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Psammomermis sericesthidis n. sp. (Nematoda: Mermithidae), a parasitoid of pasture feeding scarab larvae (Coleoptera: Scarabaeidae) in southeastern Australia

Graeme L. BAKER*, George O. POINAR, Jr. ** and Angus J. CAMPBELL***

* *Biological and Chemical Research Institute, NSW Agriculture, P.M.B. 10, Rydalmere, N.S.W. 2116, Australia,*
** *Department of Entomology, Oregon State University, Corvallis, OR 97331, USA,*
and *** *Tropical Fruit Research Station, NSW Agriculture, Allstonville, N.S.W. 2640, Australia.*

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Summary – *Psammomermis sericesthidis* n. sp. is a parasitoid of the larvae of the beetles *Sericesthis geminata* Boisduval and *Sericesthis nigrolineata* (Boisduval) (Melolonthinae), *Dasygnathus* sp., *Anoplognathus* sp. (Rutelinae), *Heteronyx* sp. and *Anomalomorpha* sp. (Dynastinae) in the tablelands of the south-eastern part of Australia. *P. sericesthidis* n. sp. can be distinguished from all other described species of *Psammomermis*, except *P. acricephala* Ipatjeva & Pimenova 1985, in possessing a single cephalic hypodermal peg. *P. sericesthidis* n. sp. differs from *P. acricephala* in the shape of the head, size and position of the amphids, and considerably greater body length.

Résumé – Psammonermis sericesthidis *n. sp. (Nematoda : Mermithidae), un parasitoïde des larves de scarabés (Coleoptera : Scarabaeidae) dans les paturages du sud-est de l'Australie* – *Psammomermis sericesthidis* n. sp. est un parasitoïde des larves des scarabés, *Sericesthis geminata* Boisduval, *S. nigrolineata* (Boisduval) (Melolonthinae), *Dasygnathus* sp., *Anoplognathus* sp. (Rutelinae), *Heteronyx* sp. and *Anomalomorpha* sp. (Dynastinae) dans la région des plateaux du sud-est australien. *P. sericesthidis* n. sp. se distingue de toutes les espèces décrites dans le genre – sauf *P. acricephala* Ipatjeva & Pimenova, 1985 – par la présence d'un seul ergot hypodermique céphalique. *P. sericesthidis* n. sp. diffère de *P. acricephala* par la forme de la tête, la taille et la position des amphides, et la taille beaucoup plus grande du corps.

Key-words : mermithid, nematode, *Psammomermis*, Scarabaeidae.

The only described species of mermithid previously recorded from Scarabaeidae larvae in Australia is *Amphimermis australoelegans* Baker & Poinar, 1994, a parasitoid of *Sericesthis* spp. larvae in the Northern Tablelands of New South Wales. *P. sericesthidis* n. sp. is the first species of the genus *Psammomermis* recorded in Australia and the second mermithid described from scarab larvae in Australia. Post-parasitic juveniles identified as *Psammomermis* spp. on the basis of morphology of tail appendage have been reared from *Heteronychus arator* (Fabr.) on the south coast of New South Wales (G. Goodyer, NSW Agriculture, pers. comm.) and recovered from soil in south-east Victoria, south-west Western Australia, South Australia, coastal New South Wales and Queensland (K. Davies, University of Adelaide, pers. comm.). An undescribed species of *Hexamermis* has been reared to the adult stage from post-parasitic juveniles reared from *Sericesthis* spp. in the Northern Tablelands of New South Wales (A.J. Campbell, unpubl.). Unidentified mermithid nematodes have been previously recorded parasitising *Aphodius howitti* Hope (Carne, 1956) and the larvae of *Rhopaea magnicornis* S., *Sericesthis geminata* Boisduval and *Sericesthis nigrolineata* (Boisduval) (Melolonthinae) (R. Bedding, CSIRO, pers. comm.). In New Zealand, *P. canterburiensis* Poinar & Jackson, 1992, is a parasitoid of the scarab *Costelytra zealandica* (White).

Postparasitic juvenile and adult mermithid nematodes were obtained from soil during routine sampling of nematodes in pasturelands in connection with a study by the senior author (G.L.B.) of parasitism in acridids (Orthoptera). Eggs and preparasitic juveniles were associated with adults. Parasitic juveniles were obtained during routine dissection of host larvae during studies of parasitism in scarabaeid larvae by the junior author (A.J.C.). Postparasitic juveniles from host larvae held in peat moss were kept for 2-3 months in regularly aerated distilled water for moulting to the adult stage.

An adult female mermithid reared from *S. geminata* Boisduval was conspecific with two field-collected adult females, one of which had a male *in copula* confirming a conspecific pair. Parasitic juveniles from sev-

* *Current address: c/o Australian Museum, 6 College Street, Sydney, N.S.W. 2000, Australia.*

eral alternative hosts were conspecific with postparasitic juveniles dissected from *S. geminata*.

All stages were killed in hot water (60-80 °C), fixed in 3 % formalin and processed to glycerin for study. In the text, in the dimensions for the females, the first figure refers to the holotype and figures in square parenthesis refer to range of paratypes. The preparasitic juveniles described are the progeny of the holotype female. One male is described.

Psammomermis Polozhentsev, 1941

= *Pologenzevimermis* Kiryanova, Karavaeva & Romanenko, 1959

DIAGNOSIS

Mermithidae (Kaiser, 1984, 1991, emend.). Very thin, elongated mermithids, body length from a few mm to 35 cm. Cuticle thin, adults without criss-cross fibres, or with very fine ones occasionally visible under high magnification. Postparasitic stage with distinct criss-cross fibres. Mouth opening terminal. Cuticularised pharyngeal lining begining with thickened collar in hypodermis. Pharynx at the maximum 50 % of body length. Eight hypodermal chords in all sections of body. Trophosome syncytial. Six head papillae in one plane. Amphids pore to cup shaped, with fine round to wide oval opening. Vagina short and muscular, with straight or slightly bent lumen. Vulva straight or with varying degree of overlap of the genital opening. Spicula paired, thin, bent distal to ventral and pointed. Proximal with "V" spread capitulae, distal calami strictly parallel, with pronounced tendency to grow together. Hind end of parasitic and postparasitic stages with small appendage. Adults with hypodermic cone extending into the cuticle instead of appendage. Preparasitic juveniles, with long pharyngeal section (more than 50 % of body length), short tail and relatively slight motility.

