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Synlophe in *Ostertagia* cf. *kasakhstanica* (Nematoda: Ostertagiinae), the Minor Morphotype of *O. bisonis* From Western North America

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ABSTRACT: *Ostertagia* cf. *kasakhstanica*, the putative minor morphotype of the polymorphic ostertagiine *O. bisonis*, is reported in *Bison bison* from South Dakota. Descriptions of the synlophe and details of other diagnostic characters useful in identification and differentiation of this minor morphotype from other ostertagiines in wild and domestic ruminants from western North America are presented. Laterally, the cervical synlophe is consistent with Type Ib pattern among ostertagiines and is within the range of variation previously described for *O. bisonis*. Among recognized minor morphotypes of ostertagiines in wild and domestic ruminants from North America, *O. kasakhstanica* is distinct from *O. kolchida*, *O. dikmansi*, and *O. arctica* based on a tapering lateral synlophe. It is further distinguished from *O. lyrata* by the pattern of the cervical synlophe in the lateral field, structure of the genital cone and spicules, and dimensions of the esophageal valve. Although morphologically similar to *T. davtianii*/*T. trifurcata* and *T. boreoarcticus* f. minor, it can be readily distinguished by the 2-1-2 bursal pattern, the structure of the spicules and genital cone, and the length of the esophageal valve. *Ostertagia bisonis*/*O. cf. kasakhstanica* circulates among pronghorn, mule deer, bison, and cattle in west-central North America.

Polymorphic ostertagiine nematodes, and particularly, both the major and minor morphotypes of species of *Ostertagia* and *Teladorsagia* (e.g., *O. ostertagii*/*O. lyrata*; *O. mossi*/*O. dikmansi*; *O. gruehneri*/*O. arctica*; *O. leptospicularis*/*O. kolchida*; *Teladorsagia circumcincta*/*T. trifurcata*

T. davtianii; and *T. boreoarcticus* f. major/f. minor), are found with some degree of regularity in ruminants from North America (Lichtenfels and Hoberg, 1993; Hoberg et al., 2001). Until recently, however, *O. kasakhstanica*, the putative minor morphotype of *O. bisonis* had eluded detection (Drózdź, 1995).

The taxonomy of Lichtenfels and Pillitt (1991) for *O. bisonis*/*O. kasakhstanica* is provisionally followed in presenting the first descriptions of the synlophe and some details of other diagnostic characters useful in identification and differentiation of this minor morphotype from other ostertagiines in wild and domestic ruminants from western North America. Observations reported here are based on a single specimen referable to *O. cf. kasakhstanica* (previously identified as *T. trifurcata* by Boddicker and Huggins [1969]; U.S. National Parasite Collection 59388) from South Dakota, in *Bison bison*, the type host of *O. bisonis*.

Lichtenfels and Pillitt (1991) predicted that the cervical synlophe in *O. kasakhstanica* should be similar to that described for *O. bisonis*. In the specimen from South Dakota, there are 40 ridges at the level of the esophageal–intestinal junction. Ventrally, the synlophe has a single ventral ridge interrupted at the excretory pore, with adjacent ridges originating at or near this level; posteriad from the excretory pore, a field of parallel ridges extends through the cervical zone, similar to the “atypical pattern” reported in 4 of 130 specimens of *O. bisonis* by Lichtenfels and Pillitt (1991) (Fig. 1a). Laterally, the synlophe has single lateral-most ridges interrupted at the cervical papillae, and 2–3 pairs of ridges converge and terminate on the lateral-

FIGURE 1. Synlophe in the minor morphotype *Ostertagia* cf. *kashstanica* (scale bar in micrometers). **a.** Cervical region, ventral view,

most ridge in each field anterior to the esophageal–intestinal junction (Fig. 1b). The overall pattern is strongly tapering and consistent with the Type Ib lateral synlophe, as defined by Lichtenfels et al. (1988), and is within the range of variation described for *O. bisonis* by Lichtenfels and Pilitt (1991).

Other characters can also be considered in this male specimen of *O. cf. kashstanica* measuring 8,445 μm in total length. The esophageal valve, 115 μm long, is consistent with that in the major morphotype *O. bisonis*. Spicules are robust, 150–152 μm long, and trifurcate at 57% from the anterior (Fig. 2); dorsal and ventral processes are unequal, with the former being longer, and neither extends to the termination of the main shaft. The gubernaculum is 75 μm in length. The genital cone and “0” papillae are prominent; the Sjöbergs organ is relatively small and contains parallel “7” papillae (Fig. 3). Bursal rays are arranged in a 2-1-2 pattern, with the separation of the tips of rays 5, 6, and 8 nearly equal (Fig. 4). The dorsal ray is 59 μm long and bifurcates near its middle at 44% from the anterior (Fig. 5). These characters are not entirely inconsistent with *O. kashstanica* as described by Dikov and Nekipelova (1963), although in the Palearctic material the spicules and gubernaculum are larger (174–198 μm and 109–118 μm long, respectively), and the trifurcation for the spicular processes is further to the posterior (61–63%).

