Key-words: Ascaropsinae. *Streptopharagus numidicus*. *Streptopharagus kutassi*. *Streptopharagus greenbergi* n. sp. *Streptopharagus schmidtii* n. sp. *Streptopharagus lerouxi*. Gerbillid rodents. Murid rodents. *Citellus fulvus*. Sciurid rodents. Iran. Israel. Sinai. Congo. Cuticular morphology. Looped pharynx. Bent pharynx.

Mots-clés : Ascaropsinae. *Streptopharagus numidicus*. *Streptopharagus kutassi*. *Streptopharagus greenbergi* n. sp. *Streptopharagus schmidtii* n. sp. *Streptopharagus lerouxi*. Rongeurs gerbillidés. Rongeurs muridés. *Citellus fulvus*. Rongeurs sciuridés. Iran. Israël. Sinai. Congo. Structures cuticulaires. Pharynx formant une boucle. Pharynx en S.

CUTICULAR MARKINGS IN SPECIES DIFFERENTIATION OF *STREPTOPHARAGUS* (NEMATODA-SPIRUROIDEA) PARASITIC IN RODENTS

G. WERTHEIM

SUMMARY

Species of *Streptopharagus*, parasitic in rodents, show a great similarity in cephalic structures of males and females and in male reproductive organs, making taxonomic separation difficult. In the present communication species are differentiated by cuticular morphology: the number (0-2) of longitudinal alae and the distribution of interstitial, irregularly spaced, short, longitudinal ridges.

Two new species are described, 2 are redescribed and some observations on cuticular markings are added to the original description of a fifth one. *S. numidicus* Seurat, 1917, parasitic in *Gerbillus pyramidum* and *G. gerbillus* in Africa, is characterized by absence of longitudinal alae and the presence of the interstitial ridges over the entire body. Pharynx looped.

S. kutassi (Schulz, 1927) Chabaud, 1954, from *Citellus fulvus*

and *Meriones persicus* in Iran, found also by Schulz in four species of sciurid rodents over an area extending from Ukraine to Central Asia (Turkmenistan), has one (left) longitudinal ala and interstitial ridges only in the anterior part of the body. Pharynx bent.

S. lerouxi Quentin, 1965, parasitic in *Tatera lobengulae* in the Congo, has one (left) longitudinal ala and a cuticle devoid of interstitial ridges. Pharynx looped. *S. greenbergi* n. sp., found in 12 species of murid and gerbillid rodents in southern Israel, in the Sinai peninsula and in Egypt, has two longitudinal alae and interstitial ridges only in the anterior part of the body. Pharynx bent.

S. schmidtii n. sp., found in *Meriones persicus* in Iran, is characterized by two lateral alae and absence of interstitial ridges. Pharynx bent.

RÉSUMÉ : Utilisation des structures cuticulaires dans la différenciation des espèces de *Streptopharagus* (Nematoda : Spiruroidea) parasites de rongeurs.

Les espèces de *Streptopharagus* parasites de rongeurs montrent une grande similitude dans leurs structures céphaliques mâles et femelles et dans celles de leurs organes reproducteurs mâles, ce qui rend la séparation taxonomique des espèces très difficile. Dans cet article les espèces sont différenciées par leurs structures cuticulaires : le nombre (0-2) des ailes longitudinales et la distribution des petites crêtes longitudinales disposées irrégulièrement entre les stries transversales. Deux nouvelles espèces sont décrites, deux sont redécrites et quelques remarques concernant les caractères de la cuticule sont ajoutées à la description originale de la cinquième espèce.

Chez *S. numidicus* Seurat, 1917, parasite de *Gerbillus pyramidum* et de *G. gerbillus* en Afrique du nord, les ailes longitudinales sont absentes et les crêtes longitudinales sont présentes tout le long du corps. Pharynx formant boucle.

S. kutassi (Schulz, 1927) Chabaud, 1954, parasite de *Citellus fulvus* et *Meriones persicus* en Iran et trouvé par Schulz chez quatre

espèces de sciuridées de l'Ukraine jusqu'à l'Asie Centrale (Turkmenistan) est caractérisé par une seule aile longitudinale (gauche) et des crêtes longitudinales présentes seulement dans la partie antérieure du corps. Pharynx tordu en S.

Chez *S. lerouxi* Quentin, 1965, parasite de *Tatera lobengulae* au Congo, on trouve une seule aile longitudinale (gauche); la cuticule est dépourvue de petites crêtes longitudinales. Pharynx formant boucle.

Chez *S. greenbergi* n. sp., parasite de 12 espèces de rongeurs muridés et gerbillidés dans le sud aride d'Israël, dans la presqu'île du Sinai et en Égypte, on trouve deux ailes, longitudinales et les petites crêtes longitudinales sont présentes seulement dans la partie antérieure du corps. Pharynx tordu en S.

Chez *S. schmidtii* n. sp., parasite de *Meriones persicus* en Iran, on trouve deux ailes longitudinales; les petites crêtes longitudinales sont absentes. Pharynx tordu en S.

INTRODUCTION

Streptopharagus, recovered in Israel from the stomach of *Acomys cahirinus* and *A. russatus*, was identified as

Laboratory of Helminthology. The Hebrew University-Hadassah Medical School, Jerusalem, Israel.

Accepted le : 20 septembre 1992.