TYPE SPECIES

Psammomermis korsakovi Polozhentsev, 1941

OTHER SPECIES

P. acricephala Ipatjeva & Pimenova, 1985
P. alechini Artyukhovski & Kharchenko, 1965
P. busuluk Polozhentsev, 1952
P. byssina Rubtsov, 1976
P. canterburiensis Poinar & Jackson, 1992
P. communis Popov, 1978
P. conjuncta Kaiser, 1984
P. cornicularis Kaiser, 1984
P. filiformis Kaiser, 1984
P. guffeldi Ipatjeva & Pimenova, 1985
P. ipatevae Popov, 1978
P. kulagini Polozhentsev, 1941
P. minor Kaiser, 1984
P. montana Ipatjeva & Pimenova, 1985
P. nitidulensis Poinar & Dowd, 1997
P. oesophaga Artyukhovski & Lisikova, 1977
P. parvula Rubtsov, 1976
P. pologenzevi Popov, 1978
P. sericesthidis n.sp.

SPECIES INQUIRENDA

P. tiliae Rubtsov, 1972 (*cf.* Kaiser, 1984, 1991; Artyukhovski, 1990).

SPECIES FORMERLY PLACED IN THE GENUS

Agamomermis agrotinae (Rubtsov & Pukhaev, 1980 *in* Rubtsov, 1980) Kaiser 1984
= *Psammomermis agrotinae* Rubtsov & Pukhaev, 1980

REMARKS

The genus *Psammomermis* was erected for species of terrestrial habitat possessing the generic characters of *Mesomermis* (Polozhentsev, 1941; Welch, 1962). Aquatic species possessing the characters of *Mesomermis* were assigned to the new genus *Neomesomermis* by Welch (1962; *cf.* Nickle, 1972) but several subsequently described species of *Mesomermis* remain to be reassigned. The genus *Psammomermis* was regarded as closely related to the aquatic genus *Bathymermis* von Daday by Artyukhovski (1990) and to *Romanomermis* Coman by Kaiser (1984). *P. agrotinae* Rubtsov & Pukhaev, 1980 (Rubtsov, 1980) is assigned to the genus *Agamomermis* on the grounds that the description is based on juvenile material (Poinar & Welch, 1981) and is in support of the observations of Kaiser (1984) and Artyukhovski (1990). Kaiser (1984) considered *P. busuluk* a *species inquirenda* on the basis that it was inadequately described without illustration. *P. tiliae* has been previously considered *species inquirenda* by Kaiser (1984) on the basis of atypical mouth opening and by Artyukhovski (1990) on the basis of position of amphids and morphology of vagina.

Psammomermis sericesthidis ★ n. sp.

(Figs 1-7)

MEASUREMENTS

Female holotype and female paratypes (in square parenthesis) (n = 3): L = 153 [149; 157] mm; at mid-body width = 0.185 [0.16; 0.21] mm; head width = 60 [60; 70] µm; cuticle width, at neck = 8 µm, at mid-body = 12 µm, at tail = 21 µm; distance of nerve ring from mouth = 390 µm; amphid aperture = 2 µm; amphid pouch = 8 × 3 µm; pharyngeal tube terminating 17 µm posterior to mouth opening; vagina length = 62 µm, vagina diameter = 80 µm; V = 42 [40; 44];

★ From the generic name of the host, *Sericesthis geminata*.

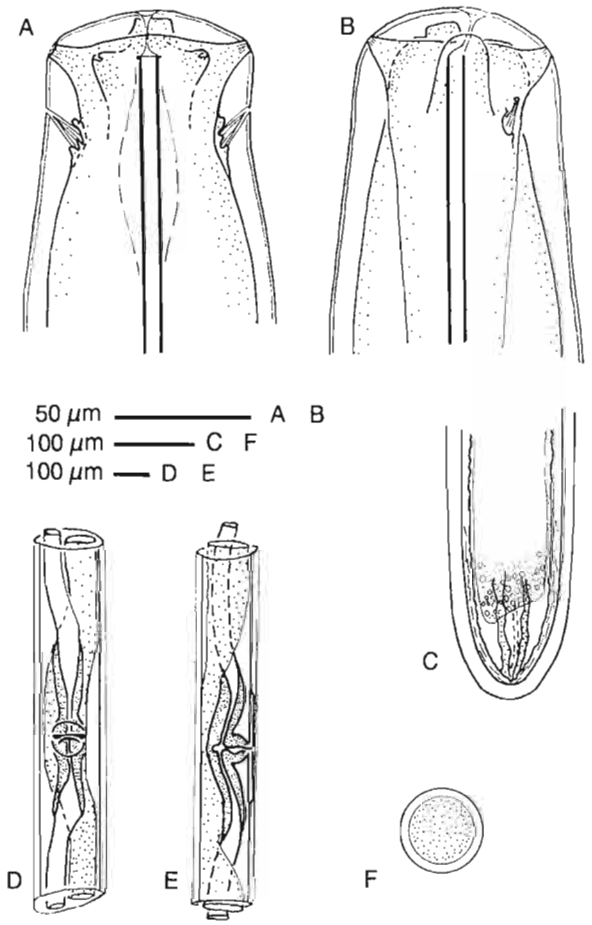

Fig. 1. Psammomermis sericesthidis *n. sp. female. A: Head, dorsal view; B: Head, lateral view; C: Tail; D: Vagina, ventral view; E: Vagina, lateral view ; F: Egg.*

hypodermis thickened for 180 µm anterior and posterior to vulva; uterus wall thickened for 280 µm anterior and posterior to vagina; eggs, medium size [diameter 90; 110 µm].

Male allotype: L = 53 mm; mid-body width = 0.120 mm; head width = 42 µm; body width at nerve ring = 85 µm; cuticle width at nerve ring = 5.5 µm; cuticle width, at neck = 7 µm; at mid-body = 7 µm; amphid aperture = 2 µm; amphid pouch = 8 × 4 µm; distance of nerve ring from mouth = 245 µm; lateral hypodermal chord width at nerve ring = 17.5 µm; spicule length = 553 µm; spicule head width = 20 µm; spicule midshaft width = 7 µm; tail length = 205 µm; width at cloaca = 163 µm; distance of proximal genital papilla anterior to cloaca = 80 µm; number of genital papillae = 56, in three rows.

Second stage juvenile (preparasitic) (n = 6): L = 910 (810-1030) µm; width at mid-body = 22 (20-23) µm; head width = 10 (9-10) µm; buccal cavity = 34 × 6 (33-38 × 6-7) µm; stylet length = 25 (24-27) µm; distance of nerve ring from mouth = 105 (96-115) µm; position of stichosome as percentage of body length = 14 to 27 (14-18 to 27-32) %; node as percentage of body length = 27 (27-32) %; length of trophosome interspaces = 20-25 µm; tail width (20 µm from tip) = 10 (10-11) µm.

Parasitic juvenile (early) (n = 1): L = 16.3 mm; width at mid-body = 83 µm; cuticle width at mid-body = 1 µm; width of hypodermis at mid-body = 3 µm; head width = 28 µm; buccal cavity = 40 × 15 µm; stylet length = 37 µm; distance of nerve ring from mouth = 213 µm; cuticle width at caudal end = 4 µm; tail width = 95 µm.

Parasitic (late) and postparasitic juveniles (n = 5): L = 83-202 mm; mid-body width = 140-175 µm; cuticle thickness at mid-body = 3-6 µm; cuticle thickness at tail = 25 µm (all specimens); width of lateral hypodermal chord = 46-52 µm; length of stylet = 32-37 µm; distance of nerve ring from mouth = 213-276 µm.

Description

Adults: Long, thin, white coloured nematodes. Head flat in dorsal view and rounded in lateral view, mouth opening with slight ventral shift; head with a single subterminal hypodermal peg dorsal to the pharynx and forming a hood-like structure around the mouth opening. Amphids small, pear shaped. Amphid aperture well posterior of level of cephalic papillae in what could be described as the neck region; wall of pouch very thin; pouch of similar size in female and male. Eight hypodermal chords mid-body. Tail rounded.

Female: Muscular vagina barrel-shaped with wide canal immediately above vulva; canal extending into dorsal wall of uterus opposite ventral opening of uterus into vagina. Wall of uterus thickened and muscular for an equal distance anterior and posterior to vagina. Vagina opening a transverse slit, flared laterally. Vaginal canal at right angle to uterus and vulva. No vestigial genital pore. Tail rounded with thick cuticle. Eggs in single row, unembryonated when laid.

Male : Spicule straight except for ventral curving at tip; head flared, dorsal angle greater than ventral; walls of shaft thin, parallel for greater part of length; tip attenuated to sharp point. Genital papillae small, widely spaced, arranged in three rows, medial row bifurcate posterior to cloaca; four to nine genital papillae anterior to cloaca and eight to ten genital papillae posterior to cloaca, in each row; tail spade shaped posterior to cloaca; ventral surface concave posterior to cloaca in lateral view; cloaca opening on transverse rim.

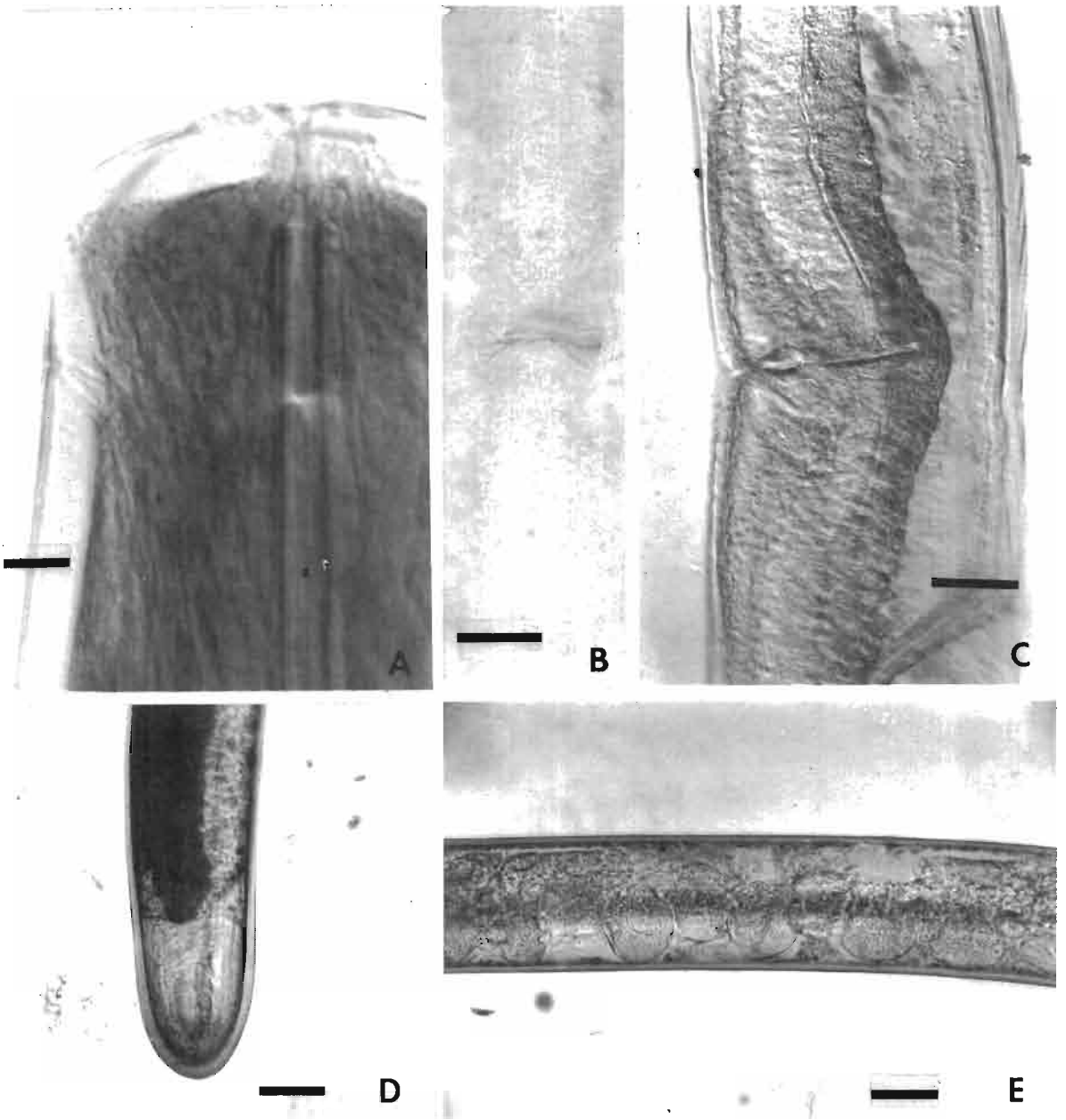

Fig. 2. Psammomermis sericesthidis *n. sp. female. A: Head, dorsal view ; B: Vulval slit, ventral view; C: Vagina, lateral view; D: Tail; E: Mid body showing uterus with single row of eggs (Bar equivalents: A = 10 µm; B, C = 50 µm; D, E = 100 µm).*

Second stage juvenile (preparasitic): Short, relatively broad; head with six cephalic papillae, large amphids posterior to level of lateral cephalic papillae. Proximal end of stylet barb-shaped on one side, distal end plain. Trophosome strongly vacuolated. Tail tapered to half body width, bluntly rounded.

Third stage juvenile (parasitic): During parasitic development there is a sustained increase in length, head width, and mid body width. A difference in the stylet length between the preparasitic (24-27 µm) and early and late parasitic juveniles (32-37 µm) indicates a moult early in the parasitic stage. Head rounded.

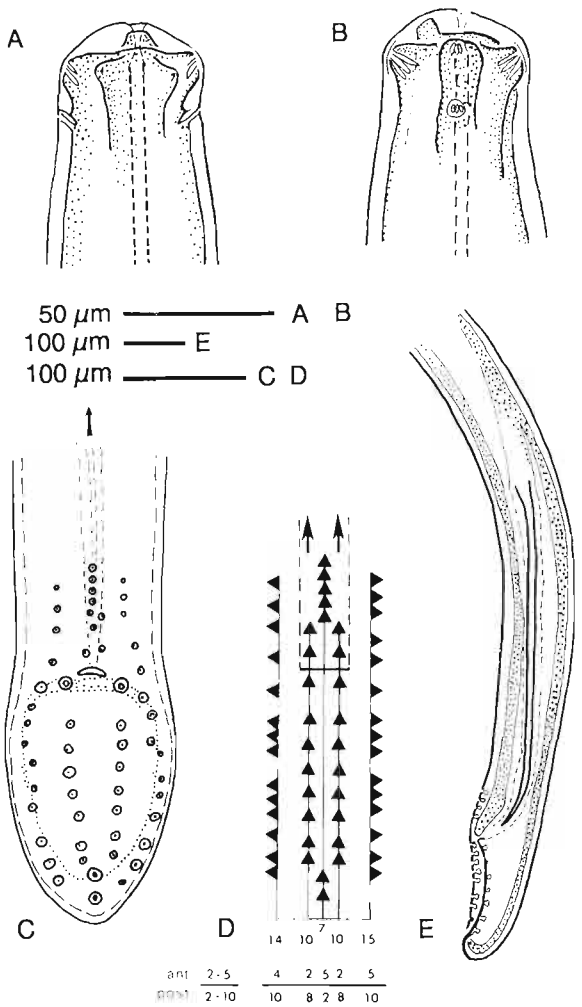

Fig. 3. Psammomermis sericesthidis *n. sp. male. A: Head, dorsal view; B: Head, lateral view; C: Tail, ventral view; D: Pattern of genital papillae; E: Tail, lateral view.*

Relatively fine cuticle. Tail bulbous with short, broad, nipple-like projection. The two moults of the post-parasitic juveniles appear as one (Fig. 7 C) due to the close apposition of two cuticles which are shed together (Fig. 6 D).

TYPE HOST AND TYPE LOCALITY

Sericesthis geminata Boisduval (Coleoptera : Scarabaeidae : Melolonthinae) at Stonehenge (29°49′5, 151°44′E), New South Wales, Australia.

HOSTS RANGE AND DISTRIBUTION

In addition to the type host, *S. geminata*, conspecific parasitic juveniles have been dissected, or reared, from *Sericesthis nigrolineata* (Boisduval) (Melolonthinae), *Dasygnathus* sp. and *Anoplognathus* sp. (Rutelinae) and *Heteronyx* sp. and *Anomalomorpha* sp. (Dynastinae).

P. sericesthidis n. sp. has been recorded parasitising scarab larvae collected throughout the New England Region of the Northern Tablelands of New South Wales. Smaller, though otherwise similar to *P. sericesthidis,* postparasitic juveniles have been collected from the soil at Captain's Flat and Jerangle in the Southern Tablelands of New South Wales. *P. sericesthidis* n. sp. is therefore widely distributed through the tableland area of south-eastern Australia.

TYPE MATERIAL

Holotype (female) and allotype (male) deposited at Sydney, Australian Museum, M.S.W., Australia (W 23871-23875). Paratype female deposited at Department of Nematology, University of California, Davis, CA, USA.

DIAGNOSIS AND RELATIONSHIPS

Head with a single subterminal hypodermal peg dorsal to the pharynx. Head flat in dorsal view. Mouth opening with slight ventral shift. Amphid aperture well posterior of level of cephalic papillae. Tail rounded.

The single, dorsal, subterminal, cephalic hypodermal peg separates *P. sericesthidis* n. sp. from all described species of the genus *Psammomermis* except *P. acricephala* from which the female differs in the shape of the head (flat *vs* attenuated in *P. acricephala*), size of amphids (small *vs* very large) and position of amphidial opening (well posterior of opening of lateral cephalic papillae *vs* posterior but in close proximity), and considerably greater body length (149-157 *vs* 6-11 mm in *P. acricephala*). The male of *P. acricephala* is unknown. *P. cornicularis* and *P. communis* also have hypodermal pegs but their pegs are paired being positioned dorsally and ventrally in *P. cornicularis* and dorsally in *P. communis*. *P. sericesthidis* n. sp. differs further from *P. cornicularis* in the shape of the hypodermal pegs (rectangular *vs* round in *P. cornicularis*), the position of the amphids (well posterior to cephalic papillae *vs* in close proximity in *P. cornicularis*), the greater length of both male and female (53 and 149-157 *vs* 8-23 and 23-103 mm in *P. sericesthidis* n. sp. and *P. cornicularis,* respectively), and the greater length of the spicule in the male (553 *vs* 140-190 µm in *P. cornicularis*) and from *P. communis* in the greater length of both male and female (53 and 149-157 *vs* 15-17 and 42-60 mm in *P. communis*) and in the greater length of the spicule in the male (553 *vs* 240 µm in *P. communis*).

Male *P. sericesthidis* n. sp. are similar to *P. filiformis* in body length, spicule length and form of the tail, but different in the possession of a cephalic hypodermal peg and in the position of the proximal genital papilla

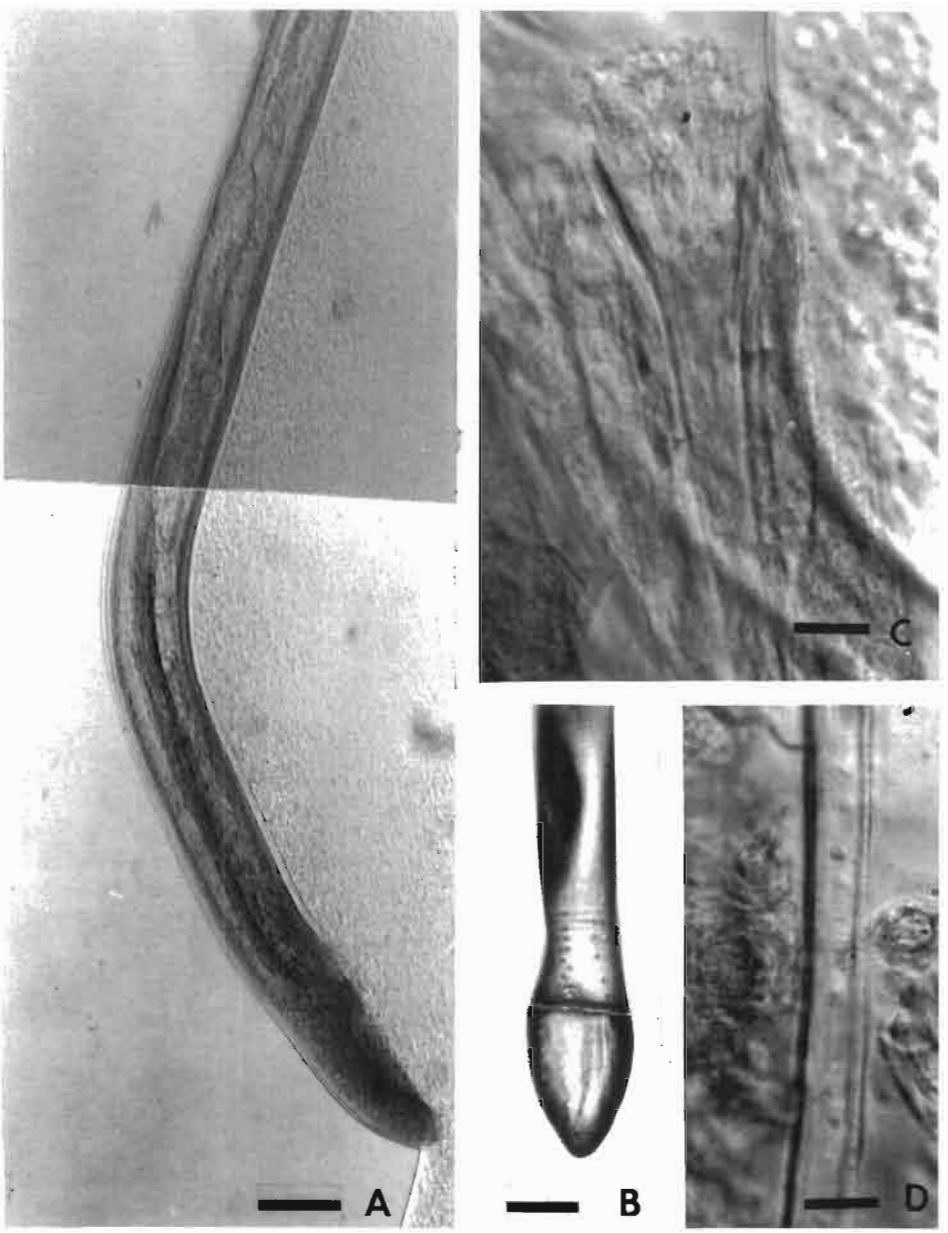

Fig. 4. Psammomermis sericesthidis *n. sp. male. A: Caudal end, lateral view; B: Tail, ventral view; C: Spicule head; D: Spicule mid-shaft (Bar equivalents: A, B = 100 µm; C, D = 10 µm).*

(80 *vs* 280 µm anterior to cloaca in *P. filiformis*) and the number of genital papillae (56 *vs* 79-83 in *P. filiformis*).

P. sericesthidis n. sp. differs from *P. canterburiensis* found in New Zealand in possessing the sub-terminal hypodermal peg in both sexes, the greater length of the male (53 *vs* 23 mm in *P. canterburiensis*) and the greater spicule length (553 *vs* 180 µm in *P. canterburiensis*).

Discussion

Seventeen of the nineteen previously described species of *Psammomermis* have been recorded from Cen-

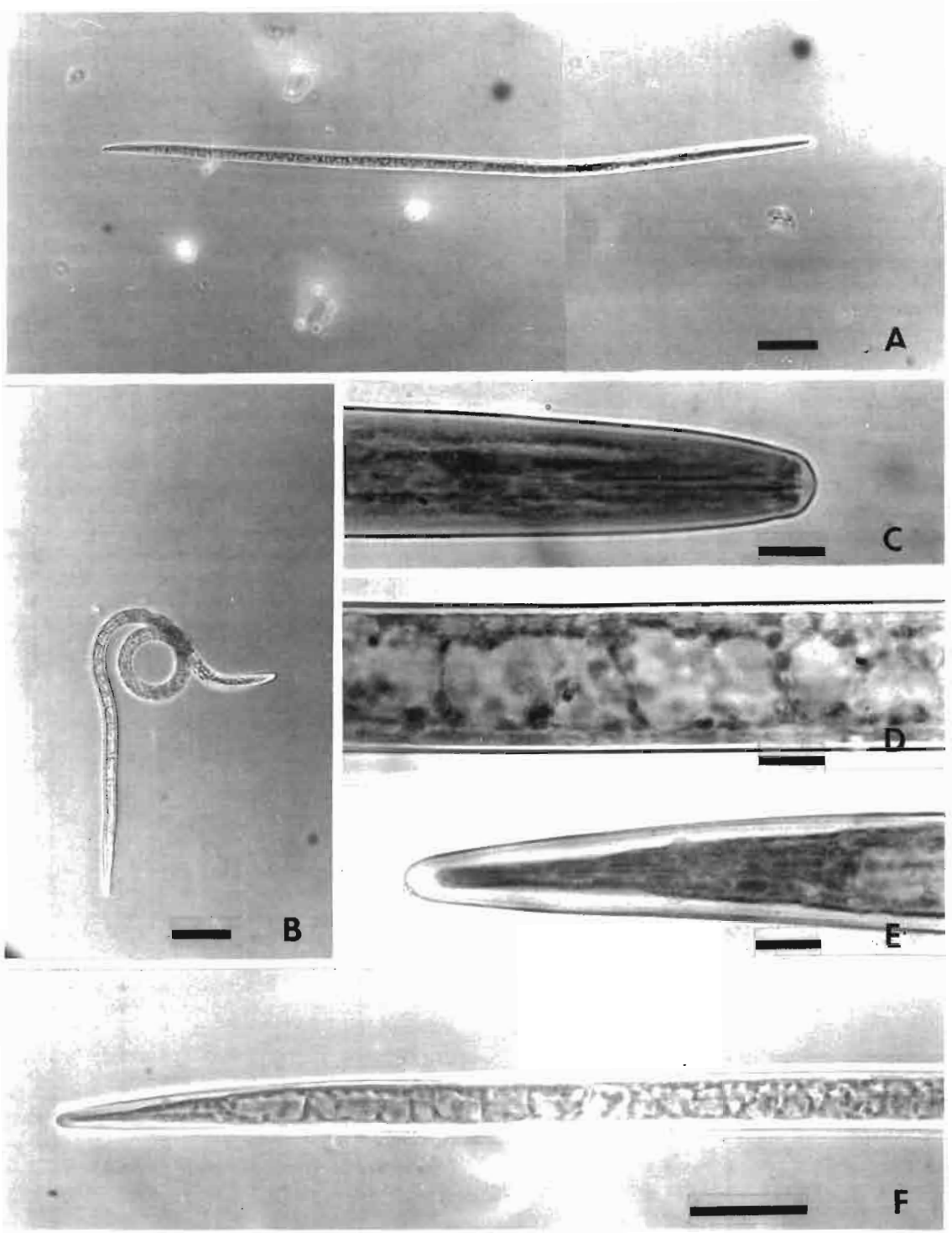

Fig. 5. Psammomermis sericesthidis *n. sp. second stage juvenile (preparasitic). A, B: Whole body; C: Head; D: Body, mid section; E: Tail; F: Caudal end of body (Bar equivalents: A, B = 100 µm; C-E = 10 µm; F = 50 µm).*

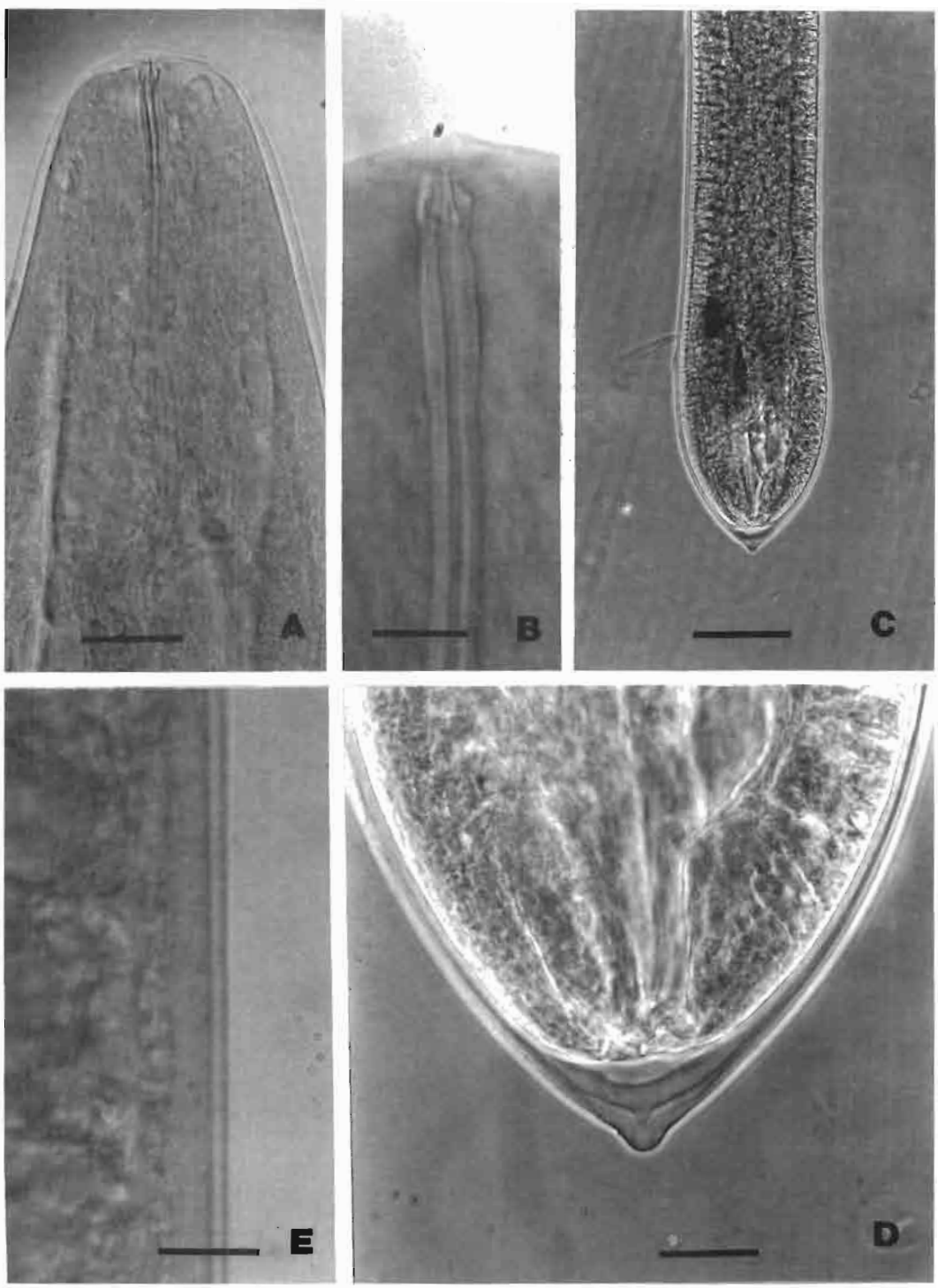

Fig. 6. Psammomermis sericesthidis *n. sp. parasitic juvenile. A: Head, lateral view; B: Stylet; C: Tail, lateral view; D: Tail, lateral view; E: Cuticle, mid-body (Bar equivalents: A, B, D = 25 µm; C = 100 µm; E = 10 µm).*

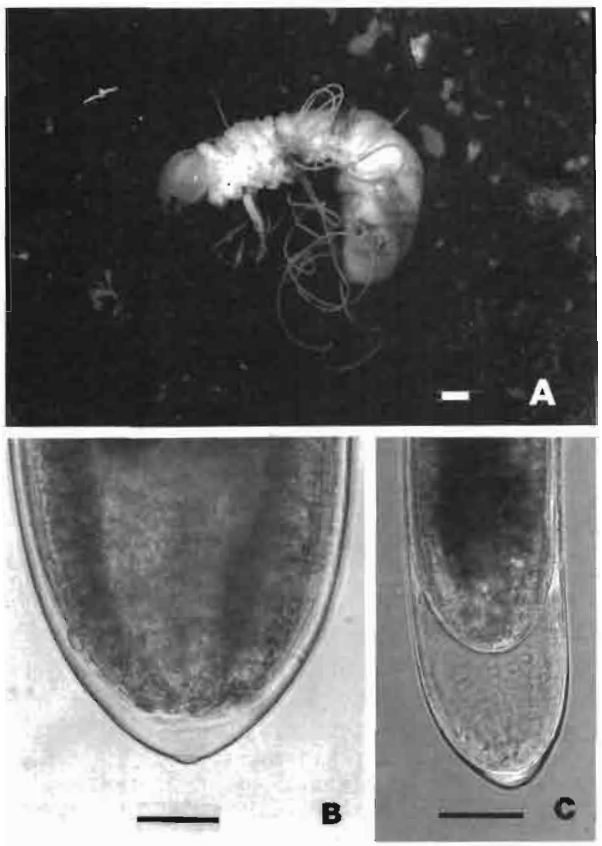

Fig. 7. Psammomermis sericesthidis *n. sp. postparasitic juvenile. A: Emerging from a 3rd instar* Sericesthis geminata *larva; B: Tail; C: Moulting, caudal end (Bar equivalents: A = 1 mm; B = 50 µm; C = 100 µm).*

tral Asia and Europe, the only exceptions being an undescribed species, closely resembling *P. korsakovi* (Klein *et al.*, 1976) and *P. nitidulensis*, from North America and *P. canterburiensis* from New Zealand.

The larvae of the scarabaeid host species are all major pests of non-leguminous pastures, while adult *Sericesthis* spp. and *Anoplognathus* spp. feed on the foliage of eucalyptus trees (Roberts *et al.*, 1982) and repeated defoliation by these species has been implicated in dieback of eucalyptus stands (Campbell, 1988; Landsberg & Wiley, 1988). The population dynamics of scarabs in pasture is mainly under the influence of climate -drought conditions preventing the emergence of adults from the soil. However, in average seasons, local perturbations are possibly dictated by biotic factors including thinid wasps, tachinid flies, and mermithid nematodes (Campbell, 1988).

Parasitism of scarabaeid larvae by *P. sericesthidis* n. sp. appears to be low. For example, between May 1983 and May 1985, only eighteen postparasitic juveniles emerged from 1922 field-collected scarabaeid larvae (0.92 %). The sampling period followed several seasons of drought (1980-1983) that may have had a detrimental impact on the nematode population and rate of turnover. In addition, the low parasitism may not be a true reflection of the significance of the parasite for several reasons, *viz.*: some of the scarabaeid larvae may not have been host species; all host larvae examined were 3rd instar larvae that may be less susceptible than other instars; the sampling occasions may not have corresponded to periods of peak parasitism; and premature death of host larvae during retention in the laboratory may have precluded the emergence of nematode parasitoids.

In determining the impact of a parasitoid on its host, account must also be taken of the relative duration of the parasitic stage of the parasitoid and the susceptible stage of the host. The life cycle of host scarabaeid larvae is extremely long (more than 18 months) while the parasitic development of *P. sericesthidis* n. sp. is relatively rapid if it approximates that of other mermithids in the region, *i.e.*, 3-4 weeks for *Hexamermis* sp. (Herron & Baker, 1991). When host and parasitoid have such disparate development rates (*i.e.*, less than 1 month *vs* more than 18 months), a low parasitism rate (*i.e.*, under 2 %), if sustained throughout the larval period of the host, could result in substantial mortality (*i.e.*, 36 %) of the larval stage in each host generation.

The abundance of mermithids in pasture has been little studied and their current status is unknown. However unrestrained clearing of timber in south-eastern Australia has resulted in environmental problems such as rising water tables and permanently saturated soils together with increased soil salinity. Such physical and chemical changes to the environment are probably detrimental to mermithid nematodes and may have contributed to the high pest status of their hosts during the last two decades.

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The authors would like to thank Dr. M. Fletcher and Mr. A.E. Westcott, NSW Agriculture, Rydalmere for, respectively, critically reading of the manuscript and translating Russian literature and Dr. A.K. Artyukhovski, Voronezh, Russia, for providing copies of several references. Adult *P. sericesthidis* n. sp. were field collected during a study of the mermithid parasites of *Phaulacridium vittatum* (Sjöstedt) supported by an Australian Meat Research Committee grant (DAN 19 S).

References

ARTYUKHOVSKI, A. K. (1990). [*Soil inhabiting mermithids: systematics, biology, use*]. Voronezh, Russia, Voronezh State University Press, 160 p.

ARTYUKHOVSKI, A. K. & KHARCHENKO, N.A. (1965). [A knowledge of the mermithids (Mermithidae, Nematodes) in the Streletskaya Steppe]. *Trudi Tsentral'nogo* -

Chernozemnogo Gosudarstvennogo Zapovednika, 9: 159-185.

ARTYUKHOVSKI, A. K. & LISIKOVA, Z. A. (1977). [*Mermithids (Mermithidae: Nematoda) of Uzbekistan of economic importance*]. Voronesh, Russia, Vorenesh Forest Institute, Dep. V VINITI (1.11.77) No 4174: 84 p.

BAKER, G. L. & POINAR, G. O., JR. (1994). Studies on the genus *Amphimermis* (Nematoda: Mermithidae): five new species including four from Orthoptera in southeastern Australia. *Fundam. appl. Nematol.*, 17: 303-321.

CAMPBELL, A. J. (1988). Farm trees -a practical guide. *In* : Enders, G., Campbell, A. J. & Madolny, C. (Eds). *Tree survival and protection.* Armidale, Australia, New England University Press : 68-95.

CARNE, P. B. (1956). An ecological study of the pasture scarab *Aphodius howitti* Hope. *Aust. J. Zool.*, 4: 259-314.

HERRON, G. A. & BAKER, G.L. (1991). The effect of host stage and temperature on the development of *Hexamermis* sp. (Nematoda: Mermithidae) in the Australian plague locust, *Chortoicetes terminifera* (Walker) (Orthoptera: Acrididae). *Nematologica*, 37: 213-224.

IPATJEVA. G. V. & PIMENOVA, I. N. (1985). [*Mermithids of Upper Altai*]. Saratov, Russia, Saratov State University: 66-75.

KAISER, H. (1984). Die Gattung *Psammomermis* nov. comb. (Mermithidae, Nematoda) - Morphologie, Beschreibung und Verbreitung einiger neuer Arten. *Mitt. naturw. Ver. Steierm.*, 144: 303-330.

KAISER, H. (1991). Terrestrial and semi-terrestrial mermithids. *In* : Nickle, W.R. (Ed.). *Manual of agricultural nematology.* New York, USA, Marcel Dekker, Inc.: 899-965.

KIRYANOVA, E. S., KARAVAEVA, R. P. & ROMANENKO, K. E. (1959). [Mermithids (Nematodes) -parasites of *Hyponomeuta malinella* and *H. padella* in southern Kirgizia.] *S.S.R., Trudi Kirgizskoi Lesnoi Opitnoi Santsii*, 2: 195-240.

KLEIN, M. G., NICKLE, W. R., BENEDICT, P. R. & DUNBAR, D. M. (1976). *Psammomermis* sp. (Nematoda : Mermithidae): a new nematode parasite of the Japanese beetle, *Popillia japonica* (Coleoptera : Scarabaeidae). *Proc. helminth. Soc. Wash.*, 43: 234-236.

LANDSBERG, J. & WILEY, F. R. (1988). Dieback of rural trees in Australia. *Geogr. J.*, 17: 231-237.

NICKLE, W. R. (1972). A contribution to our knowledge of the Mermithidae (Nematoda). *Nematologica*, 4: 113-146.

POINAR, G. O., Jr & DOWD, P. (1997). *Psammomermis nitidulensis* n. sp. (Nematoda: Mermithidae) from sap beetles (Coleoptera: Nitidulidae) with biological observations and a key to the species of *Psammomermis. Fundam. appl. Nematol.*, 20: 207-211.

POINAR, G. O., Jr & JACKSON, T. A. (1992). *Psammomermis canterburiensis* n. sp. (Mermithidae : Nematoda) parasite in the New Zealand grass grub, *Costelytra zealandica* (Scarabaeidae : Coleoptera). *Fundam. appl. Nematol.*, 15: 43-47.

POINAR, G. O., Jr & WELCH, H. E. (1981). Parasites of invertebrates in the terrestrial environment. *In* : Slusarski, W. (Ed.). *Review of advances in parasitology.* Warszawa, Poland, PWN-Polish Scientific Pub. : 947-954.

POLOZHENTSEV, P. A. (1941). [On the mermithid fauna of *Melolontha hippocastani* Fabr.]. *Tr. Bashk. Nauck. Issled. Veterin. Stantsii*, 3: 301-334.

POLOZHENTSEV, P. A. (1952). [New Mermithidae from the sandy soil of pine woods]. *Tr. Gelmintol. Lab. Akad. Nauk SSSR*, 6: 376-382.

POPOV, V. E. (1978). [New wetland Mermithid (Nematoda: Mermithidae)]. *Ts. Ch. O.-Voronezh Forest Inst., Dep. V NINITI (1.07.78)*, 1879: 77-87.

ROBERTS, R. J., CAMPBELL, A. J., PORTER, M. R. & SAWTELL, N. L. (1982). The distribution and abundance of pasture scarabs in relation to eucalyptus trees. *In* : Lee, K.E. (Ed.). *Proc. 3rd Australasian Conference on Grassland Invertebrate Ecology.* Adelaide, Australia, S.A. Govt. Printer : 207-214.

RUBTSOV, I. A. (1972). [Mermithids from Bashkir ASSR]. *Zool. Zh.*, 51: 954-962.

RUBTSOV, I. A. (1976). [Mermithids (Nematoda : Mermithidae) parasites of insects in Mongolia]. *Nasekomye Mongolii, Akad. Nauk SSR, zool. Inst.*, 4: 596-614.

RUBTSOV, I. A. (1980). [New species of mermithids from arthropods]. *Gel'minty nasekomykh."Nauka", Moscow, Russia* : 95-102.

WELCH, H. E. (1962). New species of *Gastromermis, Isomermis*, and *Mesomermis* (Nematoda : Mermithidae) from black fly larvae. *Ann. Ent. Soc. Am.*, 55: 535-542.