There is continuing disagreement over the generic placement of *O. bisonis*, as Drózd (1995) would place it in *Orloffia*, whereas Lichtenfels and Pilitt (1991) refer it to *Ostertagia*. Species of *Orloffia* are considered to differ from *Ostertagia* by lacking a proconus in the major morphotypes and having equal separation between the extremities of rays 5, 6, and 8 (Drózd, 1995); phylogenetic analysis within the Ostertagiinae is necessary for resolution. Additionally, Lichtenfels and Pilitt (1991) consider *O. bisonis* and *O. orloffi* as synonyms, with the former having priority; thus, *O. kashstanica* would represent the minor morphotype for *O. bisonis* in North America. In contrast, Drózd (1995) contends that *Orloffia orloffi/O. kashstanica* in the Palearctic is independent from *O. bisonis* and that a yet to be described minor form occurs in the Nearctic. Durette-Desset (1989) places the 2 morphotypes, *O. bisonis* and *O. kashstanica* in separate genera—*Camelostrogylus* and *Ostertagia*—which is inconsistent with present concepts for polymorphism in the Ostertagiinae (e.g., Drózd, 1995). Elucidation of these generic- and species-level issues is dependent on the availability of sufficient comparative material (particularly from North America) and is considered beyond the scope of the present paper, although current observations of *O. cf. kashstanica* may contribute to eventual clarification.

The minor morphotype, *O. cf. kashstanica*, appears to be particularly rare because it has not been found in the course of redescription of *O. bisonis*, with which it would be expected to co-occur, based on North American material (Becklund and Walker, 1967; Lichtenfels and Pilitt, 1991). The male examined in the current study represents the sole specimen of *O. cf. kashstanica* among substantial numbers of lots of ostertagiines in the USNPC that have been examined during the course of numerous systematic studies (e.g., Lichtenfels and Hoberg, 1993). Minor morphotype specimens were not reported by Worley and Sharman (1966) in their observation of parasitic gastritis in cattle attributable to *O. bisonis*. Examination (E. P. Hoberg and A. Abrams, unpubl. obs.) of numerous lots of specimens (including 228 males) of *O. bisonis* and other ostertagiines in cattle and mule deer (*Odocoileus hemionus*) provided by D. E. Worley from Montana also did not reveal the presence of *O. cf. kashstanica*. The relative proportions of major and minor morphotypes in a population from an individual host are known to be variable. For example, *O. ostertagi/O. lyrata* most often occur in the ratio of about 98:2, whereas in other species, minor morphotypes may

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showing ventral ridge interrupted at excretory pore and adjacent ridges not extending anterior to the cephalic expansion, consistent with atypical pattern demonstrated by Lichtenfels and Pilitt (1991) for *O. bisonis*. **b.** Cervical region, right lateral view, showing strongly tapering pattern (Type-Ib lateral synlophe of Lichtenfels et al. [1988]), consistent with general pattern described by Lichtenfels and Pilitt (1991) for *O. bisonis*. Abbreviations: svgo, subventral gland orifice; cp, cervical papillae; exp, excretory pore; d, dorsal; v, ventral; l, lateral.

FIGURE 2–5. Structural characters in the minor morphotype *Ostertagia* cf. *kasakhstanica* as shown in interference contrast light microscopy (scale = 50 μ m for all figures). **2.** Spicules, ventral view, showing robust form and prominent feet distally. **3.** Genital cone, ventral view, showing “0” papillae (arrow) and structure of Sjöberg’s organ with prominent “7” papillae (arrow). **4.** Copulatory bursa, right lateral view, showing 2-1-2 pattern of bursal rays; note the equal separation of 5, 6, and 8 (arrows). **5.** Copulatory bursa, dorsal view, showing prominent dorsal lobe and typical dorsal ray with bifurcation near midpoint.

occasionally be more abundant than their major counterpart, such as in *T. boreoarcticus* (Hoberg et al., 1999), or may rarely occur in the absence of the major form (Lichtenfels et al., 1988).

Among recognized minor morphotypes of ostertagiines in wild and domestic ruminants from North America, *O. kasakhstanica* is distinct from *O. kolchida*, *O. dikmansi*, and *O. arctica* based on a tapering lateral synlophe (Lichtenfels and Hoberg, 1993). Specimens of *O. kasakhstanica* are distinguished from *O. lyrata* by the pattern of the cervical synlophe in the lateral field, structure of the genital cone and spicules, and dimensions of the esophageal valve (Figs. 1–5) (Lichtenfels et al., 1988; Lichtenfels and Pilitt, 1991; Lichtenfels and Hoberg, 1993). *Ostertagia kasakhstanica* is also morphologically similar to *T. davtianii*/*T. trifucata* and *T. boreoarcticus* f. minor but can be readily distinguished by the 2-1-2 bursal pattern, the structure of the spicules and genital cone, and the length of the esophageal valve (Figs. 2–5) (Dikov and Nekipelova, 1963; Lichtenfels and Pilitt, 1991; Hoberg et al., 1999). The core range for *O. bisonis*/*O. cf. kazakhstanica* occurs across the west-central region of North America, where this polymorphic species circulates among pronghorn (*Antilocapra americanus*), bison, mule deer, and cattle (Hoberg et al., 2001); additionally, it is expected in areas where bison have been translocated, including Alaska.

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