S. kutassi (Schulz, 1927) Chabaud, 1954, because the specimens have a longitudinal ala (Greenberg, 1967). Examination of body cross sections revealed the presence of a second, narrow ala, easily overlooked in total mounts. Since no species of *Streptopharagus* with two longitudinal alae was so far described, it was decided to reexamine specimens from other rodents in Israel and in the Sinai peninsula (Wertheim and Greenberg, 1970) as well as samples from Iran (Chabaud, 1954) and the Congo (Quentin, 1965) in the helminth collection of the Museum National d'Histoire Naturelle, Paris, with emphasis on cuticular markings (logitudinal alae and interstitial, logitudinal ridges). The generic diagnosis (Baylis, 1923) was amended by clearly defining the pharynx as either looped (Seurat, 1918) or bent.

In the present paper a description is presented of two new species: *S. greenbergi* and *S. schmidtii*; two species are redescribed: *S. numidicus* Seurat, 1917, and *S. kutassi* and some observations on cuticular markings are added to the excellent description of *S. lerousi* (Quentin, 1965).

MATERIALS AND METHODS

Trapping sites in Israel and in the Sinai peninsula, methods of worm recovery, fixation and preservation were previously described (Greenberg, 1969; Wertheim and Greenberg, 1970). The following samples were also examined: specimens from *Rattus rattus* on loan from the Helminth Collection, United States National Museum, Beltsville, Maryland (USNM), deposited as *Streptopharagus kuntzi* Myers, 1954.

Samples in the Helminth Collection of the Museum National d'Histoire Naturelle (MNHN), Paris, France: 541A and 530A *S. kutassi* from *Citellus fulvus* and *Meriones persicus*, Iran; 538A, *S. schmidtii* n. sp. from *M. persicus*, Iran and Sb 175 *S. lerousi* Quentin, 1965 from *Tetera lobengulae*, Congo.

Worms were cleared in lactophenol and measurements taken with calibrated calipers from drawings made with a Wild drawing tube. Transverse sections of various body regions were prepared free-hand with a mounted razor blade, cleared in glycerine and examined in a hanging drop over a depression slide. Terminology of papillae and other structures according to Willmott (1974). All measurements are in micrometers unless otherwise indicated.

RESULTS

Streptopharagus greenbergi n. sp.

Synonyms: *S. kuntzi* Myers, 1954; *S. kuntzi* Myers, 1954 in Lewis and Ashour, 1983; *S. kutassi* (Schulz, 1927) in Bernard, 1964; *S. kutassi* (Schulz, 1927) in Greenberg, 1969; *S. kutassi* (Schulz, 1927) in Wertheim and Greenberg, 1970.

DESCRIPTION

Material examined: 1 male holotype + 7 paratypes; 1 female allotype + 4 paratypes from *Acomys cahirinus*. Samples n° 62161 and 62162 from *Rattus rattus* marked

S. kuntzi, on loan from the USNM Helminthological Collection.

Small, slender, fusiform nematodes tapering to a somewhat truncated cephalic extremity and a rounded caudal end. Cuticular transverse striation begins 25-40 from cephalic end. Numerous short, interstitial ridges only in anterior part of body (Fig. 1B). Cervical papillae asymmetrical. Two longitudinal alae originate a few μm posterior to the cervical papillae (Fig. 2A). Oral opening hexagonal, elongated dorsoventrally, formed by two lateral, trilobed pseudolabia their margins cuticularized into a ring. Six triangular teeth project from the ring into the oral opening. Chabaud and Wertheim, 1977 and Lewis and Ashour, 1983 showed SEM photomicrographs of the cephalic extremity. Six tiny interno-labial papillae, four median externo-labials, two small lateral amphids and four cephalic papillae (Fig. 2B). Pharynx, thick walled, cylindrical, bent in the middle, its posterior margin folded outwards, forming a collar-like structure at its junction with the oesophagus. Oesophagus long, distinctly divided into an anterior muscular and a long glandular part.

FIG. 1. — Cuticular ornamentation (striae and interstitial longitudinal ridges) of *Streptopharagus* spp.: a) at the oesophageo-intestinal valve; b) in front of anus.

A) *S. numidicus*, B) *S. greenbergi*; C) *S. kutassi*; D) *S. schmidtii*.

MALE: holotype

(range of 7 paratype specimens in parenthesis)

Body length: 13.60 mm (9.77-13.50 mm); width: at cephalic extremity 28 (28-48); at caudal end of oesophagus

FIG. 2. — *Streptopharagus greenbergi* n. sp.: A, B) cephalic extremity of female, ventral and apical views; C) cross section of body in oesophagal region; D) vulva and vagina, latera view; E) flexure of oviduct and proximal part of uterus; F) larvated egg; G) caudal extremity of female, lateral view; H) caudal extremity of male, ventral view; I) left spicule; J) right spicule; K) gubernaculum; L) papillae on tip of male tale.

Scale bars: A, C, K) 50 µm; B, F) 25 µm; D, E, H) 100 µm; G, I, J) 75 µm.

240 (180-220); at proximal end of seminal vesicle 240 (180-230); at cloaca 108 (83-108). Transverse striation begins 20-40 from cephalic extremity. Distance from anterior extremity: left cervical papilla 145 (140-190), right cervical papilla 320 (245-324), nerve ring 240 (218-248), excretory pore 327 (276-288). Left ala 15-18 wide extends for about 1/3 of body length. Right ala 5-8 wide, extends 250-430 posterior to oesophageo-intestinal valve. Length of pharynx 108 (104-143). Length of oesophagus 2,100 (1,720-2,280). Length of muscular part of oesophagus 318 (237-305). Posterior end of fixed specimens forming 1-2 coils. Tails length 180 (160-200). Spicules unequal. The left slender, winged 910 (780-895) long; right spicule broad, with a membranous rounded tip 262 (255-326) long. Gubernaculum 38-42 long. (Figs. 2I, J, K). Two pairs of pediculated preanal papillae, one sessile papilla on anterior lip of cloaca, two larger sessile papillae posterior to cloaca, one pair of pediculated postanal papillae and 4 pairs of small sessile papillae on tip of tail. Caudal alae 750 (440-750). Area rugosa 945 with longitudinal ornamentation. Area between cloaca and tip of tail without ornamentation (Fig. 2H, L).

FEMALE: allotype

(range of 4 paratypes in parenthesis)

Body length: 19.4 mm (15.2-18.3 mm); width at cephalic extremity 40 (30-48), at posterior end of oesophagus 223 (220-223), at vulva 225, at base of tail 78 (75-78). Distance from anterior extremity: left cervical papilla 163 (122-158), right cervical papilla 350 (225-308), nerve ring 250 (205-300), excretory pore 361 (260-382). Length of pharynx 120 (110-122). Length of oesophagus 3,030 (1,970-2,400). Length of muscular part of oesophagus 342 (270-310). Length of tail 193 (168-190). Left ala originates 10-28 posterior to cervical papilla, reaches a maximum width of 15-26 and extends from 200-1,008 anterior to vulva to about 600-700 posterior to vulva. Right ala originates 7-23 posterior to cervical papilla, has a maximum width of 15-16 μ and extends to a few mm anterior or posterior to the distal end of oesophagus. Didelphic, amphidelphic. Proximal ends of ovaries close to vulva. The anterior gonad extends to 430-2,700 from cephalic extremity, where it flexes as the oviduct and joins the spherical seminal receptacle formed by the proximal end of the anterior uterus (Fig. 2E). The posterior gonad extends to 430-2,700 from posterior end, where it flexes as the oviduct and joins the posterior seminal receptacle. The uterine branches unite to form the vagina uterina 50-482 long. Vagina vera directed posteriorly, lined with cuticle, consists of a heavily muscularized, thick part and a narrower, cylindrical part. Total length 230-664 (Fig. 2D). Eggs (Fig. 2F), thick shelled contain a developed larva when still in *utero*, 34-41 $\times$ 20-26.

Type host: *Acomys cahirinus*; other hosts: 11 species of gerbillid and murid rodents (Table I).

Site: stomach.

Type locality: Yotvata (Negev), Israel.

Types and paratypes n° 194HF in the helminth collection MNHN, Paris.

Etymology: The specific name honours Dr. Z. Greenberg, Ministry of Health, Government Central Laboratories, Jerusalem, for this contribution to helminthological research in Israel.

COMMENTS

Life history: A tenebrionid beetle, *Adesmia* sp., caught at Sharm-el-Sheikh (southern Sinai), was found infected with nematode larvae. Eight larvae were fed to a laboratory-bred spiny mouse, *Acomys cahirinus*. The mouse was autopsied 103 days later and 3 specimens of *S. greenbergi* were recovered from the stomach — a female, 24.0 mm long, with larvated eggs in the uteri and 2 males, 12.9 and 9.6 mm long.

Host spectrum, prevalence and zoogeographic distribution: data on the geographic distribution of the rodent species infected with *S. greenbergi* and on prevalence of the infection were obtained from an extensive survey of parasites of wild mammals and birds of Israel (Theodor and Costa, 1967, pro parte) and many additional trips in the years 1962-1970. Helminths from rodents in Sinai were collected during June 1968, December 1968 and June 1969 in the southern part of the peninsula and also during December 1969 and April 1970 in the central and northern parts.

In Israel *S. greenbergi* parasitizes six species of murid and gerbillid rodents. Although hosts were collected throughout the country, infected animals were found only in the arid regions: on dunes south of Be'er Sheva, in rocky areas in southern Negev and along the western coast of the Dead Sea. In southern Sinai *S. greenbergi* was found in five species of rodents and in central and northern Sinai in six (Table I).

By comparing the high prevalence of *S. greenbergi* in rodents from Israel and Sinai with the low values in rodents from Tunisia and Egypt it is obvious that the species is endemic in Sinai and southern Israel with penetration into North Africa (Table I). It is often stated that the geographic distribution of a heteroxenous parasite may be limited by the availability of the intermediate host. However, from data in Table I one must infer that some climatic, physiologic, genetic or other factors may play a role in the distribution of *S. greenbergi* infections in the various hosts. *S. greenbergi* is an abundant nematode in southern Sinai, in fact, it is the most prevalent nematode parasitizing four species of rodents there (Wertheim and Greenberg, 1970). Yet, not one of 27 *G. dasyurus* examined was infected in this biotope, despite the rodent's susceptibility to the nematode, as seen from prevalence values in Israel and central and northern Sinai (Table I). A similar relationship was observed with regard to *S. greenbergi* infections in *A. rus-*

TABLE I. — *Host range, prevalence, geographic distribution of Streptopharagus greenbergi.*

