



Taxonomy and phylogeny of *Trichuris globulosa* Von Linstow, 1901 from camels. A review of *Trichuris* species parasitizing herbivorous



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ABSTRACT

At the present work, we carried out a morph-biometrical and molecular study of *Trichuris* species isolated from *Camelus dromedarius* from Iran and from *Ovis aries* from South Africa comparatively with other species of *Trichuris* from different herbivorous hosts and geographical regions. The population from camels from Iran was identified as *Trichuris globulosa*. Two different morphometrically populations of *Trichuris* sp. from sheep from South Africa were identified: *Trichuris ovis* and *Trichuris skrjabini*. Ribosomal data did not reveal significant differences in the ITS2 sequences between *T. ovis* and *T. globulosa* to assess a specific determination. The mitochondrial data suggest that *T. globulosa* constitute a different genetic lineage to *T. ovis*. Cytochrome c-oxidase and cytochrome b partial gene sequences corroborated the existence of a different genetic lineage of *T. ovis* from sheep of South Africa that would be closely related to the populations of *T. globulosa* from camels from Iran. The cytochrome c-oxidase and cytochrome b partial gene sequences of *T. globulosa* have been reported for the first time.

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1. Introduction

The systematics of the genus *Trichuris* Roederer, 1761 is controversial at species level. Different authors have cited synonymies (Oliveros et al., 2000), cryptic species (Callejón et al., 2012) or new species (Cutillas et al., 2014; Robles et al., 2014). Many of these studies have been based on morphometrically and molecular data since Dujardin (1845) reviewed the genus for the first time.

Knight (1974) cited more than 23 species of *Trichuris* been described from ruminants. Those from domestic ruminants (*Trichuris discolor* Von Linstow, 1906, *Trichuris ovis* Abildgaard, 1795, *Trichuris globulosa* Von Linstow, 1901 and *Trichuris skrjabini* Baskakov, 1924) are widespread throughout the world (Ortlepp, 1937; Sarwar 1945, 1957; Knight, 1971; Tenora et al., 1992; Lanfredi et al., 1995; Callejón et al., 2012). Nematodes common for sheep or cattle have been documented in camelids (Fowler, 1989; Legua, 1991; Tait et al., 2002) and hence, it have been assumed that many known nematodes of domestic ruminants also parasitize camelids (Legua, 1991; Karesh et al., 1998; Tait et al., 2002). Nevertheless, camelids host other nematodes specific to them, such as *Trichuris tenuis* Chandler, 1930 (Rickard and Bishop, 1991).

T. ovis is, traditionally, a parasite of the cecum of ovine but has been isolated from several animal hosts (Wang et al., 2013). Skrjabin et al. (1957) cited about 33 different hosts for this species.

Mayer (1841) (cited by Dujardin, 1845), Wilson (1846) (cited by Dujardin, 1845), Cobbold (1864) and Ransom (1911) described *T. ovis*. Latterly, Sprehn (1927), Chandler (1930) and Baylis (1932), studied this species in comparison with *T. globulosa*.

Sprehn (1927) revised the literature of *Trichuris* of ruminants and concluded that *T. globulosa*, reported to that date only in camels, could parasitize sheep and goat. Furthermore, this author provided new morphological data on both species, *T. globulosa* and *T. ovis*, and cited the spicule sheath, spicule length and the spines in the spicule sheath as the main differential criterion. In addition, Baylis (1932) and Chandler (1930) agreed with the same characteristics as the most important parameters to differentiate both species. Other authors differentiated *T. ovis* and *T. globulosa* only by the length of the spicule (Noda, 1955; Knight, 1971; Kikuchi, 1974). Skrjabin et al. (1957) indicated that both species had a similar body shape and length, but had different length and distribution of the spines in the spicule sheath. Thus, the length of the spicule of *T. globulosa* appeared shorter and wider than that of *T. ovis*. Nevertheless, these authors found overlapping in the spicule length of both species. Tenora et al. (1997) did not find differences in the spines of the spicule sheath.

