Molecular Variations Based on RAPD among Oxyurids in Egypt

Article · December 2018

CITATIONS
0

READS
286

1 author:

Dina Abdelmottaleb
Manchester Metropolitan University
12 PUBLICATIONS **50** CITATIONS

SEE PROFILE

Oxyurids Of Wild And Laboratory Rodents From Egypt

Amal I. Khalil[(1)], Gehan H. Lashein[(2)], Gazaa H. Morsy[(2)], Dina I. Abd El- Mottaleb[(2)]

Departments of Zoology, Faculty of Science, Tanta University[(1)], and[(2)]Benha University, Egypt
gehan.lasheen@yahoo.com

Abstract: *Syphacia obvelata, Syphacia muris* and *Aspiculuris tetraptera* were recovered differentialy from the Nile rat '*Arvicanthis niloticus'*, the brown rat *'Rattus norvigicus*', the black house rat *'Rattus rattus*', the house mouse *'Mus musculus*', the lesser short tailed gerbil '*Dipodillus simony*', the laboratory rat '*Rattus norvigicus alba'*, and the laboratory mouse *'Mus musculus alba'* from different geographical localities in Egypt. The lesser short tailed gerbil was recorded as new host record. Morphometric comparison between adults recovered from different hosts revealed statistically significant variations in few structures. Scanning electron, as well as, light microscopy added to the taxonomic valid characteristics that differentiate between the encountered oxyurids. These variations include: the shape and surface structure of the lips and labial papillae; the occurrence of cephalic vesicles in both *S. obvelata* and *A. tetraptera* but not in *S. muris*; the cervical alae being prominent in male *S. obvelata* but absent in females, present in female *S. muris* but absent in males and present in both sexes of *A. tetraptera*; the caudal alae found in *A. tetraptera* and absent in *Syphacia* spp.; spicules and gubernaculum present in both species of *Syphacia*, but not in *A. tetraptera*; the number of transverse striae on mamelons varied in the reported *Syphacia* spp.; the shape of vulva varied in the three encountered species. The structure of buccal cavity and oesophagus was defined and new criteria were added. The number, shape and size of caudal papillae in males were recorded. Variations in the shape of the transverse cuticular annulations in both sexes of the three encountered species were discussed. Results were discussed in relation to previous reports.

[Amal I. Khalil, Gehan H. Lashein, Gazaa H. Morsy, Dina I. Abd El- Mottaleb. **Oxyurids Of Wild And Laboratory Rodents From Egypt.** *Life Sci J* 2014;11(3):94-107]. (ISSN:1097-8135). http://www.lifesciencesite.com. 13

Key words: Syphaci obvelata, Syphacia muris, Aspiculuris tetraptera, scanning electron microscopy, rodents, Egypt.

1. Introduction:

Oxyurids are cosmopolitan nematodes of public health importance. *Enterobius vermicularis* is one of the most common human helminth parasites. It has been implicated in serious illness due to its ectopic migration. *Syphacia obvelata*, *Syphacia muris* and *Aspiculuris tetraptera* commonly infect rodents, yet *Syphacia muris* have been reported as zoonotic (Jueco and Zabala, 1990; Mahmoud *et al.,* 2009). The wide spread and ease of infection of pinworms among cohabitating members of the community magnify its importance.

S. obvelata and *S. muris* are commonly found in the caecum and colon of laboratory rats and mice at high prevalence even in well managed habitats (Baker, 1998; Bazzano *et al.,* 2002; Perec-Matysiak *et al.,* 2006). *A. tetraptera* is a common oxyurid in the caecum and colon of mice and to a lesser extent in rats (Mathies, 1959; Sasa *et al.,* 1962; Flynn *et al.,* 1965; Owen, 1972). Although the prevalence varies in different reports, yet it is probable that most rodent colonies are infected (Hussey, 1957; Stahl, 1961; Flynn, 1973). The degree of host specificity of these pinworms is controversial and cross-infection was reported.

Differentiation between *S. muris* and *S. obvelata* is based on examination of male worms for the location of the mamelons, however, males that usually die after mating are rarely recovered. Moreover, females differ only in the location of the vulva being slightly posterior in *S. muris* to that of *S. obvelata* (Farrar *et al.,* 1994 , Parel *et al.,* 2008). The fact that these morphological differences are difficult to determine urge the need for more diagnostic criteria for the differentiation between these pinworm species (Parel *et al.,* 2008).

The present study is an analytical descriptive study that aims to reveal the role of some wild and laboratory rodents as reservoirs of oxyurids in Egypt. The study also aims to specify the degree of similarity and divergence between the encountered pinworm species through examination of unstained whole mounts and SEM aiming to contribute to the taxonomy of pinworms.

2. Material and Methods

Rodents were collected during the years 2008 and 2009 from different parts of Egypt. 39 Nile rats (*Arvicanthis niloticus*), 40 brown rats (*Rattus norvigicus*), 57 black house rats (*Rattus rattus*), 55 house mice (*Mus musculus*), and 50 Cairo spiny mice

(*Acomys cahirinus*) were collected from Giza Governorate; 68 lesser short tailed gerbils (*Dipodillus simoni*) and 50 greater gerbils (*Gerbillus pyramidum*) from Al-Fayoum Governorate; 41 lesser gerbils (*Gerbillus gerbillus*) from Cairo- Alexandria road; 30 laboratory experimental rats (*Rattus norvigicus alba*) and 17 laboratory experimental mice (*Mus musculus alba*) from National Research Center in Dukki, Cairo (N.R.C).

Animals were anesthetized and sacrificed according to the ethical rules for handling experimental animals, the alimentary canal and its off shoots were removed and each part of alimentary canal was placed separately in a Petri dish containing isotonic saline solution (0.9%). The intestines were examined using binocular dissecting microscope at 20X. The site and number of worms in each part was recorded for each animal. The collected pinworms were fixed in warm 70% ethanol, transferred to cold 70% ethanol and stored in a mixture of 95 parts 70% ethanol + 5 parts glycerin. Specimens were cleared using either glycerin or lactophenol. Specimens were mounted in the same medium and covered with cover slips and sealed with glyceel.

Specimens were measured using a calibrated ocular micrometer and photographed using Olympus CX31 microscope, Zeiss Stemi 2000-C microscope and digital camera Canon A620. Drawings were made by using a camera Lucida. All measurements are in millimeter unless otherwise mentioned.

For scanning electron microscopy (SEM), specimens were fixed in 3% phosphate buffered gluteraldhyde, post fixed in 1% osmium tetraoxide, critical point dried, coated with gold, and examined and photographed using a JEOL 5300 JSM scanning electron microscope at an accelerating voltage of 25 and 30 KV.

Pinworm species were identified according to Akhtar (1955), Hussey (1957), Oldham (1967) Ogden (1971), Quentin (1975), Petter and Quentin (2009), and Falcon-Ordaz *et al.* (2010).

Ecological terminology follows Bush et al. (1997). Statistical analyses were performed using one-way ANOVA and *t*-test to evaluate the significance of the intraspecific morphometric variations and two-way ANOVA and t-test to evaluate the interspecific variations.

3. Results

The three encountered parasites were found in the caecum, rectum and around the anal opening of wild and laboratory rodents. The prevalence, mean intensity and abundance varied in different hosts **(Table 1)**. *Syphacia obvelata* was found in the brown rats, black house rats, house mice, lesser short tailed gerbils, and laboratory rats and mice; *Syphacia muris* in the Nile rats, brown rats, black house rats, house mice, lesser short tailed gerbils, and laboratory rats; and *Aspiculuris tetraptera* in black house rats, house mice, and laboratory rats.

Description of *S. obvelata*, *S. muris* and *A. tetraptera* is based on photomicrographs of unstained cleared preparations and camera Lucida drawings, as well as scanning electron micrographs.

Worms collected from different hosts were almost identical morphologically, however statistically significant variations were reported in the morphometrics of few structures (Tables 2-7).

General description:

Description is based on examination of unstained cleared specimens, as well as scanning electron micrographs.

S. obvelata, S. muris and *A. tetraptera* are small, colorless to off-white when alive with narrow posterior extremity. The head is bulb-like (Figures 1, 19, 43) and carries lips that are well developed in *S. obvelata, S. muris,* but less developed in *A. tetraptera.* The cephalic plate "cephalic cap" present in the three species varies from round to quadrate-shaped and carries four submedian cephalic papillae and two amphidial pores (Figures 7, 26, 49). The amphidial pores of *S. muris* are always associated with two spongy-like structures (Figure 26). Behind the head region of both *S. obvelata* and *A. tetraptera*, the cuticle of the cephalic plate is inflated forming two large conspicuous cephalic vesicles (Figures 7, 47), lacking in *S. muris*.

The transversally annulated body cuticle is confined to the level of the anus/cloaca in *S. obvelata, S. muris* (Figures 9, 18, 29, 39, 51), but extends posteriorly in *A. tetraptera* (Figure 60). Transverse annulations are elaborately wrinkled and longitudinal ridges extend across the annulations of the second and third quarters of the body in both sexes (Figure 9).

Cervical alae are small, striated, and unlobed; extending posteriorly from behind the cephalic extremity to the level of the anterior cylindrical part of oesophagus in both sexes of *S. obvelata* (Figures 1, 8), but confined to female *S. muris* (Figures 23, 28). Both sexes of *A. tetraptera* bear prominent smooth cervical alae distinct from that of *S. obvelata* and *S. muris* in that they extend from behind the cephalic plate and attain maximum width at the level where the oesophageal bulb joins the anterior tubular part of the oesophagus, then taper posteriorly to a curved spearhead free end (Figures 41, 42, 53). The lateral alae of *S. muris* and female *S. obvelata* are annulated in continuity with the body cuticle (Figure 31). The lateral alae of *A. tetraptera* are smooth and extend along the length of body to a distance of 0.028 behind the posterior end of the cervical alae where they measure 0.009 in width (Figures 41, 54).

The mouth opening is small, triradiate and guarded with three equal, small, and triangular fleshy lips (one dorsal and two ventrolateral) that lack labial papillae in *S. obvelata* and *S. muris* (Figures 7, 26). In *A. tetraptera* the mouth is surrounded with three small rudimental lips that carry two sessile poorly developed labial papillae (Figure 49). The mouth is followed by a shallow, triradiate buccal cavity lined with three thickened chitinized plates provided distally by sharp tooth-like denticles in both *S. obvelata* and *S. muris* (Figures 7, 26), but lacking in *A. tetraptera* (Figure 48). The buccal cavity leads to a short oesophagus that is divided into an anterior cylindrical part, a corpus, and a globular bulb which is supported internally with triradiate valvular apparatus in both *S. obvelata* and *S. muris* (Figures 1, 2, 19, 20). In *A. tetraptera,* the oesophagus is formed of two distinct regions, a long cylindrical muscular anterior part and a short and stout clavate glandular posterior bulb that lacks valvular apparatus, but is lined by ridged cuticle (Figures 41-43). The oesophagus leads to a long intestine which opens to the exterior by an anal opening in females and cloacal opening in males.

Male worms:

Three prominent spaced cuticular protuberances "mamelons" reside on the ventral surface of both *S. obvelata* and *S. muris* (Figures 1, 19), but not in *A. tetraptera*. The middle mamelon lies almost at the middle of the body length of *S. obvelata* (Figure 1), while the first mamelon lies almost at the middle of the body length of *S. muris* (Figure 19). In *S. obvelata,* mamelons are formed of ten to twelve transverse striae, each of which is ornamented on its midline by five rows of small papillae-like structures (Figures 1, 11, 12,), while that of *S. muris* is formed of eight to nine transverse striae, where each is ornamented on its midline with two to three rows of small papillae-like structures (papillae of *S. muris* are fewer and smaller than in *S. obvelata*) (Figures 21, 22, 32, 33).

Three symmetrical pairs of caudal papillae surround the cloacal region in both *S. obvelata* and *S. muris*: 1st pre-cloacal, 2nd ad-cloacal, 3rd large and more pronounced post-cloacal lying further posterior to the cloacal opening (Figures 13, 14, 34, 35, 36). Papillae of *S. muris* are cone-shaped with a central nipple-like structure encircled with a cuticular collar (Figure 35). In *A. tetraptera*, the cloacal region is provided with twelve caudal papillae arranged as: one pair large, round, sessile pre-cloacal; one pair large, long, finger-like ad-cloacal; a single small median papilla lies between the two ad-cloacal papillae; inner and outer pairs of post-cloacal; a single sessile median papilla lies posterior to the outer pair of post-cloacal papillae; and the last pair is small and asymmetrical (the left lies slightly anterior to the right) (Figures 56, 57, 58).

The male reproductive system is similar in both *S. obvelata* and *S. muris* being formed of a testis that curves backward at the level of the anterior mamelon then narrows and unites with the posterior end of intestine to open by cloacal opening (Figures 1 and 19). Males possess a single chitinized spicule (insignificantly smaller in *S. muris* than *S. obvelata P*= 0.323) and a gubernaculum provided with an accessory hook in *S. obvelata* and may appear protruded above the surface of the body cuticle in both *S. obvelata* and *S. muris* (Figures 1, 3, 13, 19, 21, 34, 35). The male reproductive system of *A. tetraptera* is also monarchic, flexed over the anterior third of the intestine and leads posteriorly to a narrow vas deferens which forms an ejaculatory duct that unites with the posterior part of intestine to open with the cloacal opening (Figure 41).

The posterior end of the body cuticle of *A. tetraptera* extends to form two paired smooth caudal alae (one precloacal and the other postcloacal, both lacking in *S. obvelata* and *S. muris*) (Figures 44, 56, 57, 58). At the postcloacal region, the caudal alae appear formed of two or three lobes on both sides (Figures 56, 58). Unlike *S. obvelata* and *S. muris*, a spicule and a gubernaculum are lacking.

Female worms:

The body cuticle of females is transversely annulated, however the surface topography of these annulations varied in the three reported species. In *S. obvelata*, the annulations of the anterior two thirds of the body is longitudinally ridged (Figure 9). In *S. muris* the annulations seperate bands of longitudinal striations (Figures 29, 31). In *A. tetraptera* the annulations are elaborately wrinkled (Figures 51, 52).

In female *S. obvelata* and *S. muris* the uterus fills the body and is packed with eggs that obscure the rest of the genitalia (Figures 2, 20). In *S. obvelata*, the vagina vera gives rise to a muscular ovijector that opens ventrally by the vulva, which appears by SEM as tetraradiate and surrounded with two anterior and two posterior fleshy lips that protrude above the surface of body cuticle (Figures 6, 15), while that of *S. muris* is a small slit-like aperture guarded by two lips that unlike *S. obvelata* do not protrude above the body surface (Figure 24). A corrugate plug-like structure "vaginal plug" occludes the vulva as a characteristic feature of inseminated females (Figure 37).

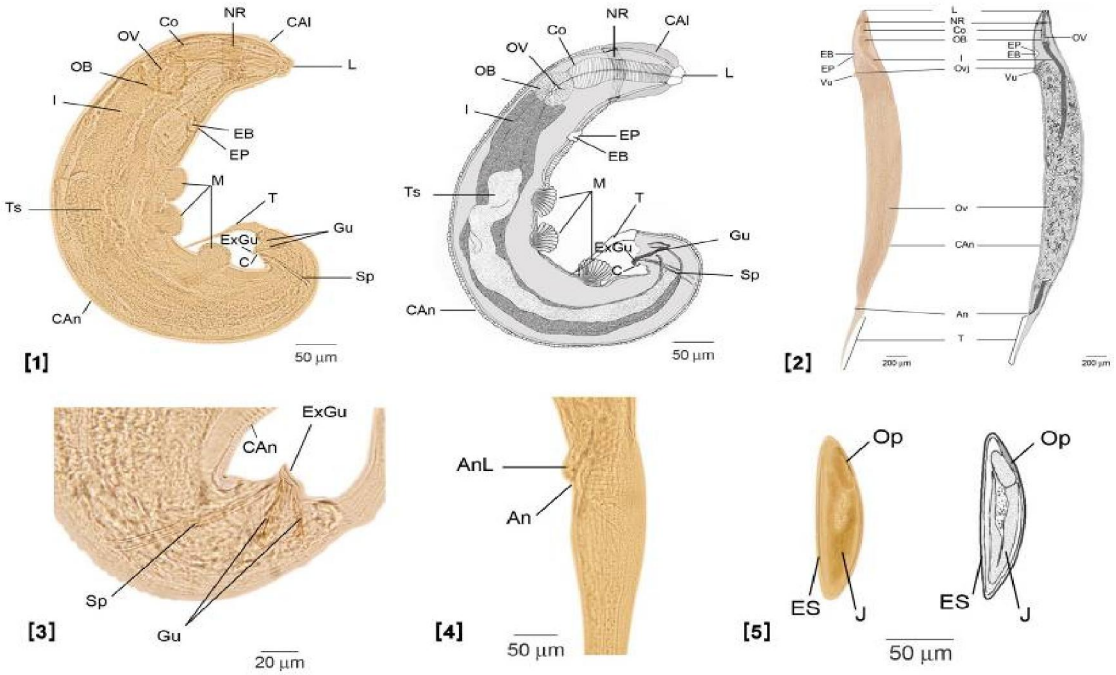
A. tetraptera is of the di-prodelphic type where it is formed of two anterior parallel ovaries which are flexed over the proximal part of the intestine. Each ovary extends posteriorly to reach a uterus (Figure 43). The two posterior parallel uteri are filled with eggs. The vagina uterina, formed by the union of the distal ends of the two uteri, extends anteriorly to reach the muscular ovijector (= vagina vera) that opens ventrally by the vulva which is guarded by an anterior

lip (Figure 55); distinct from that of *S. obvelata* and *S. muris*.

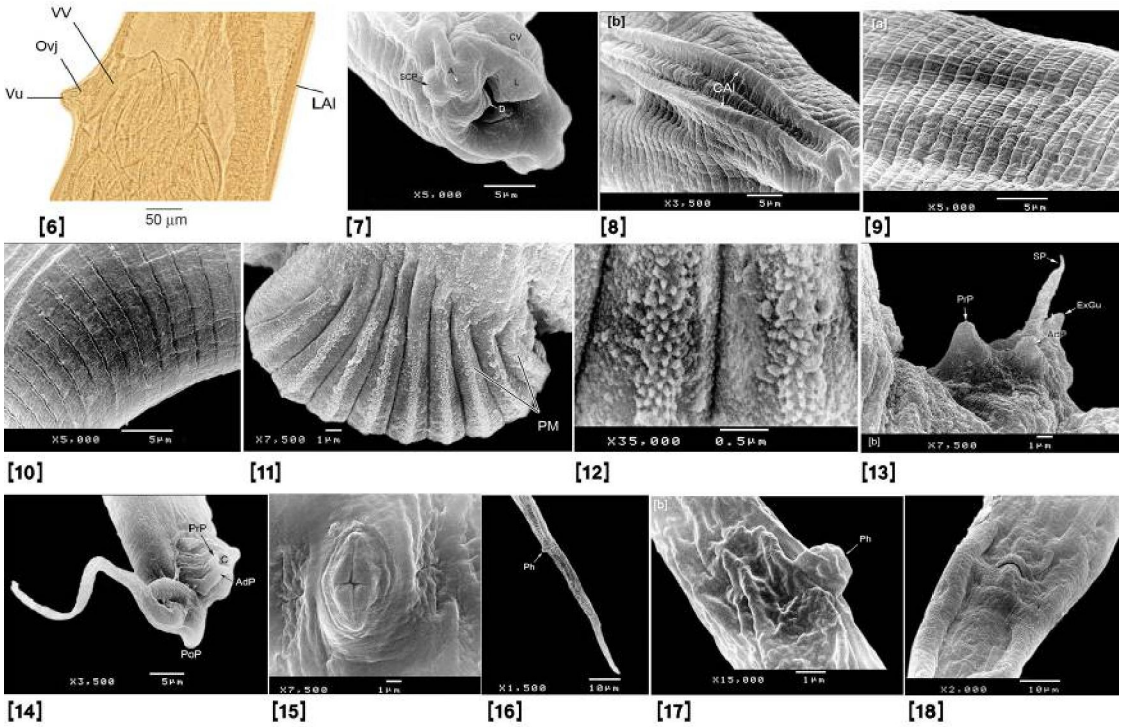
Eggs of *S. obvelata* and *S. muris* are of the typical oxyurid type being elliptical, long, flattened at one side, but convex at the other side with an oval shaped operculum at one pole of the curved side. They are surrounded with fine double walled shell (Figures 5, 25). *S. obvelata* egg encloses first stage larvae, while that of *S. muris* may be unembryonated or contain first stage larvae. The egg of *A. tetraptera* is unoperculated, smooth and may contain morula or first stage larvae (Figures 45, 46).

SEM shows the anal opening of the three pinworms as transverse to crescent shaped opening guarded by an anterior lip-like fold (Figures 4, 39). The cuticular surface of the tail is irregularly ridged in *S. obvelata* and *S. muris* (Figures 18, 39) rather than transversely striated in *A. tetraptera* (Figure 60). Phasmid-like structures are seen in both *S. obvelata* and *S. muris* at 0.044 and 0.006 respectively from the tip of the tail (Figures 16, 17 and 40), but not observed in *A. tetraptera.*

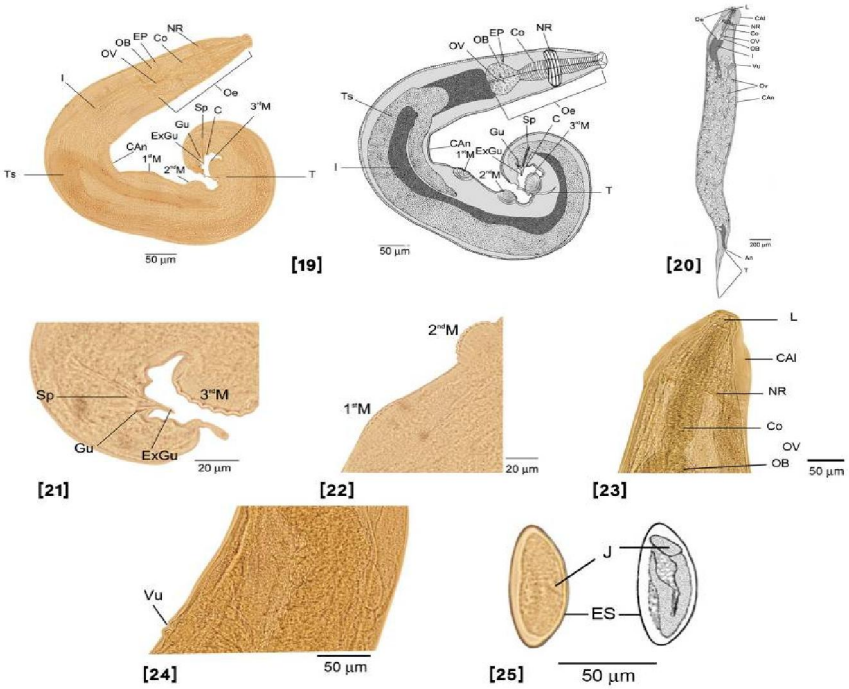
Morphometric comparison between female *S. obvelata* recovered from different hosts revealed statistical significance differences in egg length, bulb length, bulb width, and corpus length as tested by one way ANOVA (P= 0.0003; 0.014; 0.041; and 0.0003 respectively). Male *S. muris* collected from the black house rats and lesser short tailed gerbils revealed significant differences in total body length, distance of nerve ring from anterior extremity, gubernaculum length, and spicule length when tested by *t*-test (P= 0.012, 0.008, 0.046, and 0.015 respectively). Applying ANOVA test, female *S. muris* recovered from different hosts revealed significant differences in the distance of excretory pore from anterior extremity, cervical alae length, total oesophageal length, bulb width of oesophagus, width of eggs, and tail length (P= 0.003, 0.029, 0.003, 0.028, 0.001, and 0.002 respectively). Male *A. tetraptera* collected from different wild rodents revealed significant differences in the body length, oesophageal bulb width, and tail (P= 0.035, 0.0003, and 0.010 respectively) by applying ANOVA test. *A. tetraptera* recovered from different hosts revealed significant difference in distance of vulva opening from anterior extremity, cervical alae length, oesophageal bulb width, egg length and egg width by using ANOVA test (p= 0.004, 0.029, 0.033, 0.0001, and 0.0009 respectively).

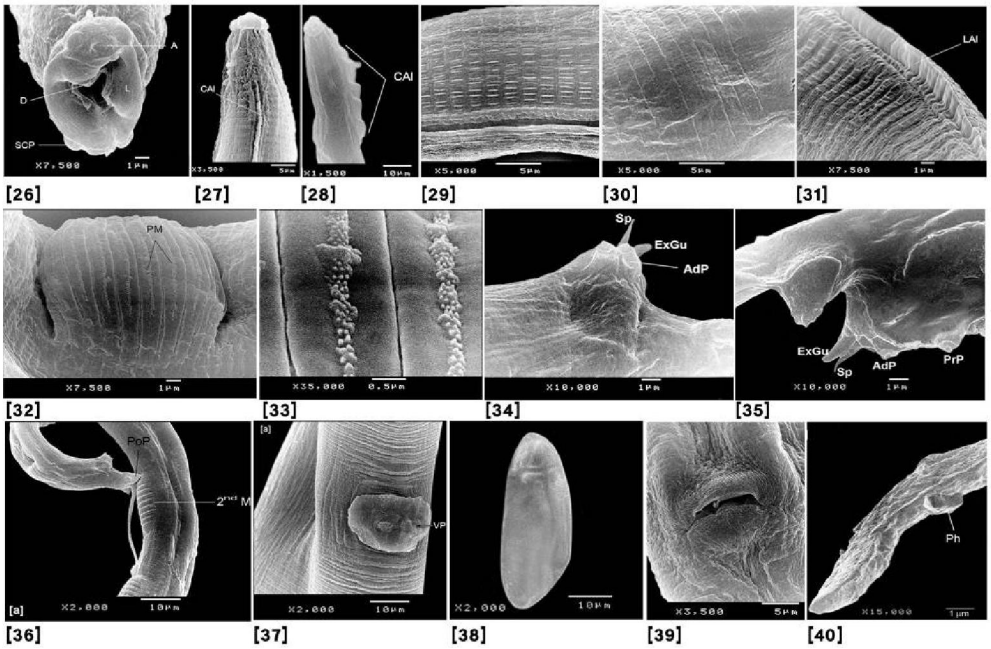


Figures 1-6: Photomicrographs and camera Lucida drawings of *S. obvelata* from house mice. **Fig. 1:** Male *Syphacia obvelata*; **2)** female *Syphacia obvelata*; **3)** posterior region of male; **4)** posterior part of female showing anus; **5)** egg; **6)** protruded vulva of female.



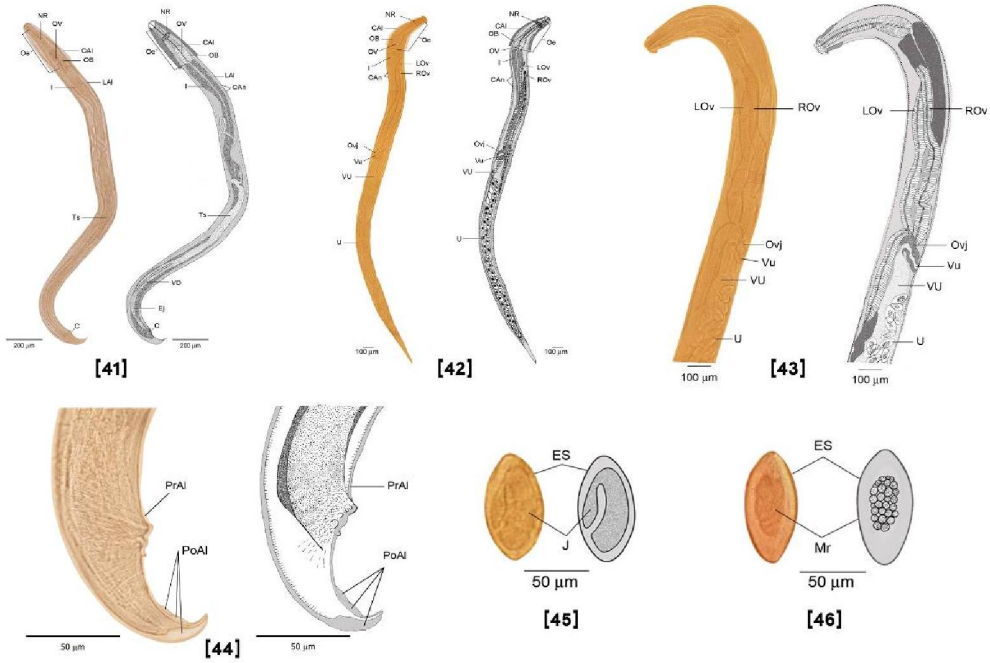
Figures 7-18: Scanning electron micrographs of *S. obvelata* from house mice. **7)** enface view of mature female; **8)** anterior extremity of annulated cervical alae in continuity with the cuticular transverse annulations mature female; **9)** transverse annulations of mature female; **10)** cuticular transverse annulations of mature male; **11)** anterior mamelon of mature male; **12)** papillae arranged in five columns along the midline on each transverse stria mature male; **13)** extruded gubernaculum, spicule and cloacal papilae of mature male; **14)** posterior end of mature male showing cloacal papillae; **15)** tetraradiate vulva of female; **16) and 17)** phasmid-like structures of mature female; **18)** crescent shaped anal opening mature female.



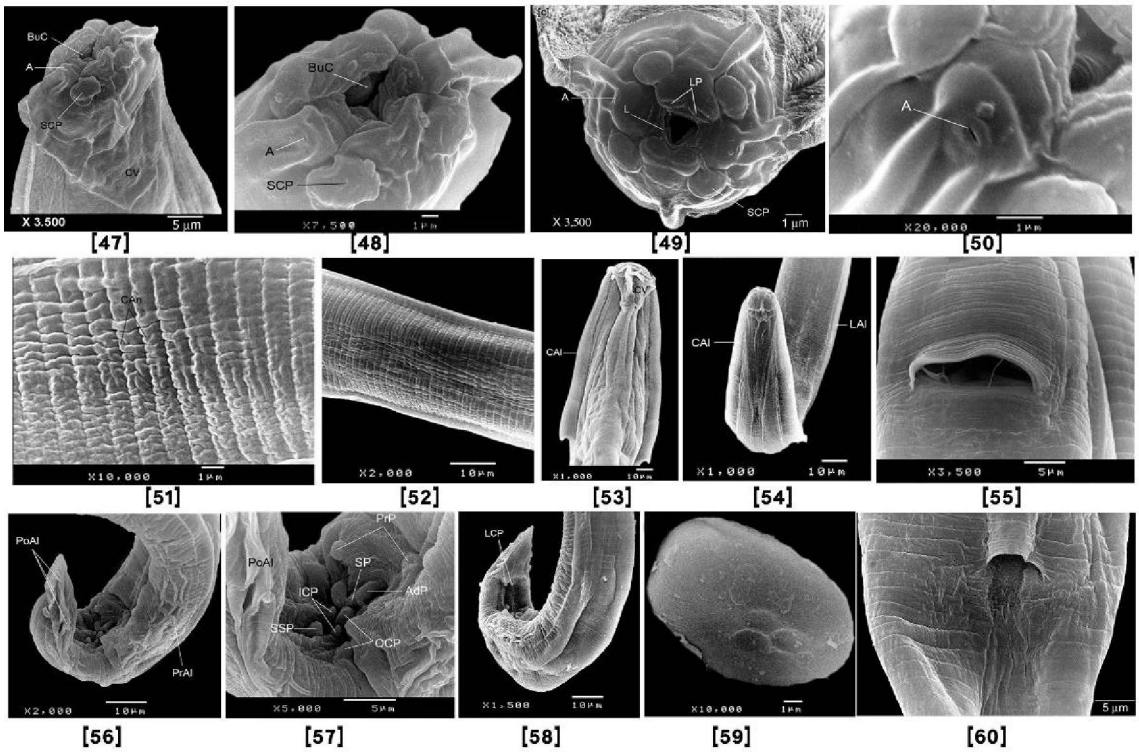


Figures 19-25: Photomicrographs and camera Lucida drawing of *S. muris* from black house rat; figures **19)** male *Syphacia muris*; **20)**female *Syphacia muris*; **21)** posterior end of male showing extruded gubernaculum and spicule; **22)** the first mamelon (1st M) formed of eight prominent transverse striae, while the second mamelon (2nd M) formed of nine transverse striae; **23)** anterior extremity of mature female; **24)** unprotruded upper and lower lip of vulva of female; **25)** egg enclosing juvenile.

Figures 26-40: Scanning electron micrographs of *S. muris* from black house rat**; 26)** enface view of mature female; **27) and 28**) anterior extremity showing cervical alae from anterior extremity of mature female; **29) and 30)** cuticular annulations of mature female; **31)** cuticular annulations of mature male; **32)** anterior mamelon of mature male; **33)** anterior mamelon of mature male showing papillae arranged in two to three columns along the midline on each transverse stria; **34), 35) and 36**) posterior extremity of mature male showing extruded gubernaculum, single sharp spicule, and cloacal papillae; **37)** female showing vaginal plug arrow; **38)** egg; **39**) anal opening of female; **40)** phasmid-like structures in female.



Figures 41-46: Photomicrographs and camera Lucida drawing of *A. tetraptera* from black house rat**. 41)** mature male; **42)** lateral view of mature female; **43)** anterior end of female showing reproductive system; **44)** posterior end of male showing pre-cloacal alae and double lobes of post-cloacal alae; **45) and 46)** egg containing juvenile and egg containing morula.



Figures 47-60: Scanning electron micrographs of *A. tetraptera* from black house rat. **47)** anterior region showing buccal cavity and hexagonal mouth opening; **48)** cephalic plate; **49)** enface view showing triangular mouth opening, rudimental lips, each with two labial papillae, and four submedian cephalic papillae; **50)** amphidial pores situated between two cephalic papillae on an elevated cuticular structure that extends posteriorly forming two longitudinal cuticular folds; **51)** elaborately wrinkled cuticular annulations; **52)** longitudinal ridges extend traversing the transverse annulations of the second and third quarters of the body; **53)** cervical alae with spear-head shaped free end; **54)** narrow lateral alae that commence at a distance of 0.028 mm behind the posterior end of the cervical alae; **55)** vulva of female; **56), 57)** posterior end of male showing cloacal papillae and caudal alae; **58)** posterior end of male showing post-cloacal alae arround the tip of tail; **59)** egg ; 6**0)** anal opening of female.

Table (1): Prevalence, intensity and abundance of pinworms recovered from different wild and laboratory rodent hosts.

rodent hosts	pinworms	number of hosts examined	Number of hosts infected	prevalence %	sSum	intensity		abundance	
						mean ± SD	range	mean ± SD	range
Nile rat	Syphacia obvelata	39	0	0	0	0	0	0	0
	Syphacia muris	39	2	5.12%	13	6.5±7.7	1-12	0.33±1.9	0-12
	Aspiculuris tetraptera	39	0	0	0	0	0	0	0
Brown rat	Syphacia obvelata	40	2	5%	12	65.65	2-10	0.3±1.6	0-10
	Syphacia muris	40	3	7.5%	10	3.33±1.15	2-4	0.25±0.9	0-4
	Aspiculuris tetraptera	40	0	0	0	0	0	0	0
Black house rat	Syphacia obvelata	57	2	3.5%	10	54.24	2-8	0.17±1.08	0-8
	Syphacia muris	57	22	38.59%	569	24.8±335	1-127	9.98±25	0-127
	Aspiculuris tetraptera	57	6	10.52%	41	6.83±5.91	1-17	0.17±2.7	0-17
house mouse	Syphacia obvelata	55	23	41.81%	643	27.1±45.6	1-223	11.3±32.1	0-223
	Syphacia muris	55	14	25.45%	137	9.7±12.4	1-45	2.4±7.4	0-45
	Aspiculuris tetraptera	55	1	1.75%	4	40	4	0.07±0.53	0-4
lesser short tailed gerbil	Syphacia obvelata	68	22	32.35%	281	12.7±11.9	1-40	4.13±8.99	0-40
	Syphacia muris	68	4	5.88%	72	18±16.43	2-35	1.05±5.5	0-35
	Aspiculuris tetraptera	68	0	0	0	0	0	0	0
white experimental rat	Syphacia obvelata	30	6	20%	72	12±5.21	5-20	2.4±5.3	0-20
	Syphacia muris	30	18	60%	1164	64.66±20.37	18-100	38.8±35.79	0-100
	Aspiculuris tetraptera	30	13	43.33%	283	21.76±10.06	6-35	9.43±12.74	0-35
white experimental mice	Syphacia obvelata	17	12	70.58%	497	41.41±17.92	21-80	29.23±24.48	0-80
	Syphacia muris	17	0	0	0	0	0	0	0
	Aspiculuris tetraptera	17	0	0	0	0	0	0	0

Table (2): Morphometric characteristics of female *Aspiculuris tetraptera* recovered from different wild and laboratory rodents.

HOST / Aspect		HOUSE RAT		HOUSE MOUSE		WHITE RAT		Total range
		Mean±SD (No.)	Range	Mean±SD (No.)	Range	Mean±SD (No.)	Range	
Body length		2.80±0.341(14)	2.14-3.2	3.83±0.403(2)	3.55-4.12	2.44±0.437(20)	1.69-3.17	1.69-4.12
Body width (at the level of the vulva)		0.139±0.014(14)	0.12-0.157	0.244±0.062(2)	0.199-0.288	0.107±0.014 (20)	0.072-0.135	0.072-0.288
Distance from anterior extremity	Nerve ring	0.121±0.019(14)	0.094-0.149	0.145±0.002(2)	0.144-0.147	0.128±0.03(20)	0.081-0.180	0.081-0.180
	Excretory pore	0.23±0.022(2)	0.22-0.25	Not observed		0.371±0.183(4)	0.171-0.585	0.171-0.585
	vulval opening**	1.17± 0.271(14)	0. 99-1.7**	1.71±0.21(2)	1.56-1.86**	1.12±0.183(20)	0.91-1.82**	0.099-1.86
Cervical alae length**		0.131±0.044(14)	0.063-0.189**	0.357±0.072(2)	0.306-0.409**	0.157±0.06(20)	0.09-0.306**	0.063-0.409
Cervical alae width*		0.020±0.004(14)	0.0135-0.027	0.022±0.006(2)	0.018-0.027	0.020±0.004(20)	0.0135-0.027	0.0135-0.027
Total oesophagus length		0.334±0.053(14)	0.243-0.405	0.35±0.038(2)	0.328-0.382	0.319±0.039(20)	0.279-0.459	0.243-0.459
Oesophageal bulb length		0.122±0.013(14)	0.099-0.139	0.108±0(2)	0.108	0.112±0.021(20)	0.072-0.162	0.072-0.162
Oesophageal bulb width**		0.08±0.015(14)	0.063-0.108**	0.081±0(2)	0.081**	0.069±0.009(20)	0.054-0.081**	0.054-0.108
Oesophageal corpus length		Absent		Absent		Absent		Absent
Tail length from anal opening to tip of tail		0.63±0.121(14)	0.378-0.860	0.393±0.016(2)	0.382-0.405	0.409±0.056(20)	0.288-0.504	0.288-0.860
Egg size**		0.121±0.004(50) ×0.062±0.008(50)	0.113-0.131 ×0.048-0.094**	0.122±0.008(4) ×0.06±0.008(4)	0.115-0.129 ×0.054-0.072**	0.111±0.015(30) ×0.050±0.02(30)	0.072-0.13 ×0.028-0.140**	0.072-0.131 ×0.028-0.140
Oesophagus length: Body length		1:8.38		1:10.94		1:7.64		1:1.764 -1:10.94

NO.: Number of individual measurements. *At the level where the oesophageal bulb joins the anterior tubular part of oesophagus; **: = Significant

Table (3): Morphometric characteristics of male *Aspiculuris tetraptera* recovered from different wild and laboratory rodents.

HOST / Aspect		BLACK HOUSE RAT		HOUSE MOUSE		WHITE RAT		Total range
		Mean ± SD (No.)	Range	Mean±SD (No.)	Range	Mean±SD (No.)	Range	
Body length**		2.02±0.252(8)	1.49-2.27**	2.56±0.014(2)	2.55-2.57**	1.95±0.304(9)	1.48-2.397**	1.48-2.57
Body width (at the middle of body)		0.109±0.027(8)	0.076-0.154	0.088±0(2)	0.088	0.089±0.011(9)	0.072-0.108	0.076-0.154
Distance from anterior extremity	Nerve ring	0.108±0.012(8)	0.0945-0.126	0.145±0.002 (2)	0.144-0.147	0.117±0.023(7)	0.081-0.153	0.081-0.153
	Execratory pore	0.193±0.108(2)	0.117-0.270	Not observed		Not observed		0.117-0.270
Cervical alae length		0.159±0.070(8)	0.103-0.274	0.266±0.015(2)	0.255-0.277	0.166±0.091(9)	0.076-0.288	0.076-0.288
Cervical alae width*		0.019±0.004(8)	0.0135-0.027	0.022±0.006(2)	0.018-0.027	0.02±0.003(9)	0.0135-0.027	0.0135-0.027
Total oesophagus length		0.289±0.049(8)	0.252-0.406	0.44±0.007(2)	0.439-0.450	0.255±0.026(8)	0.216-0.297	0.216-0.450
Oesophageal bulb length		0.118±0.034(8)	0.0855-0.172	0.24±0(2)	0.244	0.100±0.004(8)	0.0945-0.108	0.085-0.244
Oesophageal bulb width**		0.062±0.011(8)	0.049-0.079**	0.08±0.007(2)	0.077-0.088**	0.046±0.005(8)	0.0405-0.058**	0.0405-0.088
Oesophageal corpus length		Absent		Absent		Absent		Absent
Distance from anterior extremity	1st mamelon	Absent		Absent		Absent		Absent
	2nd mamelon	Absent		Absent		Absent		Absent
	3rd mamelon	Absent		Absent		Absent		Absent
Distance from cloacal opening	1st mamelon	Absent		Absent		Absent		Absent
	2nd mamelon	Absent		Absent		Absent		Absent
	3rd mamelon	Absent		Absent		Absent		Absent
Gubernaculum length		Absent		Absent		Absent		Absent
Spicule length		Absent		Absent		Absent		Absent
Tail length from anal opening to tip of tail**		0.136±0.04(8)	0.094-0.198**	0.132±0.016(2)	0.12-0.144**	0.088±0.015(9)	0.054-0.108**	0.054-0.198
Post caudal alae length		0.054±0.012(8)	0.0396-0.073	0.064±0(2)	0.0648	0.045±0.008(9)	0.027-0.054	0.027-0.073
Oesophagus length: Body length		1:6.9		1:5.81		1:7.64		1:5.81-1:7.64

NO.: number of individual measurements. *At the level where the oesophageal bulb joins the anterior tubular part of oesophagus. **: = Significant

Table (4): Morphometric characteristics of male *Syphacia obvelata* recovered from house mouse.