	ISRAEL (south) Be'er Sheva to Elath		SINAI center-north		SINAI south		TUNIS Bernard, 1964		EGYPT	
	Nb Exa.	Prev. (%)	Nb Exa.	Prev. (%)	Nb Exa.	Prev. (%)	Nb Exa.	Prev. (%)	Nb Exa.	Prev. (%)
<i>Rattus rattus</i> L., 1758									112	1.3
									Lewis & Ashour, 1983	
<i>Rattus alexandrinus</i> L., 1758							368	1.6		
<i>Acomys cahirinus</i> Desm., 1819	m 105 f 109	m 66.7 f 36.7	m 21 f 13	m 52.4 f 84.6	m 23 f 53	m 38.7 f 28.3			73	1.4
									Lewis and Ashour, 1983 ± Myers, 1954	
<i>Acomys russatus</i> Wagner, 1840	m 10 f 12	m 40.0 f 8.3	m 0 f 2	m 0 f 0	m 11 f 5	m 0 f 0				
<i>Gerbillus nanus</i> Blanford, 1875	17	23.5	-	-	-	-				
<i>Gerbillus dasyurus</i> Wagner, 1842	m 16 f 9	m 22.2 f 33.3	m 11 f 8	m 27.2 f 25.0	m 15 f 12	m 0 f 0				
<i>Gerbillus henleyi</i> (de Winton, 1903)	-	-	-	-	2	50				
<i>Gerbillus gerbillus</i> Olivier, 1801	-	-	m 11 f 3	m 18 f 0	m 13 f 15	m 38.5 f 26.7				
<i>Gerbillus pyramidum</i> Geoffroy, 1825	27	11.1	m 17 f 8	m 4	-	-				
<i>Meriones crassus</i> Sund., 1842	m 2 f 2 ? 6	m 50 0 50	m 0 f 6	m 0 f 100	m 3 f 65	m 66.7 f 60.0				
<i>Meriones libycus</i> Licht., 1823							40	2.8	+ Myers, 1954, 1957	
<i>Sekeetamys calurus</i> Thomas, 1892	m 7 f 5	m 40.0 f 8.3	m 6 f 7	m 83.3 f 81.7	m 31 f 19	m 54.8 f 42.1				

Nb Exa. : number examined; Prev. (%) : prevalence; m : male; f : female; ? : sex not recorded; + : *Streptopharagus* present but no quantitative data given; - : host not found.

satus. In Israel, five animals out of 20 examined were infected whereas in Sinai (south and north) none of the 20 examined was infected. The low infection rate of *A. russatus* as compared to that of *A. cahirinus* living in the same biotope was first observed by Greenberg (1969).

Streptopharagus schmidtii n. sp.

DESCRIPTION

Material examined: 1 male, 5 females

Small, slender, fusiform nematodes tapering to a narrow, cephalic extremity and a somewhat truncated caudal end. Cuticle transversely striated. Interstrial cuticle smooth without longitudinal ridges (Fig. 1D). Cervical papillae asymmetrical. Two longitudinal alae originate a few μ m posterior to cervical papillae (Fig. 3A, C). Oral opening hexagonal, slightly elongated dorsoventrally, formed by two trilobed lateral pseudolabia. Six triangular teeth project from the labial lobes into the buccal cavity. Six tiny interno-labial papillae, four median externo-labials, two small lateral amphids and four cephalic papillae (Fig. 3B). Pharynx, thick walled, cylindrical, bent in the middle, its posterior margin folded outwards, forming a collar-like structure at

its junction with the oesophagus. Oesophagus long, distinctly divided into an anterior muscular and a long glandular part.

MALE: 1 specimen — holotype
(partly broken)

Body length: 10.10 mm; width: at cephalic extremity 30, at caudal end of oesophagus 170. Maximum width at proximal end of left spicule 210. Distance from cephalic extremity: of nerve ring 218. Cervical papillae and excretory pore not seen. Length of pharynx 112. Length of oesophagus 1,220. Length of muscular part of oesophagus 210. Posterior end of fixed specimens coiled. Tail 180 long. Spicules unequal. The left slender, vinged 1,100 long, right spicule broad, with a membranous rounded tip, 280 long. Gubernaculum 50 long (Fig. 3I, J K). Two pairs of pediculated preanal papillae, one sessile papilla on anterior lip of cloaca, two larger sessile papillae posterior to cloaca, one pair of pediculated post anal papillae and 4 pairs of tiny sessile papillae on tip of tail (Fig. 3F, G). Caudal alae do not meet posterior to tip of tail. Size of caudal alae and area rugosa could not be measured because of the specimen's poor state of preservation.

FIG. 3. — *Streptopharagus schmidtii* n. sp.: A, B) cephalic extremity of female, ventral and apical views; C) cross section of body in oesophageal region; D) caudal extremity of female, lateral view; E) larvated egg; F) caudal extremity of male, ventral view; G) papillae on tip of male tale; H) ornamentation of area rugosa (detail); I) distal end of left spicule; J) distal end of right spicule; K) gubernaculum. Scale bars: A, D) 100 µm; B, E) 20 µm; G) 10 µm; C) 50 µm; F) 75 µm; H, I, J, K) 25 µm.

FEMALE: allotype

(range of 5 paratypes in parenthesis)

Body length: 16.3 mm (15.9-17.18 mm); width at cephalic extremity 34 (34-43), at caudal end of oesophagus 200 (193-220), at vulva 218 (230-260), at anus 90 (108-110). Distance from anterior extremity: left cervical papilla 138

(115-150), right cervical papilla 227 (224-283), nerve ring 228 (210-238). Excretory pore not seen. Length of pharynx 120 (93-115). Length of oesophagus 1,970 (1,826-2,070). Length of muscular part of oesophagus 357 (383-480). Tail length 205-220. Didelphic, amphi-delphic. Vulva not salient at a distance of 39.5 (39.1-43.4) percent of body length from cephalic end. Proximal ends of ovaries close to vulva.

The anterior gonad extends to 2,630 (2,300-3,170) from cephalic extremity, where it flexes (as the oviduct) and joints the somewhat spherical seminal vesicle, formed by the proximal end of the anterior uterus. The posterior gonad extends to 500 (640-730) from posterior extremity where it flexes as the oviduct and joints the posterior seminal vesicle. The two uteri unite to form the vagina uterina 310 (318-550) long. Vagina vera, directed posteriorly, consist of a heavily muscularized thick part 290 (250-450) long and a narrow, cylindrical tube 210 (160-290) long. Eggs mostly unembryonated 28-30 × 13-18.