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Knight (1984) concluded that individuals of *T. ovis* isolated from different hosts, showed different spicule length. Špakulová (1994) cited the spicule length as the main differential character between species of *Trichuris*, but she studied *T. ovis* and not *T. globulosa*.

T. tenuis, *T. skrjabini* and *T. globulosa* were firstly, recovered and described from camelids by different authors (Skrjabin et al., 1957; Knight, 1971; Cutillas et al., 1995). Thus, *T. tenuis* is a rarely reported parasite, but is intimately associated with Camelidae and suggested to be the typical whipworm of aboriginal camelids (Cafune et al., 1999). Chandler (1930) made the first description of this species from a camel (*Camelus dromedarius*) and different authors (Skrjabin et al., 1957; Knight, 1974; Mirzayans, 1974; Beveridge and Green, 1981) reported this species from other species hosts. Rickard and Bishop (1991) redescribed this species isolated from *Lama lama* in Oregon but any report of *T. globulosa* is known from America.

Females of whipworms are more difficult to differentiate than males, and some authors suggested that the structure of vulva could be used for species differentiation (Chandler, 1930; Knight, 1971; Barus et al., 1978; Gibbons, 1986; Rickard and Bishop, 1991). Tenora et al. (1993) stated that there are two different types of vulva in trichurid females—with and without spines. Tenora et al. (1993), Kikuchi (1974) and Zaman (1984) concluded that the everted vagina can be of variable size and shape between the individuals of the same species and can appear with or without spines. In this context, different types of vulva in *T. ovis* is not a differential character in females of *T. ovis*.

Skrjabin et al. (1957) observed in *T. ovis* a vagina long and curved, in *T. ovis* appeared long, curved uniformly, while in *T. globulosa* appeared short and thin. Barus et al. (1978) carried out a comparative study by electronic microscopy of the vulva of *T. skrjabini*, *Trichuris lani* Artjuch, 1948, *T. globulosa* and *T. ovis*. They concluded that vulva in *T. globulosa* never appeared everted while in *T. ovis* everted.

In conclusion, the specific differentiation between *T. ovis*, *T. globulosa* and *T. tenuis* by morph-biometrical characteristics is very difficult.

Goswami (1978) did not find differences between *T. ovis* and *T. globulosa* by cytogenetic analysis. Cutillas et al. (1995) carried out a morphological, biometrical and isoenzymatic analysis of *T. ovis* and *T. globulosa* concluding that both are the same species so the names are synonymous. Oliveros et al. (2000) corroborated the synonymy of *T. ovis* and *T. globulosa* by amplification and sequencing of the Internal Transcribed Spacer 2 (ITS2) ribosomal

DNA. Oliveros et al. (2002) carried out a bibliographic review of *T. ovis* isolated of *Ovis aries* and *Capra hircus*, while Oliveros and Cutillas (2003) redescribed *T. ovis* based on morphological, biometrical and genetic data considering *T. globulosa* and *T. ovis* as synonymous.

A morphological and molecular study, using the first and second Internal Transcribed Spacers (ITS-1 and ITS-2) of nuclear ribosomal DNA (rDNA) and a portion of Small Subunit Ribosomal RNA (16S) gene of the mitochondrial (mt) genome as genetic markers, supported that *T. ovis* and *T. discolor* isolated from bovines represent two distinct species (Callejón et al., 2012).

Liu et al. (2012) characterized the complete mitochondrial genomes of *T. ovis* and *T. discolor*. These authors concluded that represent distinct nematode species.

Wang et al. (2013) studied the genetic variability among *T. ovis* from different hosts in Guangdong Province (China) by sequences of three mitochondrial genes. They concluded that exists a low-level sequence variation in mt *cox1*, *nad5* and *cytb* genes among *T. ovis* isolates from different geographical hosts and localities.

Salaba et al. (2013) determined by ITS1–5.8S–ITS2 segment of rDNA that all females present in roe deer (*C. capreolus*) belong to the species *T. discolor*. However, these authors identified, morphologically, all females as *T. globulosa*, while only one male as *T. ovis*. According to these authors, four species of *Trichuris* are known to parasitize in the caecum of sheep and goats in Europe: *T. ovis*, *T. globulosa*, *T. skrjabini* and *Trichuris capreoli* (Artjuch, 1948; Barth and Dollinger, 1975; Baruš et al., 1977, 1978; Špakulová, 1994; Cutillas et al., 1995, 1996, 2004; Oliveros et al. 2000; Callejón et al., 2009; Callejón et al., 2012).

In summary, the taxonomy of *Trichuris* species parasitizing herbivorous remains unclear.

In order to clarify this situation, in this work, we carried out a morph-biometrical and molecular study of *Trichuris* species isolated from *C. dromedarius* from Iran and of *O. aries* from South Africa comparatively with *T. ovis*, *T. globulosa*, *T. skrjabini*, *T. tenuis* and *T. discolor* from different hosts and geographical regions.

2. Material and methods

Adults of *Trichuris* sp. were collected from the caecum of camel (*C. dromedarius*) from Gonband, Golestan province (Iran) and of sheep (*O. aries*) from Limpopo province, South Africa (SA) (Table 1). Worms were washed extensively in 0.9% saline solution

Table 1
Distribution of *Trichuris* samples collected from different hosts and different geographical areas.

Sample codes	Species	Host	Geographical area
M1	<i>T. globulosa</i>	<i>Camelus dromedarius</i> 1	Gonband, Golestan (Iran)
M2	<i>T. globulosa</i>	<i>Camelus dromedarius</i> 1	Gonband, Golestan (Iran)
M3	<i>T. globulosa</i>	<i>Camelus dromedarius</i> 1	Gonband, Golestan (Iran)
M4	<i>T. globulosa</i>	<i>Camelus dromedarius</i> 1	Gonband, Golestan (Iran)
M5	<i>T. globulosa</i>	<i>Camelus dromedarius</i> 1	Gonband, Golestan (Iran)
F1	<i>T. globulosa</i>	<i>Camelus dromedarius</i> 1	Gonband, Golestan (Iran)
F2	<i>T. globulosa</i>	<i>Camelus dromedarius</i> 1	Gonband, Golestan (Iran)
F3	<i>T. globulosa</i>	<i>Camelus dromedarius</i> 1	Gonband, Golestan (Iran)
F4	<i>T. globulosa</i>	<i>Camelus dromedarius</i> 1	Gonband, Golestan (Iran)
F5	<i>T. globulosa</i>	<i>Camelus dromedarius</i> 1	Gonband, Golestan (Iran)
Sh1M4	<i>T. ovis</i>	<i>Ovis aries</i> 1	Limpopo (South Africa)
Sh1M5	<i>T. ovis</i>	<i>Ovis aries</i> 1	Limpopo (South Africa)
Sh2M6	<i>T. skrjabini</i>	<i>Ovis aries</i> 2	Limpopo (South Africa)
Sh2M7	<i>T. skrjabini</i>	<i>Ovis aries</i> 2	Limpopo (South Africa)
Sh2F8	<i>T. ovis</i>	<i>Ovis aries</i> 2	Limpopo (South Africa)
Sh3F9	<i>T. ovis</i>	<i>Ovis aries</i> 3	Limpopo (South Africa)
Sh6M2	<i>T. skrjabini</i>	<i>Ovis aries</i> 6	Limpopo (South Africa)
Sh6M3	<i>T. skrjabini</i>	<i>Ovis aries</i> 6	Limpopo (South Africa)
Sh6F1	<i>T. skrjabini</i>	<i>Ovis aries</i> 6	Limpopo (South Africa)

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