

Revision of the Genus *Paratylenchus* Micoletzky, 1922 and Descriptions of New Species. Part III of Three parts—*Gracilacus*¹

D. J. RASKI²

Abstract: Part III covers species with female stylet length $>41\ \mu\text{m}$ which are considered by this author to comprise the genus *Gracilacus* Raski, 1962. Seven new species of *Gracilacus* are described and further observations given on 14 other species. *Paratylenchus strenzkei* (Volz, 1951) Oostenbrink, 1960 is transferred to *species inquirendae*. A key to the species of *Gracilacus* is included. **Key Word:** taxonomy.

This report completes the present revision of the genus *Paratylenchus* and the related genus *Gracilacus*. It includes those species in which the females bear a stylet longer than $41\ \mu\text{m}$.

The genus *Gracilacus* Raski, 1962 (10) was proposed for those species of *Paratylenchus* previously described as having a female stylet greater than $48\ \mu\text{m}$ and for five new species. Other characters used to distinguish *Gracilacus* from *Paratylenchus* were: (i) swollen females found in some species, (ii) most juveniles with elongate stylet, and (iii) excretory pore mostly in region of metacarpus (opposite isthmus in some species). *Gracilacus* was distinguished from the genus *Cacopaurus* Thorne, 1943 by the elongation of its body posterior to vulva (tail very short and blunt in *Cacopaurus*) and a finely annulated cuticle without ornamentation.

This concept was not accepted by Siddiqi and Goodey (11) who synonymized *Gracilacus* with *Paratylenchus*. That action of synonymy has been variously received;

it was accepted by Allen and Sher (1) and by Geraert (6), and rejected by Thorne and Malek (12) and by Golden (7). The six new species with long stylets (described since 1962) and the seven species (described in this paper) contribute some new information which supports the concept of this group of nematodes as representing a separate and distinct taxon.

The species described by Colbran (3) as *Paratylenchus mutabilis* indicates a closer relationship between these long-stylet species and *Cacopaurus pestis* Thorne, 1943 because of the cuticular ornamentation on swollen females of *P. mutabilis*. On the other hand, some species judged to belong to *Gracilacus* are found to have what appears to be fourth-stage juveniles with very reduced stylets, a characteristic most frequently found in species of *Paratylenchus* with female stylets $38\ \mu\text{m}$ or less. This characteristic indicates relationship with *Paratylenchus*.

It is my opinion that these long stylet species are more closely related to *Cacopaurus* than to *Paratylenchus*. *Gracilacus* differs in tail shape from the short, blunt tail of *C. pestis*. In addition, senile, swollen females of *C. pestis* change to brownish, empty cuticular remnants which persist for long periods in the soil. Such forms have not yet been reported for any species of *Gracilacus*. So far, none of the species of *Paratylenchus* with stylet $38\ \mu\text{m}$ or less are known to form swollen females as found in *Gracilacus* and *Cacopaurus*.

Received for publication 1 July 1975.

¹The kind cooperation of many nematologists, including I. Andr  ssy, M. W. Brzeski, R. C. Colbran, A. DeGrisse, J. C. Edward, R. P. Esser, E. Geraert, A. M. Golden, D. J. Hooper, W. R. Jenkins, P. A. A. Loof, W. F. Mai, G. Merny, R. H. Mulvey, B. W. Ngundo, J. W. Seinhorst, A. R. Seshadri, S. A. Sher, G. Swarup, A. C. Tarjan, G. Thorne and W. M. Wouts, who sent type specimens, identified material, and new collections, is gratefully acknowledged. The technical assistance of N. Jones, U. K. Mehta, H. Chang, and J. Pinochet, especially in mounting and measuring specimens, was most valuable in this study.

²Professor of Nematology, Department of Nematology, University of California, Davis 95616.

Therefore, it is concluded that *Gracilacus* should be recognized as a separate genus.

MATERIALS AND METHODS

The study was based on more than 550 slides holding approximately 2,100 specimens. Most of the specimens examined were mounted in glycerin, but the precise methods of killing, fixing, and processing to dehydrated glycerin are not known. After specimens were collected, they were separated from soil by a combined gravity-screening and mist-extraction technique, killed by gentle heat, and fixed in 5% formaldehyde. The specimens then were passed through F.A.A., 2.5% glycerin in 30% alcohol, and 5% glycerin in 30% alcohol. They were allowed to dehydrate from the last solution to glycerin and then were mounted in dehydrated glycerin.

Gracilacus Raski, 1962

Diagnosis (emended): Paratylenchidae. Individuals small, less than 0.50 mm. Most juveniles with elongate stylet but some species with reduced stylet in fourth-stage juvenile. Female slender to swollen, with a stylet 41-119 μ m in length. Body elongate posterior to vulva. Cuticle finely annulated, without ornamentation (except *G. mutabilis*). Excretory pore generally in region of metacarpus near valve or further anterior, but may be near nerve ring. Male slender, active; stylet absent. Caudal alae lacking or at most represented by slight, thickened, cuticular evaginations. Ovary single. Testis one.

Type species: *Gracilacus epacris*
(Allen and Jensen, 1950)
Raski, 1962

syn. *Cacopaurus epacris*
Allen and Jensen, 1950
Paratylenchus epacris
(Allen and Jensen, 1950)
Siddiqi and Goodey, 1963

Other changes:

Gracilacus crenata (Corbett, 1966)
n. comb.
syn. *Paratylenchus crenatus* Corbett, 1966

Gracilacus micoletzkyi
(Edward, Misra and Singh, 1967) n. comb.

syn. *Paratylenchus micoletzkyi*
Edward, Misra and Singh, 1967

Gracilacus robusta
(Wu, 1974) n. comb.
syn. *Paratylenchus robustus*
Wu, 1974

Endings of specific names are changed throughout to conform with feminine gender of *Gracilacus*.

Gracilacus aonli
(Misra and Edward, 1971) n. comb.
syn. *Paratylenchus aonli*
Misra and Edward, 1971

Type specimens have not been accessible and judgment of *G. aonli* is based on the published description. The authors (8) consider *G. aonli* to be most closely related to *G. goodeyi* and *G. straeleni*. The head of *G. aonli* is described as "truncate conoid," but in the illustrations it appears to be more rounded in outline. *G. aonli* also is described as having oval spermatheca, but there are no detailed drawings indicating its precise structure. In some species, the spermatheca is oval and is about the same in length as in width, whereas the elongate, ovoid spermatheca of *G. goodeyi* and of *G. pandata* is very long, 2 to 3 times as long as the corresponding body diam. The shorter stylet (44-56 μ m) and conical head of *G. goodeyi* appear to be distinctive from *G. aonli* (stylet = 55-65 μ m).

The distinction of *G. aonli* from *G. straeleni* seems to be based on the spherical spermatheca of *G. straeleni* as contrasted with the oval spermatheca of *G. aonli*. Also the esophagus is shorter in *G. straeleni* (b = 3.0-4.5 vs. 2.5-3.0 in *G. aonli*) and the tail more rounded in *G. aonli* (finely rounded to acute in *G. straeleni*).

Gracilacus abietis
(Eroshenko, 1974) n. comb.
syn. *Paratylenchus abietis*
Eroshenko, 1974

Type specimens have not been accessible so judgment is based on the published description. The evidence indicates the author's diagnosis of relationship with *G. straeleni* is correct (5). The characteristics used to distinguish *G. abietis* from *G. straeleni* are not entirely convincing. The

smooth head of *G. abietis* may be a dependable character (as it is in *Paratylenchus projectus*) although it is not common in these genera. Other species have been considered to have the head smooth or without annulation, but occasionally fine head annulation is apparent. The corpus, described and illustrated as being narrow in the anterior half and then swelling to nearly twice that diameter in posterior half, also seems distinctive but has not been noted or used heretofore. The position of hemizonid relative to the excretory pore is not dependable as a specific character in other species. It has been found to vary from anterior to posterior in various specimens of the same population. The range of 'V' values in the paratypes (76-82) is more anterior than the composite for all the populations of *G. straeleni* reported in this paper. Until more collections of this nominal species are made, and more specimens are available for examination, the diagnosis is acknowledged as given and *G. abietis* is considered a distinct species.

Gracilacus acicula (Brown, 1959)
Raski, 1962

Two slides identified by G. L. Brown as *G. acicula* were loaned by the Canadian National Collection of Nematodes for this study. One slide had 13 females, 1 male and 1 juvenile (labelled paratypes) from pasture sod at Mer Bleu, Ontario. The second slide contained 5 females from meadow sod near Nesbitt, Manitoba, which was reported in the original description as a record of its distribution.

This species also has been found in soil with mixed roots from several plant species in a nursery near Winter Park, Florida. There are 32 females and 9 males in that collection. Two of the females retained the fourth-stage cuticle with very short pro-rhabdions attached. No juveniles were found. The juvenile described by Brown (2) as having a stylet 34 μm long probably is the third stage.

One other collection, identified tentatively as *G. acicula*, has three females from soil in a greenhouse at Michigan State University, Ingham County, Michigan. Unfortunately these are considerably flattened and some characters are difficult to discern. The tails are more slender-conoid and finely

rounded than those of most females seen in other collections. In all other respects, these specimens fit *G. acicula*.

Gracilacus aculenta (Brown, 1959)
Raski, 1962

Two slides with 35 female and 4 male paratypes were loaned by the Canadian National Collection of Nematodes for this study. These are not from the type locality but from grass sod in Gatineau Park, Quebec, which was reported by Brown (2) as one of the distribution records of *G. aculenta*. These specimens conform closely with the original description.

Five new collections, identified as *G. aculenta*, are reported here. One is from soil about the roots of a mixture of plants (including cactus) near the tide line at Bay-side, Texas. Dimensions are as follows:

7 females: L = .28 (.22-.31) mm; a = 23 (19-26); b = 2.7 (2.4-3.0); V = 74 (73-76); stylet = 51 (48-53) μm .

3 males: L = .33 (.31-.34) mm; a = 28 (27-30); c = 12 (10-14).

Another collection is from a tea plantation, Balanoor Estate, Balehonnur District, Karnataka State, India. The dimensions are:

5 females: L = .25 (.24-.26) mm; a = 21 (17-25); b = 2.4 (2.3-2.5); c = 15; V = 75 (74-76); stylet = 54 (53-56) μm ; pro-rhabdion = 48 (47-50) μm ; excretory pore = 76 (69-89) μm .

3 males: L = .27 (.26-.28) mm; a = 26 (23-30); c = 12 (11-13); spicules = 16 (15-18) μm ; gubernaculum = 4 (3-4) μm ; T = 32 (26-44); excretory pore = 59 (54-64) μm .

The Texas sample also held specimens of *P. minutus* and the Balanoor Estate sample held specimens of *P. neoamblycephalus*.

The other three collections, identified as *G. aculenta*, included 12 females, 1 male and 1 juvenile from soil about the roots of sagebrush at German Flats, Salina, Utah; 9 females from grassy soil at Gobbler Spring, Williams, Arizona; and 2 females, 3 males in natural grassland at Matador, Saskatchewan, Canada; 5 females, 1 male from strawberry at Strzeloe, Poland.

Some of these specimens, including some labelled paratypes, have an inconspicuous lateral vulvar membrane which is

not clearly present in most of the specimens. In all other respects, they resemble *G. aculeata* and are so considered in this paper. A small lateral vulvar membrane indicates close relationship of *G. idalima* with *G. aculeata*, which differs in stylet length [58 (54-62) μm for *G. aculeata* vs. 83 (75-88) μm for *G. idalima*].

A composite of the dimensions of all five collections is:

Female: L = .29 (.24-.34) mm; a = 23 (17-28); b = 2.7 (2.3-3.0); c = 12 (10-15); V = 72 (69-76); stylet = 57 (48-68) μm ; excretory pore = 73 (59-89) μm .

Male: L = .31 (.26-.35) mm; a = 27 (23-30); c = 13 (10-15); spicules = 18 (15-21) μm ; gubernaculum = 4 (3-5) μm ; T = 33 (26-44); excretory pore = 66 (54-77) μm .

Gracilacus epacris

(Allen and Jensen, 1950)

Raski, 1962

G. epacris from three new locations in California has been added to the UCNS Collection, Davis. Two females and 1 juvenile were found in soil about the roots of California laurel, *Umbellularia californica* Nutt., near Fairfield, Solano County. A single female was found in soil about the roots of *U. californica* near Shell Beach, Marin County. Three females and 1 juvenile were found in soil about the roots of *Quercus* sp. near Livermore, Alameda County. This is the same locality in which 17 females, 8 males and 4 juveniles were found in soil about the roots of *Platanus racemosa* Nutt. The measurements and descriptions of juveniles reported by Raski (10) were based on these specimens from *P. racemosa* but a reference to the host source was not included in that report.

Gracilacus goodeyi

(Oostenbrink, 1953) Raski, 1962

Two slides with 10 females labelled as paratypes of *P. goodeyi* are on deposit in the UCNS Collection, Davis. Three other slides with six females labelled as *P. goodeyi* from Arnheim, The Netherlands (and apparently from the type collection also) are in the UCNS Collection. Unfortunately, all the specimens on the five slides are flattened beyond recognition.

Nine other collections from six different countries have been identified as *G.*

goodeyi. According to Geraert (6), the elongate spermatheca of *G. goodeyi* is an important character differentiating it from closely related species. It may be 3 times as long at the corresponding body diameter. The identification of *G. goodeyi* as having an elongate spermatheca is at variance with the published description by Oostenbrink (9). He described the spermatheca as round. This character must be confirmed in other type specimens since the paratypes at University of California, Davis, are useless.

Another character which distinguishes *G. goodeyi* is the conoid head which presents a narrow tapering outline with fine but definite annules and is rounded at the apex. This appearance may be more pronounced in mature, swollen females. The tail of *G. goodeyi* also is more often subacute to finely rounded as contrasted with that of the related species, *G. straeleni*, which has an acute or pointed tail outline.

It is doubtful that the male described by Oostenbrink is indeed *G. goodeyi*. Two other species of *Paratylenchus* were reported in that type collection of soil about a pear tree near Arnheim. One of those could be *P. hamatus*, males of which bear a stylet. A similar situation was found in a collection from Austria in which one male of *Paratylenchus* was found with 9 females of *G. goodeyi*, 1 female of *P. microdorus*, and 1 female which appears to be *P. neoamblycephalus*. The male has no stylet but does have fairly well-defined caudal alae, a characteristic which is unique for a male of *Paratylenchus*. Geraert (6) reports a male of *G. goodeyi* without stylet. So many collections are mixtures of species that it is very difficult to associate specimens of one sex with the appropriate opposite sex. Mono-specific collections are invaluable for resolving such problems.

The nine collections mentioned previously include 8 females from strawberry soil near Gliwice-Labedy, Poland; 6 females from grass and weed soil, Laffrey, France; 5 females from grass and weed soil, Digne, France; 6 females, Jembloux, Belgium; 9 females from grass soil, Innsbruck, Austria; 14 females in soil at roots of *Lolium*, *Agrostis* and *Festuca*, at Kirton, Lincolnshire, England; 2 females from old meadow soil, Limburg (Gronsveld), The Netherlands; 1 female from arable soil, Ruurlo,

The Netherlands; 9 females from soil in garden at queen's palace, Soestdijk, The Netherlands. Except for stylet length, all these specimens fit the description of *G. goodeyi*. Several females have stylets which are shorter (the shortest being 44 μm) than the minimum reported in the type collection. Thus the range of stylet length is 44-56 μm .

Gracilacus intermedia Raski, 1962

A collection of 6 females identified as *G. intermedia* was made from soil about roots of *Pinus ponderosa* Dougl. and *Chamaebatia foliolosa* Benth. near Volcano, Amador County. Also present were specimens of *G. straeleni*. Other collections include a single female of *G. intermedia* from California laurel, *Umbellularia californica* Nutt., near Fairfield, Solano County, together with *G. epacris* and *G. straeleni*; 2 females from grapevine near Napa, Napa County; 2 females, 2 juveniles from prunes in Sonoma County; and 1 female from cypress, *Cupressus* sp., on the University of California Berkeley campus together with *Paratylenchus neoamblycephalus*.

Gracilacus ivorensis
(Luc and de Guiran, 1962) n. comb.
syn. *Paratylenchus ivorensis*
Luc and de Guiran, 1962

Paratypes, 7 females and 1 male, of this species were available for study. The specimens conform closely with the description, but I noted a greater range of variability in female tail shape than was illustrated. The tails of some females end in an extremely fine, acute terminus and one female has a rather bluntly rounded tail terminus.

Gracilacus macrodora
(Brzeski, 1963) n. comb.
syn. *Paratylenchus macrodorus*
Brzeski, 1963
Paratylenchus longistylus
Dement'eva, 1972 n. syn.

Eight females and 3 juvenile paratypes of *G. macrodora* were available for study. The female paratypes fit the description precisely. The juveniles were measured as follows: (3 second stage ?): L = .25 (.20-.30) mm; a = 20 (18-21); b = 2.3-2.4; stylet = 45 (43-49) μm ; prorhabdion = 38 (37-39)

μm . Head similar to that of female. Tail conoid; tip subacute to rounded. Developing gonad 9-11 μm long (about 5 μm wide), 49-60 μm from terminus.

Another collection of 4 females and 21 juveniles from a peach nursery at Chateaufort du Luc, near Valence, France was also identified as *G. macrodora* with dimensions as follows:

4 females: L = .32 (.31-.34) mm; a = 24 (21-27); b = 2.6 (2.4-2.7); V = ²¹₍₁₉₋₂₃₎ 77 (74-78); stylet = 81 (75-86); prorhabdion = 74 (68-80) μm ; excretory pore = 82 (79-86) μm .

3 juveniles (fourth stage ?): L = .31 (.30-.34) mm; a = 23 (22-24); b = 4.2 (4.1-4.4); stylet = lacking; excretory pore = 70 μm . Head as in female of *G. macrodora*. Excretory pore opposite posterior bulb. Gonad 43-46 μm long, 74-76 μm from terminus. Tail slender conoid; tip rounded.

No specimens of *P. longistylus* were available for study and the conclusion that it is synonymous with *G. macrodora* is based on the published description. The diagnosis of *P. longistylus* (4) indicates that it is most closely related to *P. macrophallus*, a conclusion which is doubtful. In appearance and most measurements, it is more closely related to *G. macrodora*. Range of total length (given as .27-.31 mm for *P. longistylus*) is the only major difference noted [for *G. macrodora* L = .34 (.33-.39) mm], and this is not sufficient for specific differentiation.

Gracilacus mira Raski, 1962

Specimens identified as *G. mira* have been collected from five new localities in California. One female was collected from soil about roots of *Arctostaphylos* sp. in Mix Canyon near Vacaville, Solano County. The collection also held specimens of *Paratylenchus neoamblycephalus* and *G. straeleni*. Fifteen females and 7 juveniles were collected from soil about roots of California juniper, *Juniperus californica* Carr., and 3 females from soil about roots of *Rhus trilobata* Nutt. in Joshua Tree National Monument, San Bernardino County. Eight females of *Paratylenchus variabilis* Raski, 1975 also were found in the *Rhus trilobata* sample. Three females and 1 juvenile were collected about roots of Tartarian cherry on Mahaleb rootstock near

Linden, San Joaquin County. Four females were collected about prunes in Tehama County and 1 female from peach near Modesto, Stanislaus County.

Gracilacus mutabilis
(Colbran, 1969) n. comb.
syn. *Paratylenchus mutabilis*
Colbran, 1969

Four slides with 10 females, 3 males, and 4 juveniles from the type locality (two of the slides labelled paratypes), were available for this study. The adults are precisely as described by Colbran. The juveniles, two of which were in the process of molting, appear to be third stage. Dimensions of the juveniles are as follows: L = .23-.25 mm; a = 17-18; b = 2.5-2.7; stylet = 33-37 μ m; prorhabdion = 26-29 μ m; excretory pore = 69 μ m. Head similar to that of adult females with distinctly rounded submedian lobes not set off by constriction. Excretory pore opposite isthmus. Tail conoid, subacute to bluntly rounded. One specimen showed a conspicuous parasite similar to the one illustrated in *G. pandata* n. sp.

Gracilacus oostenbrinki
(Misra and Edward, 1971) n. comb.
syn. *Paratylenchus oostenbrinki*
Misra and Edward, 1971

G. oostenbrinki is diagnosed by the authors (8) as being related to *G. peratica*, *G. intermedia* and *G. mira*. Its description, however, indicates it is more closely related to *G. macrodora*. The greater size of *G. macrodora* (.33-.39 mm vs. .25-.28 mm for *G. oostenbrinki*) and position of excretory pore (near stylet knobs in *G. mira* vs. opposite nerve ring in *G. oostenbrinki*) is evidence these are two separate and distinct species.

Gracilacus peratica Raski, 1962

Four new records of this species were from samples taken in Italy. Five females, 2 males, and 9 juveniles were identified from soil collected near Pescara. Thirteen females, 2 males, and 5 juveniles were found in soil about roots of olive near Molise, Campobasso. Three females were found in soil about roots of Paulsen grape hybrid 1103 in the government nursery near Palermo, Sicily. Also present in that sample were specimens of *Paratylenchus*

baldacci Raski, 1975 and *Paratylenchus nainianus* Edward and Misra, 1963.

Six swollen females were recovered directly from roots of *Laurus nobilis* L. near Bari together with 5 swollen females of *Rotylenchulus macrodorus* Dasgupta, Raski and Sher, 1968.

Gracilacus robusta (Wu, 1974)
n. comb.
syn. *Paratylenchus robustus*
Wu, 1974

Specimens of *G. robusta* were not available for this study. According to the description and illustration (14), *G. robusta* has a number of characters to support a relationship with *G. straeleni*. The range of total length, 'V' value, position of excretory pore opposite isthmus, and rounded head with fine annules are all similar to *G. straeleni*. However, the presence of a spermagonium is unique for this genus and also for *Paratylenchus*. Because of the spermagonium and the greater stylet length [55 (44-66) μ m for *G. straeleni* vs. 58-73 μ m for *G. robusta*], this species is accepted as distinct and separate.

Gracilacus steineri (Golden, 1961)
Raski, 1962
syn. *Paratylenchus steineri*
Golden, 1961

Three slides with single female paratypes were available for this study. In addition, a single slide with 4 females and 1 male, identified as *G. steineri*, was sent by R. C. Colbran from soil around a native legume at Western Ridge, corner of west Road, Mt. Tamborine, Australia. These have the following dimensions:

4 females: L = .29 (.28-.31) mm; a = 26 (24-29); b = 2.4 (2.3-2.5); V = 76 (76-77); stylet = 73 (68-75) μ m; excretory pore = 86 (75-96) μ m.

1 male: L = .35 mm; a = 33; c = 15; spicules = 17 μ m; gubernaculum = 4 μ m; T = 32; excretory pore = 86 μ m.

The stylet of these specimens is longer but overlaps the range described for *G. steineri*. In other respects these specimens and *G. steineri* are considered conspecific.

Gracilacus straeleni
(de Coninck, 1931) n. comb.
syn. *Procriconema straeleni*

de Coninck, 1931
Paratylenchus audriellus
 Brown, 1959, n. syn.
Paratylenchus straeleni
 (de Coninck, 1931) Oostenbrink, 1960
Paratylenchus sarissus
 Tarjan, 1960

There are no original type specimens of *G. straeleni* extant. Geraert (6) reported a collection from moss and soil from the type locality, Baraque Michel, Liege, Belgium, in which he found one female. He briefly described that specimen and designated it as neotype. Eight collections, identified as *G. straeleni*, from Europe were studied in this review. One collection from sphagnum moss at Gribsee-Moor, Denmark held 11 females and 1 male. No other species of *Paratylenchus* or *Gracilacus* were present. This is the first record of a male of *G. straeleni* from Europe. The dimensions for that population are as follows:

5 females: L = .39 (.37-.44) mm; a = 24 (22-25); b = 3.6 (3.4-4.0); c = 13 (12-13); V = ³² (25-41) 81 (80-82); stylet = 60 (57-63) μ m; prorhabdion = 47 (45-49) μ m; excretory pore = 93 (88-98) μ m.

1 male: L = .36 mm; a = 30; c = 10; spicules = 21 μ m; gubernaculum = 5 μ m; T = 28; excretory pore = 82 μ m.

Two female and 2 male paratypes of *G. sarissa* were studied. Also 14 female and 5 male paratypes of *G. audriella* were loaned from the Canadian National Collection of Nematodes for this review. On the basis of the synonymy of these two species with *G. straeleni*, 31 collections from the U. S. A. and Canada, 11 of which have 1 or more males, have been identified as *G. straeleni*. Females and males also were found in 1 collection from New Zealand.

The decision of Geraert (6) that *G. sarissa* is a synonym of *G. straeleni* is accepted. Geraert further judged that *G. straeleni* is not so different from *G. audriella* and noted that *G. audriella* has a more sharply pointed tail and shorter stylet.

Brown (2) stressed the hook-like terminus of the tails in both males and females of *G. audriella* as a distinguishing character. In fact, the paratypes show conoid, sharply-pointed tails on some females as well as typical hook-like processes on others. In all other respects, these paratypes con-

form closely with *G. straeleni*. Therefore, it is concluded *G. audriella* is a synonym of *G. straeleni*. Other collections from the U. S. A. and Europe show similar variations with a longer stylet more typical of *G. straeleni*. The specimens are strong evidence that *G. straeleni* is widely distributed and has a variable tail shape and a variable stylet length.

A composite of all the previous identifications indicates a species with the following ranges of dimensions:

Female: L = .37 (.28-.44) mm; a = 23 (16-30); b = 3.5 (3.0-4.5); c = 12 (10-14); V = 82 (79-85); stylet = 55 (44-66) μ m.

Male: L = .37 (.35-.40) mm; a = 31 (28-35); c = 12 (10-15); spicules = 22 (21-24) μ m; gubernaculum = 4 (4-5) μ m; T = 27 (24-35); excretory pore = 83 (79-90) μ m.

New distribution records in California include: Cypress, *Cupressus* sp., near Bolinas, Marin County; California laurel, *Umbellularia californica* Nutt., near Fairfield, Solano County, near Willits, Mendocino County, and on the American River near Auburn, Placer County; soil on University of California Berkeley campus; *Pinus attenuata* Lemmon and *Arctostaphylos* sp., Moraga Ridge, Contra Costa County; Black sage, *Artemisia arbuscula* Nutt., Badger Canyon; *Quercus* sp., Mt. Diablo, Contra Costa County; *Quercus* sp., near Monticello, Napa County; *Quercus* sp., and *Pinus* sp., Hobo Gulch Camp, Trinity County; *Quercus* sp., near Vacaville, Solano County; *Quercus* sp., Tecate area, San Diego County; *Quercus* sp., near San Lucas, Monterey County; *Quercus* sp., near Millbrae; *Camellia japonica* L., Huntington Gardens, Los Angeles County; *Opuntia* sp., locality unknown; grassy soil, Asilomar; *Pinus ponderosa* Dougl. and *Chamaebatia foliolosa* Benth., near Volcano, Amador County; *Aesculus californica* (Spach) Nutt., in Mix Canyon, near Vacaville, Solano County; and redwoods and *U. californica*, on a stream bed in Henry Cowell Redwoods State Park, near Felton, Santa Cruz County.

Distribution records in other states include: Grey birch roots and soil, Lafayette Campground, Franconia Notch, New Hampshire; *Quercus* sp., Great Smoky National Park, Tennessee; pecan grove, Byron, Georgia; *Pinus* sp., 9.7 km south of

Alexandria on Mt. Vernon Highway, Virginia; elm and cottonwood, bank of Mississippi River, Brooklyn Park, Minneapolis, Minnesota; yellow birch, Florence, Wisconsin; ironwood tree, Wasau, Wisconsin.

Distribution records in other countries include: in moss near a stream at Chatterton, Canada; grass and willow, Ngatimoti, New Zealand; grassy soil, Digne, France; grape soil, Department Garden, Beaucare, France; grape soil, Camaraque, Delta of Rhône, France; sphagnum moss, near Gribsee-Moor, Denmark; strawberry soil, Garwolin, Poland; Dobrzyce pow. Kalisz, Poland; *Salix* sp. torf, Sosnowica, Poland; grassy soil, University of Upsala, Upsala, Sweden.

Gracilacus latescens n. sp.
(Fig. 1-8)

Paratypes (19 slender females): L = .27 (.22-.29) mm; a = 19 (14-23); b = 2.2 (1.7-2.5); c = 13 (10-13); V = ¹⁶ (14-18) 71 (68-73); stylet = 75 (63-80) μ m; prorhabdion = 67 (58-74) μ m; excretory pore = 71 (64-82) μ m.

Paratypes (8 males): L = .29 (.23-.35) mm; a = 26 (20-29); b = 3.5 (3.3-3.7); c = 12 (11-13); spicules = 20 (18-23) μ m; gubernaculum = 4 μ m; T = 37 (27-47); excretory pore = 65 (58-77) μ m.

Holotype (female): L = .25 mm; a = 17; b = 2.3; c = 10; V = ¹⁷ 72; stylet = 71 μ m; prorhabdion = 63 μ m; excretory pore = 74 μ m. Body almost straight, only slightly curved ventrad after fixation. Head rounded; submedian lobes or lips only slightly distinguished on anterior surface. Head sclerotization light; stylet guiding apparatus appears as two darker, almost straight lines near base of sclerotization. Stylet slender; slightly curved ventrad; knobs moderately developed, backwardly directed. Length of stylet shaft plus knobs 8 μ m [7(5-10) μ m in paratypes]. Excretory pore near base of stylet (Fig. 1). Hemizonid small; immediately posterior to excretory pore. Valve in metacarpus 9 μ m long. Isthmus distinct, slender, 11 μ m long, 2 μ m wide. Esophago-intestinal valve small, lobate. Ovary outstretched; spermatheca elongate, about twice as long as wide; filled with sperm (Fig. 2, 4). Vulva lips rounded; protrude slightly, lateral vulvar membranes lacking. Tail broadly conoid;

tapers only slightly to bluntly rounded terminus. Average width of body annules ranges from 1.0-1.4 μ m (1.0-1.6 μ m in paratypes). Lateral field with 3 incisures equally spaced; inner incisure lighter than outer 2 (Fig. 3).

Allotype (male): L = .35 mm; a = 29; b = 3.6; c = 13; spicules = 23 μ m; gubernaculum = 4 μ m; T = 47; excretory pore = 77 μ m. Body curves slightly ventrad after fixation. Head rounded; sclerotization light (Fig. 7). Stylet lacking; esophagus degenerate. Hemizonid immediately posterior to excretory pore. Testis outstretched, with large, irregularly-shaped cells in anterior half; filled with numerous smaller sperm in posterior half (Fig. 8). Testicular gland distinct (40-49 μ m long in paratypes). Spicules curve very slightly ventrad. Cloacal sheath short, without projecting posterior margin. Indistinct caudal alae extend about 8-9 μ m anterior and posterior to cloacal opening. Tail broadly conoid; annules distinct almost to bluntly rounded terminus. Average width of body annules ranges from 1.0-1.4 μ m. Lateral field with 3 incisures as in female.

Paratypes (5 swollen females): L = .37 (.36-.39) mm; a = 5.5 (4.1-9.3); b = 3.8 (3.6-4.1); V = 78-79 (Fig. 5-6); excretory pore = 111 μ m. Body variously swollen; greatly variable in size (Fig. 5, 6); often reniform with distinctly projecting tail. Head rounded. Stylet of fully swollen females invariably broken in collection process. Metacarpus greatly enlarged, 20-28 μ m in width; swells gradually but major swelling 30-35 μ m long. Isthmus remains slender but posterior bulb enlarges slightly to 9-10 μ m wide by 11-13 μ m long. Ovary coils many times; few eggs seen are oval, nearly spherical and occur singly in uterus. Body narrows abruptly immediately posterior to vulva; then becomes broadly conoid; tapers slowly to blunt rounded terminus. Cuticle very thick, with annules coarse, especially in head region. Lateral field indistinct in most swollen females; seen as 3 incisures in a few. Tail elongate and terminus bluntly rounded. Swollen females found completely inside root tissues of host plant.

Juveniles (5 fourth-stage ?): L = .26 (.23-.29) mm; a = 15 (14-15); b = 3.7 (3.5-4.1); stylet = 15 (13-16) μ m; prorhabdion = 10 (9-11) μ m; excretory pore = 64 μ m.

FIG. 1-8. *Gracilacus latescens* n. sp.

Body rather broad, narrowing only slightly to rounded head with slightly projecting, rounded submedian lobes as in female. Stylet small; knobs only slight swellings. Body contents coarsely granular throughout; details of internal morphology obscured. Tail bluntly rounded. Developing gonad appears to be 9-10 μm long, 65-93

μm from terminus; suggests second stage. No juveniles with elongate stylet present. Two slender females in last molt present inside a swollen female. