrows) in this early lesion. H&E. Bar = 500 μm. Inset includes a typical inflammatory cell reaction consisting of mostly eosinophils (e) and macrophages (m) as well as lymphocytes and necrotic mucosal cell nuclei localized in the degenerating mucosal layer of the proventricular gland. H&E. Bar = 5 μm.

FIGURE 15. Typical mature *Tetrameres* (*Petrowimeres*) *striata* male (M) and female (F) in the proventricular gland of a mallard. Note the loss of glandular mucosa from pressure atrophy and lack of an inflammatory response in this advanced lesion. H&E. Bar = 500 μm.

ated from *T.* (*P.*) *ryjikovi in situ* and the early acute lesions were not studied.

Epizootiology

Eurasian records are incomplete, but based on available data we believe that *T.* (*P.*) *striata* usually is a parasite of low prevalence and intensity in dabbling ducks in North America. For example, Kinsella and Forrester (1972) found only 29 specimens from five (6%) of 78 mottled ducks in Florida and we found 18 (4%) of 462 mallards on the SHP of Texas infected with only 50 specimens (total mean abundance ± SE = 2.6 ± 0.8) in the present study.

Pathology

A few of the proventricular gland lesions had a foamy, eosinophilic necrotic material containing scattered lymphocytes and eosinophils immediately surrounding the nematodes. The proventricular gland mucosal architecture was obliterated but there were islets of normal appearing mucosal cells and acini within the surrounding intense inflammatory response that extended into the submucosa (Fig. 14). Eosinophils and macrophages predominated; lymphocytes and epithelioid cells also were present (Fig. 14). Lesions were surrounded by fibroplasia and resembled foreign body granulomas, but without multinucleated giant cells; there were few developed eggs in sections of the female nematodes, and we infer that these lesions had developed recently. Ramaswamy and Sundaram (1981) noted similar acute to subacute lesions just following establishment and early growth phases in experimental infections of *T.* (*P.*) *mohtedai* in domestic fowl.

In most specimens we examined, the infected proventricular gland mucosa was compressed and destroyed with complete loss of acini by pressure atrophy as a result of the large gravid female which contained

numerous mature eggs; there was little or no inflammatory response within the central cavity around the parasites or in the adjacent compacted mucosa or surrounding submucosa (Fig. 15). These terminal lesions surrounding mature females resembled the advanced lesions caused by *T.* (*P.*) *fissispina* as initially described by Graubmann and Grafner (1967) and subsequently by other species of *Tetrameres* (as referenced in Appleton, 1983).

The few lesions observed in the submucosa were surrounded by a thin layer of fibrous tissue forming a cyst with or without adjacent inflammatory cells surrounding the adult nematodes. Except for the absence of islets of mucosal cell acini, these lesions otherwise resembled those in which the nematodes had developed within the proventricular gland.

Ramaswamy and Sundaram (1983) have shown morbidity due to tetrameriasis in domestic fowl given 25 infective larvae of *T.* (*P.*) *mohtedai;* clinical manifestations included reduced body weight, delayed maturity, decreased egg production, and anemia. Similar morbidity could be extrapolated for waterfowl infected with high intensity infections of species such as *T.* (*P.*) *ryjikovi.* However, despite their large size, it is doubtful that the usual one or two isolated lesions of *T.* (*P.*) *striata* ever induce such clinical changes in their hosts.

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