Host: *Meriones persicus* (type), also in *M. lybicus*.

Types and paratypes N) 538A in the helminth collection MNHN, Paris.

Site: stomach.

Type locality: 130 Km north of Hamadan, Iran.

Etymology: *S. schmidt* is named in memory of Dr. G. D. Schmidt in appreciation for his contribution to helminthological research.

COMMENTS

S. schmidt differs from the *S. greenbergi*, the other form with two longitudinal alae, by the smooth cuticle, without longitudinal, interstitial ridges and by the diminutive size of the papillae on the tip of male tail.

Streptopharagus lerouxi Quentin, 1965

Certain morphological features, used in the present study for differentiation of rodents species of *Streptopharagus* and not mentioned or not clearly defined in Quentin's description of *S. lerouxi*, were studied in female (n° Sb 275) deposited in helminth collection of the MNHN, Paris.

The cuticle of *S. lerouxi*, like that of *S. schmidt* n. sp., is smooth without any interstitial longitudinal ridges. The pharynx, like that of *S. numidicus*, is looped.

Streptopharagus kutassi

(Schulz, 1927) Chabaud, 1954

Synonymy: *Arduenna kutassi* Schulz, 1927.

REDESCRIPTION

Material examined: 3 males, 2 females.

General: Small, slender, fusiform nematodes tapering to a somewhat truncated cephalic extremity and a rounded caudal end. Cuticle transversely striated with interstitial, longitudinal ridges in anterior part of body (Fig. 1C). Cervical papillae asymmetrical. A single longitudinal ala originates a few μ m posterior to cervical papilla (Fig. 4A, C). Oral opening hexagonal, elongated dorso-ventrally, formed by two trilobed lateral pseudolabia. Six triangular teeth

project from the labial lobes into the buccal cavity. Six tiny interno-labial papillae, four median externo-labials, two small amphids and four cephalic papillae (Fig. 4B). Pharynx, thick walled, cylindrical, bent in the posterior third, its posterior margin folded outwards, forming a collar-like structure at its junction with the oesophagus. Oesophagus long, distinctly divided into a short muscular and a long glandular part.

MALE: range with data on the type specimen (Schulz, 1927) in parenthesis

Body length: 12.1-14.2 mm (13.3); width: at cephalic extremity 30-42, at caudal end of oesophagus 220-230, at cloaca 118-180 (200). Maximum width 255-268 (247). Distance from cephalic extremity: left cervical papilla 140-172 (152), nerve ring 256-268 (256), excretory pore (332), right cervical papilla 182-270. Longitudinal ala originates 205-230 (182) from cephalic extremity and extends for about 1/2 body length (1/8 of body length). Length of pharynx 94-110 (76). Length of oesophagus 1,750-2,100 (2,580), muscular part 275-490. Posterior end of fixed specimens coiled 1-2 times. Tail 173-240 long. Spicules unequal. The left pointed, winged 1,050-1,150 (1,250) long; right spicule broad with a membranous rounded tip 260-295 (311) long. Gubernaculum 33-46 long (Fig. 4I, J). Two pairs of pediculated preanal papillae, one sessile papilla on anterior lip of cloaca, two sessile papillae posterior to the cloaca, one pair of pediculated postanal papillae and 4 pairs of tiny, sessile papillae on tip of tail (Fig. 4F, G). Caudal alae do not unite posterior to tail. Area rugosa 1,400-1,550 long. Ornamentation of area rugosa absent in a narrow field between papillae, posterior to the cloaca (Fig. 4F, H).

FEMALE

Body length: 23.0 and 26.3 mm (28.5 mm); width: at cephalic extremity 24.42, at caudal end of oesophagus 270, 280; at level of vulva 330, 340; at anus 128, 146. Maximum width posterior to the vulva 347, 380 (425). Distance from anterior extremity: left cervical papilla 184, 187 (190-197) (115-150), nerve ring 267, 270 (266), excretory pore 345 (387), right cervical papilla 386, 407 (285). Pharynx length 108, 125 (114). Oesophagus length 2,600, 2,930 (2,580). Muscular part of oesophagus 358, 386. Length of tail 247, 250 (300) (Fig. 4D).

Didelphic, amphidelphic. Vulva not salient at a distance of 32.5, 37.4 (30, 40) percent of body length from cephalic extremity. Anterior flexure of oviduct 3,580 from cephalic extremity; posterior flexure 2,140 from posterior end. Vagina vera, directed posteriorly, consist of a heavily muscularized part 450 long and a narrow, cylindrical part 490 long; vagina uterina 370 long. Eggs larvated *in utero* 34-36 × 22-24 (39 × 24) (Fig. 4E).

FIG. 4. — *Streptopharagus kutassi*: A, B) cephalic extremity of female, ventral and apical views; C) cross section of body in oesophageal region; D) caudal extremity of female, lateral view; E) larvated egg; F) caudal extremity of male, ventral view; G) papillae on tip of male tale; H) ornamentation of area rugosa (detail); I) gubernaculum and tip of right spicule; J) distal end of left spicule. Scale bars: A, D) 100 µm; B) 20 µm; C) 50 µm; E) 15 µm; F) 75 µm; G) 10 µm; H, I, J) 25 µm.

Host: *Citellus fulvus*, *Meriones persicus* (cf. Chabaud, 1954).

Site: stomach.

Locality: 130 Km north of Hamadan, Iran.

COMMENTS

Life history: A tenebrionid beetle *Pimelia angustata* var. *angulosa* was found infected with larvae of *S. kutassi* (Chabaud, 1954).

Data on the hosts-spectrum, prevalence and zoogeographic distribution are based on findings of Schulz (1927) and Chabaud (1954). *S. kutassi* was recorded in sciurid and gerbillid rodents over an area extending from eastern Europe to central Asia. The ground squirrel, *Citellus musiculus planicola* Satun., with a prevalence of 28.3 % in 53 hosts examined, was established as type species and Novoczevsk in the Ukraine as type locality. In the same locality one out of 5 examined *Marmota bobac* Schreb., was found infected. Other hosts reported by Schulz: *Citellus* sp. from Askanya Nova in Bielorussia (no further data), and the Asian ground squirrel, *Spermatophilopsis leptodactylus* Licht, in the Turkmen Republic (Central Asia) (two hosts infected with one female each). Chabaud found *S. kutassi* in Iran in 2 *Citellus fulvus* Licht., one infected with 3 male worms and one with 3 males and 2 females as well as in one *Meriones persicus* Blanf., infected with one male.

Streptopharagus numidicus Seurat, 1917

Synonym: *S. sudanensis* (female) Baylis, 1923 (cf. Chabaud, 1954); *S. sudanensis* (male) Nazmi Gohar, 1932.

Material examined: 5 males and 7 females.

REDESCRIPTION

Medium sized, stout nematodes, truncated anteriorly and tapering to a rounded posterior end. Males shorter and more slender than females, cuticle 9 — 12 thick with transverse striae 12 to 18 apart, beginning 20 — 30 from anterior extremity and numerous, short, irregularly spaced, longitudinal, interstitial ridges over entire body (Fig. 1A). Longitudinal ala absent, a tiny alar skeletal support embedded in the cuticle (Fig. 5D). Cervical papillae asymmetrical. Oral opening hexagonal, elongated dorso-ventrally, formed by two lateral trilobed pseudolabia. From each lobe a tricuspid tooth projects into the oral cavity. Each tooth consists of central cusp and two smaller cusps on its external surface (Fig. 5B, C). Six small interno labials papillae, 4 median externo-labials, two lateral amphids and 4 cephalic papillae (Fig. 5B). Pharynx thick walled, looped in the middle (Fig. 5A). Posterior margin of pharynx directed outwards forming a collar-like ringue at the pharyngo-oesophageal junction (Fig. 5A). Oesophagus long, clearly divided into an anterior muscular and a posterior glandular part.

MALE

Body length: 17.8-22.9; width: at anterior extremity 70-90, at caudal end of oesophagus 440-450, maximum at origine of seminal vesicle 390-500. Pharynx length 110-160. Length of oesophagus 2,400-2,648, muscular part of oesophagus 430-480. Distance from anterior end: left cervical papilla 208-250, right cervical papilla 325-440, nerve ring 367-390, excretory pore 403-468. Length of tail 270-360. In fixed specimens caudal end rolled into 1-3 coils. Caudal alae 800-900 long, 100-120 wide, do not meet posterior to tail end of body. Area rugosa extend for 1/10 to 1/6 of body length. Cuticle in median postcloacal region smooth. Two pairs of pediculated preanal papillae, one sessile papilla on anterior lip of cloaca, two larger sessile papillae on posterior lip, one pair of pendiculated postanal papillae and 4 pairs of small sessile papillae close to tip of tail. Spicules unequal. Left spicule 1,900-2,350 long, slender, winged at the tip. Right spicule 520-630, stout, with a membranous, rounded distal end. Gubernaculum funnel shaped 42-70 long (Fig. 5H, J).

FEMALE

Body length: 28.0-51.2 mm. Width at anterior extremity 90-140, maximum 560-710. Length of pharynx 100-148. Length of oesophagus 2,950-4,680, of muscular part 480-722. Distance from anterior end: left cervical papilla 243-250, right cervical papilla 420-490, nerve ring 400-485, excretory pore 490-570. Length of tail 255-380, Didelphic, amphidephic. Vulva not salient, 24.6-28.4 percent of body length from cephalic end. Vagina vera 1,770-2,100 long, directed posteriad, formed by a wide, muscularized part and a narrow, cylindrical part (both lined with cuticle). Vagina uterina 255-640. Eggs larvated *in utero* 44-49 × 30-33, covered with a thin envelop except for both poles. No opercula or polar plugs (Fig. 5E).

Hosts: *Gerbillus pyramidum*, *Rattus rattus*.

Site: stomach.

Locality: Dunes around Ismailia, Egypt.

COMMENTS

Seurat (1917) established the species *S. numidicus* for two young specimens (1 male, 1 female) found in a fennec fox, *Fennecus zebra*, in southern Tunisia. The original short communication was followed by a detailed study in which the most characteristic features of the species were described and illustrated; the tricuspid teeth projecting from the labial lobes into the buccal cavity and the looped pharynx (Seurat, 1918). Unfamiliar with this publication Baylis (1923) described *S. sudanensis* from females with three cuspid teeth recovered from *Gerbillus gerbillus* trapped in Khartum. Subsequently Nazmi (1932) described the males

of *S. sudanensis* she received from the type host and the type locality. Aware of Seurat's (1918) publication, Ortlepp (1925) identified 2 specimens found in *G. pyrgarus* in Egypt as *S. numidicus*. (According to Dr. F. Petter, Museum National d'Histoire Naturelle, Paris, Zoology-Mammals and Birds, *Gerbillus pyrgarus* is found only in Senegal: Ortlepp's specimens were probably *G. gerbillus* or *G. pyramidum*). He suggested that *S. sudanensis* may be a synonyme of *S. numidicus*, and that the gerbil is the natural host of this nematode and the infection in the fennec fox was most probably accidental. The two species were formally synonymized by Chabaud (1954).

A study of *S. numidicus* from *G. pyramidum* using light and SEM microscopy was published recently (Lewis and Ashour, 1983).

New information in the present work extends the range of worm size and confirms Seurat's observations that *S. numidicus* has a looped pharynx and has neither longitudinal alae nor pharyngeal teeth.

Specimens examined in the present study were found in 4 *G. pyramidum* trapped on dunes around Ismailia by Y. Wharman. Of the 40 specimens of *G. pyramidum* from the southern arid areas of Israel and from the Sinai peninsula, not a single one was infected with *S. numidicus*. *S. numidicus* appear to be a north african species limited in its distribution to the eastern bank of Suez Canal. This distribution is most probably limited by the distribution of the insect intermediate host, unknown at present (See comments regarding *S. greenbergi*).

To date three species of rodent *Streptopharagus* were found in Africa: *S. numidicus*, *S. geosciuri*, Le Roux 1930 and *S. lerouxi*. All three are characterized by a looped pharynx and long spicules. Range of spicules — combined data of the three species —: left 700-1,320, right 235-410.

The three African species can be easily differentiated from one another by cuticular morphology: *S. lerouxi* — a left longitudinal ala and no interstrial, longitudinal ridges, *S. numidicus* and *S. geosciuri* — no longitudinal ala but interstrial ridges over entire body in the first and only in the anterior body part in the second.

DISCUSSION

In addition to the two new species described herein, there are in print descriptions of 8 species of rodent *Streptopharagus*.

Of these 4 — *S. numidicus* Seurat, 1917, *S. kutassi* (Schulz, 1927) Chabaud, 1954, *S. geosciuri* Le Roux, 1930 and *S. lerouxi* Quentin, 1965 are valid, easily separable from each other. Two species: *S. sudanensis* Baylis, 1923 (females) Nazmi Gohar, 1932 (males) and *S. kuntzi* Myers, 1954 are synonyms of *S. numidicus* (cf. Chabaud, 1954) and *S. greenbergi* n. sp. respectively. *S. indicus* Johnson, 1969 and *S. kolayatensis* Soota and Chaturvedi, 1971 are inadequately described.

By comparing the description of the type species *S. armatus* Blanc, 1912 and the generic diagnosis (Baylis, 1923) with observations made during the present work, one can easily point to the source of mistakes in interpretation in the pertinent studies.

Streptopharagus is a stomach parasite; it is found in the intestine only when the host is dissected some time after death (Myers, 1954; Johnson, 1969; Lewis and Ashour, 1982). Inflation of the cephalic cuticle observed in some specimens is an artefact (Blanc, 1912).

In the generic diagnosis Baylis (l.c.) described a *cervical* ala « originating behind the left cervical papilla and extending throughout the oesophageal region ». This description obviously refers to a longitudinal ala. Although later the Chitwoods (1937) defined the three types of lateral alae in nematode cuticle: cervical, longitudinal, caudal, the confusion persisted and Yamaguti ascribed to the genus *Streptopharagus* « cervical alae on one side only » (1959, vol. 3, part. 1, page 610). By examining body *cross sections* it was shown that species of *Streptopharagus* can be differentiated by the number (0-2) of longitudinal alae.

Interstrial, short, rode-like, longitudinal ridges and asymmetrical cervical papillae are included in the generic diagnosis (Baylis, l.c.). Cervical papillae were overlooked in *S. kuntzi* Myers, 1952 and *S. indicus* Johnson, 1969. *S. indicus* and *S. kolayatensis* were found in the same host *Tatera indica* and at close sites, Bikana, Rajasthan. There is no doubt that they represent a single species but, whereas in *S. kolayatensis* a left longitudinal ala was noted, there is no mention of an ala in the description of *S. indicus*. Judging by the zoogeographic distribution this nematode could be either *S. kutassi* or, if two longitudinal alae would be observed in cross-sections—*S. schmidtii*.

There are two forms of pharynx in rodent *Streptopharagus*: a looped one (Seurat, 1918, Fig. 1, 2) and a bent one in which the cylindrical pharynx makes a slight bend in its posterior half (present paper Fig. 2A). The statement

FIG. 5. — *Streptopharagus numidicus*: A, B) cephalic extremity of female, lateral and apical views; C) tricuspid tooth; D) cross section of body in oesophageal region; E) larvated egg; F) caudal extremity of female, lateral view; G) papillae on tip of male tale; H) caudal extremity of male, ventral view; I) gubernaculum.

Scale bars: A, H) 150 µm; B, C) 30 µm; D) 100 µm; E) 10 µm; F) 200 µm; G) 25 µm; I) 50 µm.

FIG. 5.

that the pharynx forms, at about the middle of its length, a half turn (Baylis, 1923) was ambiguous and confusing. Some authors applied this description to a looped form and some to a bent form. A looped pharynx is present in *S. numidicus*, *S. geosciuri* and *S. lerouxi*. These three species have long spicules: left 2.20 mm-2.26 mm, right 0.375-0.480 mm. *S. kutassi*, *S. greenbergi* and *S. schmidt*i have a bent pharynx and short spicules: left 0.700-1.920 mm, right 0.235-0.390 mm.

The following key may help to avoid misinterpretations in describing species of *Streptopharagus* from rodents:

Key to species of *Streptopharagus* parasitic in rodents.

- 1 (4) Longitudinal alae absent, pharynx looped.
- 2 (3) Rod like, longitudinal, interstitial ridges extend over entire body.
Buccal teeth tricuspid ... *S. numidicus* Seurat, 1917.
- 3 (2) Interstitial ridges only in anterior part of body.
Buccal teeth simple ... *S. geosciuri* Le Roux, 1930.
- 4 (1) One or two longitudinal alae.
- 5 (8) One (left) longitudinal ala. Pharynx bent or looped.
- 6 (7) Interstitial ridges in anterior part of body.
Pharynx bent *S. kutassi* (Schulz, 1927) Chabaud, 1954.
- 7 (6) Interstitial cuticle smooth.
Pharynx looped *S. lerouxi* Quentin, 1965.
- 8 (5) Two longitudinal alae. Pharynx bent.
- 9 (10) Interstitial ridges in anterior part of the body ...
..... *S. greenbergi* n. sp.
- 10 (9) Interstitial cuticle smooth *S. schmidt*i n. sp.

Acknowledgements. — The author is grateful to colleagues in the Laboratoire de Biologie Parasitaire (MNHN, Paris): A. G. CHABAUD for reading and commenting on the manuscript; O. BAIN, A. J. PETTER, G. PETIT, R. TCHEPRAKOFF, J. CASSONE for council and helpful suggestions. She also thanks Dr. J. R. LICHTENFELS, US National Helminth collection for loan of specimens and Dr. Y. WHARMAN, Department of genetics, The Hebrew University of Jerusalem for specimens of *Gerbillus pyramidum* from Ismailiya and surrounding territories.

REFERENCES

Baylis H. A. : On the genus *Streptopharagus* with some remarks on the genus *Spirocerca*. *Trans. R. Soc. Trop. Med. Hyg.*, 1923, 16, 486-497.

- Bernard J. : Études sur la faune parasitaire de Tunisie. Données supplémentaires sur les nématodes parasites de Muridae. *Arch. Inst. Past. Tunis*, 1964, 49, 39-52.
- Chabaud A. G. : Sur le cycle évolutif de spirurides et de nématodes ayant une biologie comparable. Valeur systématique de caractères biologiques. *Ann. Parasit. Hum. Comp.*, 1954, 29, 42-88.
- Chitwood B. G., Chitwood M. B. : The external cuticle and hypodermis. In: *An introduction to nematology*. Published by M. B. Chitwood, 1937, Section 1, Part 1, Chapter III, p. 24-25.
- Greenberg Z. : Helminths of mammals and birds of Israel. I. Helminths of *Acomys* spp. (Rodentia-Murinae). *Israel J. Zool.*, 1969, 18, 25-38.
- Johnson S. : A new nematode of the genus *Streptopharagus* (Spiruroidea) from the Indian gerbil, *Tatera indica indica*. *J. Helm.*, 1969, 93, 343-346.
- Le Roux P. L. : A spirurid (*Streptopharagus geosciuri*, sp. nov.) from the stomach of the Cape ground squirrel (*Geosciurus capensis*). Report of the Director of Veterinary Services and Animal Industry, 16th 1930, Onderstepoort, pp. 201-204.
- Lewis J. W., Ashour A. A. : The morphology of *Streptopharagus kuntzi* and *S. numidicus* (Nematoda: Spiruroidea) from the Egyptian rodents. *Sys. Parasitol.*, 1983, 5, 223-233.
- Myers B. J. : Helminth parasites of reptiles, birds and mammals in Egypt. I. *Streptopharagus kuntzi* sp. nov. from rodents, with a review of the genus. *Can. J. Zool.*, 1954, 32, 366-374.
- Nazmi G. : *Streptopharagus sudanensis* Baylis, 1923. *Trans. R. Soc. Trop. Med. Hyg.*, 1932, 26, 295-296.
- Ortlepp R. J. : A review of the member of the genus *Streptopharagus* Blanc, 1912. *J. Helm.*, 1925, 3, 209-216.
- Quentin J. C. : Nématodes parasites de rongeurs du Congo. *Parc National de l'Upemba, Mission G. F. de Witte*, 1965, 69, 73-91.
- Schulz R. E. : Zur Kenntnis der Helminthenfauna der Nagetiere der Union SSR. II. Spirurata Railliet et Henry. *Œuvres de l'Institut d'État de la Médecine Vétérinaire Expérimentale*, 1927, 4, 36-65.
- Seurat L. G. : Sur les Spiroptères des Carnivores Nord-Africain. *Bull. Soc. Hist. Nat. Afrique Nord*, 1917, 8, 21-24.
- Seurat L. G. : Contribution à l'étude de la faune parasitaire de la Tunisie. Nématodes. *Arch. Inst. Past. Tunis*, 1918, 10, 243-275.
- Soota T. D., Chaturvedi Y. : On five nematodes from vertebrates. *Zool. Anz.*, 1971, 187, 310-317.
- Theodor O., Costa M. : A survey of the parasites of wild mammals and birds in Israel. Part one: Ectoparasites. *The Israel Acad. Scien. Human.*, 1967, Jerusalem.
- Wertheim G., Greenberg Z. : Notes on helminth parasites of myomorph rodents from Southern Sinai. *J. Helm.*, 1970, 44, 243-252.
- Willmott S. : *CIH Keys to the Nematodes parasites of vertebrates*. R. C. Anderson, A. G. Chabaud, S. Willmott. Eds. No. 1 Glossary of terms pp. 1-5, Commonwealth Agricultural Bureau, 1974.
- Yamaguti S. : *Systema Helminthum*. Vol. III *The nematodes of vertebrates*, p. 610. Interscience Publishers Inc. New York, London, 1961.