HOST / ASPECT		HOUSE MOUSE	
		MEAN±SD (No.)	RANGE
Body length		0.677±0.234(8)	0.432-1.09
Body width (point ant. to foremost mamelon)		0.108±0.028(8)	0.067-0.150
Distance from anterior extremity	Nerve ring	0.065±0.028(8)	0.040-0.126
	Excretory pore	0.134±0.043(8)	0.099-0.220
Cervical alae length		0.137±0.022(6)	0.095-0.153
Cervical alae width		—	—
Total oesophagus length		0.174±0.065(8)	0.122-0.300
Oesophageal bulb length		0.047±0.022(8)	0.027-0.090
Oesophageal bulb width		0.037±0.014(8)	0.016-0.064
Oesophageal corpus length		0.037±0.010(8)	0.016-0.045
Distance from anterior extremity	1st mamelon	0.242±0.064(8)	0.157-0.315
	2nd mamelon	0.300±0.134(8)	0.202-0.441
	3rd mamelon	0.393±0.134(8)	0.252-0.612
Distance from cloacal opening	1st mamelon	0.287±0.115(8)	0.153-0.504
	2nd mamelon	0.215±0.097(8)	0.108-0.387
	3rd mamelon	0.106±0.059(8)	0.058-0.207
Gubernaculum length		0.036±0.006(8)	0.030-0.048
Spicule length		0.073±0.015(8)	0.058-0.097
Tail length*		0.105±0.009(8)	0.094-0.117
Caudal alae length		Absent	
Esophagus length: Body length		1:3.8	

NO.: Number of individual measurements. *: from cloacal opening to tip of tail.

Table (5): Morphometric characteristics of male *Syphacia muris* recovered from different wild and laboratory rodents.

HOST aspect		BROWN RAT		Black HOUSE RAT		LESSER SHORT TAILED GERBIL		Total range
		Mean±SD (No.)	Range	Mean±SD (No.)	Range	Mean±SD (No.)	Range	
Body length**		0.814±0(1)	0.814	1.038±0.046(4)	0.99-1.1**	1.24±0.097(3)	1.16-1.35**	0.814-1.35
Body width (point ant. to foremost mamelon)		0.045±0(1)	0.045	0.079±0.023(4)	0.054-0.11	0.099±0.015(3)	0.084-0.115	0.045-0.115
Distance from anterior extremity	Nerve ring**	0.072±0(1)	0.072	0.089±0.014(4)	0.076-0.109**	0.126±0.004(3)	0.122-0.131**	0.076-0.131
	Excretory pore	0.126±0(1)	0.126	0.149± 0.025(4)	0.128-0.18	0.175±0.011(3)	0.162-0.183	0.126-0.183
Cervical alae length		Absent		Absent		Absent		Absent
Cervical alae width		Absent		Absent		Absent		Absent
Total oesophagus length		0.121±0(1)	0.121	0.156±0.057(4)	0.112-0.241	0.253±0.115(3)	0.13-0.36	0.112-0.360
Oesophageal bulb length		0.036±0(1)	0.036	0.034±0.021(4)	0.036-0.054	0.040±0.012(3)	0.027-0.05	0.027-0.054
Oesophageal bulb width		0.031±0(1)	0.036	0.032±0.022(4)	0.036-0.054	0.040±0.012(3)	0.027-0.05	0.027-0.054
Oesophageal corpus length		0.027±0(1)	0.027	0.032±0.004(4)	0.027-0.036	0.022±0.008(3)	0.013-0.027	0.013-0.036
Distance from anterior extremity	1st mamelon	0.27±0(1)	0.27	0.321±0.0327(4)	0.279-0.355	0.338±0.002(3)	0.337-0.342	0.27-0.355
	2nd mamelon	0.369±0(1)	0.369	0.406±0.030(4)	0.382-0.45	0.396±0.031(3)	0.36-0.414	0.360-0.450
	3rd mamelon	0.504±0(1)	0.504	0.497 ±0.042(4)	0.445-0.549	0.534±0.005 (3)	0.531-0.54	0.445-0.549
Distance from cloacal opening	1st mamelon	0.225±0(1)	0.225	0.269±0.115(4)	0.18-0.439	0.408±0.080(3)	0.329-0.49	0.225-0.490
	2nd mamelon	0.171±0(1)	0.171	0.166±0.091(4)	0.099-0.3006	0.292±0.064(3)	0.218-0.329	0.099-0.329
	3rd mamelon	0.063±0(1)	0.063	0.075±0.055(4)	0.045-0.158	0.144±0.010(3)	0.132-0.15	0.045-0.158
Gubernaculum length**		0.028±0(1)	0.028	0.037±0.004(4)	0.032-0.041**	0.045±0.004(3)	0.043-0.050**	0.028-0.050
Spicule length**		0.057±0(1)	0.057	0.064±0.010(4)	0.057-0.0792**	0.090±0.007(3)	0.084-0.099**	0.057-0.099
Tail length*		0.166±0(1)	0.166	0.156±0.036(4)	0.104-0.189	0.123±0.009(3)	0.113-0.132	0.113-0.189
Caudal alae length		Absent		Absent		Absent		Absent
Oesophagus length: Body length		1:6.7		1:6.65		1:4.9		1:4.9-1:6.7

No.: Number of individual measurements. *: from cloacal opening to tip of tail; **: =Significant difference

Table (6): Morphometric characteristics of female *Syphacia muris* recovered from different wild and laboratory rodents.

HOST Aspect		nile rat		BROWN RAT		HOUSE rat		HOUSE MOUSE		LESSER SHORT TAILED GERBIL		White rat		Total range
		Mean± SD (No.)	Range	Mean± SD (No.)	Range	Mean± SD (No.)	Range	Mean± SD (No.)	Range	Mean± SD (No.)	Range	Mean± SD (No.)	Range	
Body length		2.69±0.845(5)	2.28-4.21	2.70±0.784(6)	1.59-3.56	2.38±0.599(32)	1.33-3.88	2.62±0.943(11)	1.72-4.86	2.701±0.891(14)	1.12-4.21	2.03±0.539(15)	1.15-2.88	1.12-4.86
Body width (at the level of the vulva)		0.136±0.027(5)	0.117-0.184	0.164±0.040(6)	0.108-0.229	0.159±0.042(31)	0.081-0.25	0.131±0.044(11)	0.067-0.229	0.119±0.029(13)	0.085-0.171	0.142±0.036(15)	0.081-0.198	0.067-0.250
Distance from anterior extremity	Nerve ring	0.096±0.046(5)	0.014-0.126	0.112±0.024(6)	0.081-0.148	0.11±0.043(33)	0.058-0.094	0.098±0.028(11)	0.063-0.148	0.135±0.022(14)	0.108-0.18	0.111±0.021(15)	0.081-0.153	0.0149-0.180
	Excretory pore**	0.292±0.053(5)	0.235-0.369**	0.424±0.081(6)	0.328-0.54**	0.313±0.049(23)	0.243-0.423**	0.343±0.079(11)	0.266-0.54**	0.352±0.088(11)	0.153-0.468**	0.386±0.081(15)	0.198-0.468**	0.153-0.540
	Vulval opening	0.461±0.207(5)	0.333-0.819	0.622±0.111(6)	0.47-0.76	0.551±0.134 (29)	0.36-0.909	0.509±0.124(11)	0.346-0.76	0.562±0.076(12)	0.445-0.697	0.594±0.111(15)	0.414-0.828	0.333-0.909
Cervical alae length**		0.104±0.036(5)	0.076-0.147**	0.161±0.053(6)	0.121-0.261**	0.179±0.067(21)	0.072-0.288**	0.136±0.087(11)	0.018-0.27**	0.105±0.057(14)	0.045-0.222**	0.159±0.068(15)	0.026-0.27**	0.018-0.288
Cervical alae width		—	—	—	—	—	—	—	—	—	—	—	—	—
Total oesophagus length**		0.285±0.042(5)	0.261-0.36**	0.257±0.069(6)	0.189-0.383**	0.219±0.038(31)	0.162-0.324**	0.243±0.056(11)	0.171-0.383**	0.255±0.025(14)	0.208-0.297**	0.220±0.035(15)	0.162-0.274**	0.162-0.383
Oesophageal bulb length		0.094±0.032(5)	0.06-0.13	0.064±0.011(6)	0.049-0.081	0.055±0.009(19)	0.045-0.091	0.067±0.015(11)	0.054-0.099	0.064±0.011(14)	0.045-0.095	0.057±0.012(15)	0.036-0.081	0.036-0.130
Oesophageal bulb width**		0.138±0.101(5)	0.063-0.133**	0.066±0.017(6)	0.045-0.093**	0.071±0.022(22)	0.049-0.126**	0.070±0.023(11)	0.049-0.122**	0.059±0.013(13)	0.045-0.095**	0.056±0.010(15)	0.04-0.081**	0.040-0.133
Oesophageal corpus length		0.109±0.015(5)	0.099-0.131	0.052±0.006(6)	0.045-0.063	0.065±0.015(16)	0.031-0.09	0.067±0.014(11)	0.054-0.099	0.061±0.008(13)	0.081-0.049	0.066±0.016(15)	0.045-0.09	0.031-0.099
Tail length*		0.630±0.098(5)	0.55-0.799**	0.405±0.138(6)	0.283-0.59**	0.466±0.132(33)	0.112-0.896**	0.543±0.309(11)	0.328-1.42**	0.555±0.11(13)	0.468-0.738**	0.354±0.084(15)	0.234-0.549**	0.112-0.799
Egg size (length × width**)		0.161±0.007 × 0.045±0.002(13)	0.144-0.169 × 0.039-0.05	0.117±0.021 × 0.040±0.004(7)	0.1-0.162 × 0.036-0.046	0.109±0.026 × 0.042±0.005(33)	0.075-0.18 × 0.032-0.054	0.143±0.040 × 0.041±0.006(11)	0.093-0.185 × 0.036-0.054	0.166±0.018 × 0.039±0.007(8)	0.133-0.18 × 0.028-0.050	0.094±0.014 × 0.034±0.008(11)	0.064-0.108 × 0.028-0.054	0.064-0.185 × 0.036-0.054
Oesophagus length: Body length		1:9.4		1:10.5		1:10.96		1:10.78		1:10.58		1:9.22		1:9.22 - 1:10.96

No.: number of individual measurements. *: from anal opening to tip of tail; **: = Significant difference

Table (7): Morphometric characteristics of female *Syphacia obvelata* recovered from different wild and laboratory rodents.

HOST Aspect		BROWN RAT		HOUSE RAT		HOUSE MOUSE		LESSER SHORT TAILED GERBIL		White rat		WHITE MOUSE		Total range
		Mean±SD (No.)	Range	Mean±SD (No.)	Range	Mean±SD (No.)	Range	Mean±SD (No.)	Range	Mean±SD (No.)	Range	Mean±SD (No.)	Range	
Body length		2.136±0.740(9)	1.487-3.79	2.168±0.542(9)	1.154-2.87	2.12±0.596 (15)	1.443-3.14	4.024±0.945(19)	1.498-5.25	2.92±0.988(4)	1.48-3.71	1.96±0.594(9)	1.443-3.08	1.15-5.25
Body width (at the level of the vulva)		0.151±0.043(9)	0.112-0.25	0.194±0.044(9)	0.14-0.245	0.037±0.007 (15)	0.081-0.252	0.166±0.047 (19)	0.103-0.310	0.119±0.028(4)	0.093-0.157	0.1663±0.042(9)	0.13-0.252	0.081-0.310
Distance from anterior extremity	Nerve ring	0.161±0.033(9)	0.103-0.194	0.160±0.073(9)	0.081-0.234	0.081±0.024(15)	0.0405-0.14	0.165±0.055(17)	0.097-0.31	0.122±0.029(4)	0.085-0.153	0.082±0.026(9)	0.063-0.14	0.0405-0.31
	Excretory pore	0.294±0.031(9)	0.247-0.36	0.247±0.067(9)	0.193-0.369	0.260±0.056(11)	0.175-0.369	0.401±0.107(16)	0.18-0.531	0.275±0.158(4)	0.126-0.45	0.251±0.059(9)	0.175-0.369	0.126-0.531
	vulval opening	0.412±0.040 (9)	0.337-0.472	0.388±0.105(9)	0.225-0.52	0.401±0.105(12)	0.279-0.585	0.624±0.110(17)	0.344-0.78	0.404±0.165(4)	0.247-0.603	0.40±0.109(9)	0.279-0.585	0.225-0.780
Cervical alae length		0.104±0.023(9)	0.054-0.118	—	—	0.052±0.021(12)	0.022-0.081	0.081±0.018(15)	0.045-0.115	0.064±0.019(4)	0.054-0.094	0.051±0.022(9)	0.022-0.081	0.022-0.115
Cervical alae width		—	—	—	—	—	—	—	—	—	—	—	—	—
total oesophagus length		0.264±0.022(9)	0.234-0.315	0.267±0.142(9)	0.079-0.61	0.233±0.036(15)	0.162-0.29	0.340±0.055(22)	0.234-0.45	0.255±0.045(4)	0.189-0.288	0.229±0.032(9)	0.18-0.29	0.079-0.450
Oesophageal bulb length**		0.076±0.018(9)	0.05-0.092**	0.064±0.003(9)	0.058-0.067**	0.065±0.020(15)	0.0405-0.118**	0.090±0.029(22)	0.054-0.17**	0.066±0.011(4)	0.054-0.076**	0.069±0.024 (9)	0.045-0.118**	0.040-0.170
Oesophageal bulb width**		0.078±0.013(9)	0.054-0.092**	0.070±0.006(9)	0.063-0.085**	0.065±0.018(15)	0.0405-0.118**	0.085±0.024(14)	0.054-0.15**	0.060±0.010(4)	0.049-0.072**	0.068±0.021(9)	0.049-0.118**	0.0405-0.150
Oesophageal corpus length**		0.084±0.017(9)	0.058-0.104**	0.079±0.003(9)	0.063-0.081**	0.063±0.017(12)	0.023-0.094**	0.113±0.048(14)	0.07-0.199**	0.070±0.007 (4)	0.063-0.081**	0.066±0.009(9)	0.054-0.081**	0.023-0.199
Tail length*		0.396±0.148(9)	0.216-0.666	0.498±0.091(9)	0.382-0.612	0.432±0.103(13)	0.3195-0.576	0.727±0.140(20)	0.44-0.9	0.47±0.108(4)	0.351-0.571	0.455±0.099(9)	0.319-0.576	0.216-0.900
Egg size**		0.18±0 - 0.047 ±0.003(4)	0.18** ×0.043 -0.05	0.17±0.01 - 0.044±0.003(9)	0.16-0.18** ×0.037 -0.046	—	—	0.126±0.03 - 0.031±0.009(20)	0.087-0.18** ×0.02-0.05	0.228±0.134 - 0.041±0.003(10)	0.126-0.483** ×0.036 -0.046	0.103±0.006 ×0.024±0.001(10)	0.087-0.11** ×0.022 -0.027	0.087-0.483 ×0.037-0.050
Oesophagus length: Body length		1:8.09		1:8.11		1:8.79		1:11.8		1: 9.3		1:8.2		1:8.09-1:11.8

No.: number of individual measurements. *: from anal opening to tip of tail. **: =Significant difference

4. Discussion

Order Oxyurida incorporates three families namely: Oxyuridae Cobbold, 1864; Pharyngodonidae Travassos, 1919; and Heteroxynematidae (Skrjabin and Schikhobalova, 1948).

Petter and Quentin (2009) and Schmidt (1986) included *Syphacia obvelata* (Rudolphi, 1802) Seurat, 1916 and *Syphacia muris* (Yamaguti, 1935) and 1941 together with twenty two genera in the family Oxyuridae (Cobbold, 1864) and included *Aspiculuris*, together with seven genera in the subfamily Heteroxynematinae (Skrjabin and Schikhobalova, 1948) of the family Heteroxynematidae (Skrjabin and Schikhobalova, 1948).

Members of the subgenus *Syphacia* incorporate helminth species with males possessing three ventral cuticular swellings "mamelons", cephalic papillae near amphids, and members are parasites of Sciuridae, Cricetidae, Gerbillidae, Muridae and Microtidae (Chabaud and Biocca, 1955 and Petter and Quentin, 2009).

Syphacia obvelata and *Syphacia muris* are distinguished from other species of *Syphacia* by structure of the head; shape and size of spicule and gubernaculum, pronounced post-cloacal papillae, length of tail and number and form of mamelons in males; and length of oesophagus, position of vulva, and size of eggs in females (Ogden, 1971).

Species of the genus *Aspiculuris* are characterized by being parasites of Muroidea, the cervical alae are well developed extending into cephalic vesicle, and cuticular striations are poorly marked (Petter and Quentin, 2009), and by possessing three pairs of alae in the tail of males (Hugot, 1988 and Inglis *et al.,* 1990). *Aspiculuris* is one of five subgenera listed by Akhtar (1955) in which the cephalic bulb and lateral alae are present, the cervical alae end in a sickle shaped margins, but the cervical and lateral alae are not continuous. Quentin (1975) divided members of genus *Aspiculuris* into two groups based on the shape of the outline of the cervical alae.

The three reported pinworm species agree in most of their characteristics with previous reports. *Syphacia obvelata* reported in the present study coincides to a great extent with the reports of Hussey (1957), Bernard (1963), Ogden (1971), Ashour (1980), Pinto *et al.* (1994), and Hugot (2005). Likewise the structure of *Syphacia muris* coincides with that reported by Yamaguti (1941), Hussey (1957), Ogden (1971), Ow-Yang (1971), Ashour (1980), and Pinto *et al.* (2001); and the description of *Aspiculuris tetraptera* (Nitzsch, 1821) Schultz, 1924 reported in the present study agrees with the reports of Schultz (1924), Yamaguti (1935), Ashour (1980) and Pinto *et al.* (1994).

Slight host induced morphological variations were reported in the present study such as the

significant morphometric variations of *S. obvelata* in egg length, bulb length, bulb width, and corpus length; and also for *Syphacia muris* in the total body length, distance of nerve ring from anterior extremity, gubernaculum length, and spicule length of males from black house rats and lesser short tailed gerbils and the distance of excretory pore from the anterior extremity, cervical alae length, total oesophageal length, bulb width, eggs width, and tail length of females from different hosts. Similarly, in *A. tertaptera,* variations were registered in the body length, oesophageal bulb width, and tail of males and the distant of vulva opening from anterior extremity, cervical alae length, oesophageal bulb width, egg length and egg width of females. These findings indicates that characteristics which demonstrated significant host induced morphometric variations (intraspecific) should not be used in species discrimination, while those that revealed significant interspecific variations are reliable for species identification.

The use of SEM in the present study revealed that presence of cuticular annulations but Riley (1919), Ogden (1971), Dick and Wright (1973) and Ashour (1980) referred to as striations. The term annulation is more accurate, since according to Willmott (1974) annulations refer to deep transverse grooves giving the body a segmented appearance, while striations refer to fine transverse grooves. SEM also revealed that transverse annulations are elaborately wrinkled and that longitudinal ridges traverse the transverse annulations.

The use of SEM also showed the topography of the buccal cavity described by Ogden (1971) and Ashour (1980) as lined with three thickened cuticular plates that are chitinized anteriorly forming tooth-like structures “denticles” in *Syphacia* spp., but not in *A. tetraptera*.

The present study disagrees with the reports of Ashour (1980) and Pinto *et al.* (2001) who described cephalic vesicles in *S. muris*. The present study revealed the presence of cephalic vesicles in *S. obvelata* and *A. tetraptera*, but not in *S. muris*.

Amphidial pores of adult *S. muris* were always associated with spongy-like structures as also described by Tenora *et al.* (1978) and Lewis and D´Silva (1986). Lewis and D´Silva (1986) reported that these spongy areas are also present in fourth stage larva and remains in adult females, but disappear from adult males. They suggested that these structures have chemo-sensitive properties that play a role in the attraction of sexes before copulation.

SEM revealed that *Aspiculuris tetraptera* possess four distinct cephalic papillae lying on the cephalic plate and three small rudimental lips that carry two sessile poorly developed labial papillae. This finding contradicts the reports of Ashour (1980) who reported the absence of labial papillae and that of Schultz (1924) who reported that the cephalic papillae are indistinct. The present study did not report the presence of cervical papillae that were described by Schultz (1924) and Yamaguti (1935).

Three pairs of cloacal papillae were reported in both species of *Syphacia*. In agreement with Ashour (1980) and Pinto *et al.* (1994) twelve papillae were revealed in *A. tetraptera*; on the other hand, Schultz (1924) reported ten and Yamaguti (1935) and Falcon-Ordaz *et al.* (2010) reported fourteen. Phasmid-like structures were illustrated on the tail in female *S. obvelata* and *S. muris.*

The presence of cuticular alae in pinworms is controversial. Ogden (1971) described small cervical alae in both sexes and caudal alae in male *S. muris*, Tenora *et al.* (1978) recorded the absence of both cervical and lateral alae, while Mahmoud *et al.* (2009) reported the presence of cervical alae and absence of lateral alae from females. SEM in the present study revealed the presence of large, distinct cervical alae in female *S. muris* and both sexes of *S. obvelata.* Cervical alae in both sexes of *A. tetraptera* are abruptly interrupted, with the posterior ends pointed to form an acute angle toward the anterior. Lateral alae were prominent in both sexes of *S. muris* and *A. tetraptera* and only in female *S. obvelata*; while caudal alae were only present in male *A. tetraptera*, but absent in both *Syphacia* species. The presence of caudal alae in male *A. tetraptera* is explainable to make for the absence of the spicule and gubernaculum which act as accessory copulatory structures in male *Syphacia*. The present study also revealed the presence of a pair of mid ventral elevated cuticular ridges that extend anteriorly from the cloacal opening along the posterior fifth of the length of *A. tetraptera*.

The three mamelons which function to grasp females during copulation were not equally spaced and the number of transverse striae on each mamelon varies from ten to twelve and each stria appeared ornamented with five columns of small papillae-like structures in *S. obvelata* and eight to nine striae ornamented on the midline with two to three rows of small papillae-like structures in *Syphacia muris*. Ashour (1980) reported that each mamelon is formed of twelve striae, while Ogden (1971) reported that the mamelons are equally spaced and that each stria is split into two elevations (not revealed in the present study) carrying five to seven papillae along the mid line. Dick *et al.* (1973) used the term spines instead of papillae. Further studies are needed to confirm the nature of these structures.

SEM in the present study revealed the structure of the ovijector in S. *obvelata*. The vaginal plug described in the present study was previously reported

by Dick and Wright (1973) in *Syphacia obvelata* as a characteristic feature for inseminated females.

The oesophagus of both *S. obvelata* and *S. muris*, is clearly divided into an anterior cylindrical part, a corpus, and a globular bulb which is supported internally by triradiate valvular apparatus. On the other hand, the structure of the oesophagus of *A. tetraptera* coincides with the description of Inglis *et al.* (1990) as formed of two distinct regions, a long cylindrical muscular anterior part typically of the oxyurid type and a short and stout clavate glandular posterior bulb lined with ridged cuticle that lacks valvular apparatus. This finding disagrees with Ashour (1980) who reported the presence of a valve.

Hussey (1957) differentiated between *S. obvelata* and *S. muris* by the body length of *Syphacia obvelata* being longer than that of *Syphacia muris*; both the excretory opening and vulva lie further anterior in *Syphacia obvelata* than those of *Syphacia muris*; the male tail of *Syphacia obvelata* is smaller than that of *Syphacia muris*. In *Syphacia obvelata* the middle mamelon lie at the middle of body length, while in *Syphacia muris* the anterior mamelon lie close to the middle of the body length; and the egg of *Syphacia obvelata* are larger in length and equal in width to those of *Syphacia muris*. Oldham (1967) distinguished *Syphacia obvelata* from *Aspiculuris tetraptera* by the shape and size of the eggs being asymmetrical, reniform or crescent-shaped with larval stage in *Syphacia obvelata* and almost symmetrical along its axis, spindle shaped with morula stage in *Aspiculuris tetraptera*. The cervical alae are smaller in *Syphacia obvelata* while in *Aspiculuris tetraptera* it is prominent and broad, ending behind the level of the oesophageal bulb. The shape of oesophageal bulb is sub-spherical or globular in *Syphacia obvelata* and club-shaped with oval bulb in *Aspiculuris tetraptera*. The spicule and gubernaculum are present in *Syphacia obvelata* and absent in *Aspiculuris tetraptera*. The position of the vulva of the female at $1/7^{th}$ of the body length from mouth in *Syphacia obvelata*, but more posterior in *Aspiculuris tetraptera*.

The present study contributed to the taxonomy of the three encountered pinworms by using SEM in addition to unstained whole mount techniques to add, reveal and adjust some taxonomic valid characteristics that differentiate between *Aspiculuris tetraptera*, *Syphacia obvelata* and *Syphacia muris*, these are:

- Cephalic vesicles present in *Syphacia obvelata* and *Aspiculuris tetraptera*, but not *Syphacia muris*.
- *Syphacia obvelata* and *Syphacia muris* possess three equal sized fleshy lips without labial papillae, while *Aspiculuris tetraptera* has three poorly developed lips, each with two indistinct labial papillae.
- Two sponge-like structures situated just posterior to the two amphidial pores is a characteristic feature of both sexes of *Syphacia muris* but absent from *Syphacia obvelata* and *Aspiculuris tetraptera*.
- Transverse annulations of female *Syphacia obvelata* traversed by longitudinal ridges; while in *Syphacia muris* the annulations appear with separating bands of longitudinal striations.
- Cervical alae present in both sexes of *Syphacia obvelata* and *Aspiculuris tetraptera*, but only in female *Syphacia muris*. The morphometric data analysis of cervical alae length in females of the three pinworm species varies significantly, being longer in *Aspiculuris tetraptera* recoverd from black house rats than that of *Syphacia obvelata* recovered from wild house mice and *Syphacia muris* from black house rats; and it tapers posteriorly to give characteristic curved spearhead free end.
- Lateral alae in both sexes of *Syphacia muris* and *Aspiculuris tetraptera*, but confined to female *Syphacia obvelata*. In *Aspiculuris tetraptera,* alae continue along the length of body, in contrary to that in *Syphacia obvelata* and *Syphacia muris*, where lateral alae end at the level of anal opening in females and cloacal opening in males.
- Caudal alae present in *Aspiculuris tetraptera*, but lacking in *Syphacia obvelata* and *Syphacia muris*.
- Mamelons are not equally spaced formed of 10-12 transverse striae in *Syphacia obvelata*, 8-9 in *Syphacia muris*, but lacking in *Aspiculuris tetraptera*.
- Papillae-like structures that appear on the mid line of each stria in *Syphacia muris* are fewer and smaller in size compared with that of *Syphacia obvelata*.
- Males of both *Syphacia* species possess a spicule and a gubernaculum supported with an accessory piece capable of extruding, while *Aspiculuris tetraptera* lacks both structures.
- Cloacal papillae of *Syphacia muris* morphologically distinct from those of *Syphacia obvelata*. The three pairs of cloacal papillae are pedunculated in *Syphacia obvelata*, but cone-shaped with a central nipple-like extension encircled with a cuticular collar in *Syphacia muris*.
- Phasmid-like structures in the tail region of females of both *Syphacia* species.
- Tetraradiate ovijector protrude above the surface of the cuticle and opens by vulva guarded by four fleshy lips in *Syphacia obvelata*. Vulva in *Syphacia muris* guarded by two lips, while that of *Aspiculuris tetraptera* has an upper lip only. Position of vulva from anterior extremity is significantly different in different pinworm species.
- Buccal cavity lined with three thickened longitudinal ridges with teeth-like structures in

Syphacia obvelata and *Syphacia muris*, lacking in *Aspiculuris tetraptera.*

- Oesophagus of *Aspiculuris tetraptera* distinct from that of *Syphacia obvelata* and *Syphacia muris*, being formed of two parts rather than three and the bulb clavate rather than globular or subglobular. The clavate bulb of *Aspiculuris tetraptera* lacks the triradiate valve-like apparatus present in both *Syphacia obvelata* and *Syphacia muris*, but the lumen is lined by serrated ridges.
- Eggs of *Aspiculuris tetraptera* are non operculated, while that of both *Syphacia* spp. are operculated.
- Taxonomic validity of the reported statistically significant interspecific morphometrics variations such as the worm and cervical alae length of the three encountered species.
- Taxonomic invalidity of the intraspecific host induced morphological variations.

Explanation of figures

Abbreviations: 1st M= first mamelon, 2nd M= second mamelon, 3rd M= third mamelon, A= amphid, AdP= ad-cloacal papilae, An= Anus, AnL= anal lip, BuC= buccal cavity, C= Cloacal opening, CAl= cervical alae, CAn= cuticular annulation, Co= corpus, CP= cephalic plate, CV= cephalic vesicle, D= denticles, EB= excretory bladder, Ej= ejaculatory duct, EP= excretory pore, ES= egg shell, ExGu= extruded gubernaculum, Gu= gubernaculum, I= intestine, ICP= inner cloacal papillae, J= juvenile, L= lip, LAl= lateral alae, LCP= last caudal papillae, LOv= left ovary, LP= labial papillae, M= mamelon, MO= mouth opening, Mr= morula, NR= nerve ring, OB= oesophageal bulb, OCP= outer cloacal papillae, Oe= oesophagus, Op= operculum, OV= oesophageal valve, Ov= ova, Ovj= ovijector, Ph= phasmid, PM= mamelon papillae, PoAl= post-cloacal alae, PoP= post-cloacal papillae, PrAl= pre-cloacal alae, PrP= pre-cloacal papillae, ROv= right ovary, SCP= sub median cephalic papillae, SP= single papilla, Sp= spicule, SSP= single sessile papilla, T= tail, Ts= testis, U= uterus, VD= vas deferens, VP= vaginal plug, VU= vagina uterina, Vu= vulva, and VV= vagina vera.

References

1. Akhtar, S. A. 1955. On nematode parasites of rats and mice of Lahore. Pakistan Journal of Scientific Research 7: 104-111.
2. Ashour, A. A. 1980. Ultrastructural and other studies on intestinal nematodes of small mammals from Egypt. Thesis, Ain Shams University, Faculty of Science, Department of Zoology, Cairo, Egypt.
3. Baker, D. 1998. Natural pathogens of laboratory mice, rats, and rabbits and their effects on research. Clinical Microbiology Reviews 11: 231-226.
4. Bazzano, T., Restel, T. I., Pinto, R. M., and Gomes, D. C. 2002. Patterns of infection with nematodes *Syphacia obvelata* and *Aspicularis tetraptera* in conventionally maintained laboratory mice. Memorias Do Instituto Oswaldo Cruz 97: 847-853.
5. Bernard, J. 1963. Etudes sur la faune parastaire de Tunisie. I. Nematodes parasites des muridae. Extrait des Archives del Institute Pasteur de Tunis 40: 5-64.
6. Bush, A. O., Lafferty, K. D., Lotz, J. M., and Shostak, A. W. 1997. Parasitology meets ecology on its own terms: Margolis *et al.* revised. Journal of Parasitology 83(4): 575-583.
7. Chabaud, A. G. and Biocca, E. 1955. Vicariances specifiques (et non generiques) chez des oxyures parasites de *Xerus africains*. Description de *Syphacia transafricana* n. sp. Et division du genre *Syphacia* Seurat, 1916. Bulletin of the Zoological Society of France, 80: 124-131.
8. Cobbold, 1864. Quoted from Petter and Quentin (2009).
9. Dick, T. A. and Wright, K. A. 1973. The ultrastructure of the cuticle of the nematode *Syphacia obvelata* (Rudolphi, 1802) Seurat, 1916. I. The body cuticle of larvae, males and females and observations on its development. Candian Journal of Zoology. 51 (2): 187-196.
10. Dick, T. A.; Quentin, J. C.; Freeman, R. S. 1973. Redescription of *Syphacia mesocriceti* (Nematoda: Oxyuroidea) Parasite of the Golden Hamster. *The Journal of Parasitology*, 59 (2): 256-259.
11. Falcón-Ordaz, J., Pulido-Flores, G., and Monks, S. 2010. New species of *Aspiculuris* (Nematoda: Heteroxynematidae), parasite of *Mus musculus* (Rodentia: Muridae), from Hidalgo, Mexico. Revista Mexicana de Biodiversidad 81: 669 – 676.
12. Farrar, P. L., Wanger J. E., Kagiyama N. 1994. *Syphacia* spp. In Waggie K, Kagiyama N, Allen A, Nomura, T. (Eds.), Manual of Microbiologic Monitoring of laboratory animals. 2nd ed. Natl I Health, USA 219-24.
13. Flynn, R. J. 1973. Parasites of laboratory aminals, Ames: lowa State University Press.
14. Flynn, R. J., Brennan, P. C. and Fritz, T. E. 1965. Pathogen status of commercially produced laboratory mice. Laboratory Animal Care 15: 440-447.
15. Hugot, J. P. 1988. Les ne´matodes Syphaciinae parasites de Rongeurs et de Lagomorphes. Taxinomie. Zoogeographie. Evolution. Memoires du Museum National d'Histoire Naturelle, Paris, Serie A, Zoologie 141: 1-153.
16. Hugot, J. P. 2005. *Syphacia (Syphacia) millardiae* n. sp. (Nematoda: Oxyurida: *Syphaciinae*) from the Soft-Furred Field Rat, *Millardia meltada*, in India. Comparative Parasitology 72(1): 1–5.
17. Hussey, K. L. 1957. *Syphacia muris* vs. *S. obvelata* in laboratory rats and mice. Journal of Parasitology 43: 555-559.
18. Inglis, W. G., Harris, E. A., and Lewis, J. W. 1990. A new species of the nematode genus *Aspiculuris* Schulz, 1924 from *Aethomys namaquensis* (Mammalia: Rodentia) in the Kruger National Park, South Africa. Systematic Parasitology 17: 231-236.

19. Jueco, N. L. and Zabala, Z. R. 1990. The nematodes of *Rattus norvegicus* and *Rattus rattus mindanensis*. Philippine Journal of Veterinary Medicine 27: 39-46.
20. Lewis, J. W. and D Silva, J. 1986. The life cycle of *Syphacia muris* Yamaguti (Nematoda: Oxyuroidea) in the laboratory rat. Journal of helminthology 60: 39-46.
21. Mahmoud, A. E., Attia, R. A. H., Eldeek, H. E. M., Abdel Baki, L., and Oshaish, H. A. 2009. Oxyurid Nematodes detected by colonscopy in patients with unexplained abdominal pain. Parasitologists United Journal 2 (2): 93-102.
22. Mathies, A. W. 1959. Certain aspects of the host-parasite relationship of *Aspiculuris tetraptera*, a mouse pinworm. n. Sex resistance. Experimental Parasitology 8: 39-45.
23. Nitzsch, 1821. Quoted from Quentin (1975).
24. Ogden, C. G. 1971. Observations on the systematic of nematodes belonging to the genus *Syphacia* Seurat, 1916. The British Museum (Natural History) Zoology 20: 255-279.
25. Oldham, J. N. 1967. Helminths, ectoparasites, and protozoa in rats and mice. In Pathology of laboratory rats and mice (ed. E. Cotchin and F. J. C. Roe), pp. 641-679. Oxford and Edinburgh: Blackwell.
26. Owen, D. 1972. Common parasites of laboratory rodents and lagomorphs. Medical research council laboratory animals centre Handbook No. 1.
27. Ow-Yang, C. K. 1971. Studies on the nematode parasites of Malaysian rodents. I. The Rhabdiasidea, Trichiuridea and Oxyuridea. Journal of Helminthology 45(2/3): 93-109.
28. Parel J. D. C., Galula J. U. and Ooi H. K. 2008. Characterization of rDNA sequences from *Syphacia obvelata*, *Syphacia muris*, and *Aspiculuris tetraptera* and development of a PCR-based method for identification. Veterinary Parasitology 153: 379-83.
29. Perec-Matysiak, A., Okulewicz, A., Hildebrand, J., and Zalesny, G. 2006. Helminth parasites of laboratory mice and rats. Wiadomosci-Parazytologiczne 52: 99-102.
30. Petter, A. J. and Quentin, J. C. 2009. Keys to the genera of the Oxyuroidea. P. 1-30. In R. C. Anderson, A.G. Chabaud and S. Willmott (eds). CIH keys to the nematode parasites of vertebrates. Commonwealth Agricultural Bureaux, England.
31. Pinto, R. M., Goncalves, L., Noronha, D., Gomes, D. C. 2001. Worm burdens in outbred and inbred laboratory rats with morphometric data on *Syphacia muris* (Yamaguti, 1935) Yamaguti, 1941 (Nematoda, Oxyuroidea). Memorias Do Instituto Oswaldo Cruz 96 (1): 133-136.
32. Pinto, R. M., Vicente, J. J., Noronha, D., Goncalves, L., and Gomes, D. C. 1994. Helminth parasites of conventionally maintained laboratory mice. Memorias Do Instituto Oswaldo Cruz, Rio de Janeiro 89 (1): 33-40.
33. Quentin, J. C. 1975. Essai de classification des Oxyures Heteroxynematidae. Memoires du Museum National d' Histoire Naturelle, Zoologie 94:51-96.
34. Riley, W. A. 1919. A mouse Oxyurid, *Syphacia obvelata*, as a parasite of man. The Journal of Parasitology 6 (2): 89-93.
35. Rudolphi, C. A. 1802. Forsetung der Beobachtungen uber die Eingeweide Wurmer. *Archiv Fur Zoologie Und Zootomie*, 2: 1-67. Quoted from Tiner, 1948.
36. Sasa, M., Tanaka, H.,Fukui, M., and Takata, A. 1962. Internal parasites of laboratory animals in the proplems of laboratory animal disease (ed. R.J.C. Harris) pp. 195-214. London and New York. Academic Press.
37. Schmidt, G. D. 1986. "Book review". CIH keys to the nematode parasites of vertebrates by Roy C. Anderson; Alain G. Chabaud; Sheila Wilmott. Journal of Parasitology, 72(6): 969-971.
38. Schultz, R. E. S. 1924. On the helminth parasites of mice. Reports tropical institute Armnia 2 (1): 137-148.
39. Seurat, L. G. 1916. Sur les oxyures des Mammiféres. Canadian Creamics Society of Biology, 79: 64-68. Quoted from Ogden (1971).
40. Skrjabin and Schikhobalova, 1948. Quoted from Petter and Quentin (2009).
41. Stahl, W. 1961. *Syphacia muris*, the rat pinworm. Science, New York 133: 576-577.
42. Tenora, F., Barus, V., Wiger, R., and Mas-Coma, S. 1978. Scanning electron microscopic study of *Syphacia muris* and *Syphacia arvicolae* (Nematoda: Oxyuridae). Acta Universitatis Agriculturae, Brno, Facultas Agronomica 26(3): 195-207.
43. Tiner, J. D. 1948. *Syphacia eutamii* n. sp. From the least chipmunk, *Eutamias minimus*, with a key to the genus (Nematoda : Oxyuridae). The Journal of Parasitology, 34(2): 87-92.
44. Travassos, L. 1919. Quoted from Petter and Quentin (2009).
45. Weaver, H. J. and Smales, L. R. 2006. *Syphacia* (*Syphacia*) *abertoni* N. Sp. (Nematoda: Oxyuridae) from *Zyzomys argurus* (Thomas) (Rodentia: Muridae) from Northern Australia. Transactions of the Royal Society of South Australia, 131(2): 260-210.
46. Willmott, S. 1974. Glossary of terms. CIH Keys to the nematode parasites of vertebrates. Commonwealth Agricultural Bureaux, Farnham Royal, Slough, UK, No. 1 PP. 1-5. Edited by R.C.Anderson, A.G.Chabaud and S.M. Willmott [Archival volume 2009].
47. Yamaguti, S. 1935. Studies on the helminth fauna of Japan. Part 13. Mammalian nematodes. Japanese Journal of Zoology 6: 433-457.
48. Yamaguti, S. 1941 Studies on the helminth fauna of Japan. Part 35. Mammalian nematodes II. Japanese Journal of Zoology 6: 409-439.

1/29/2014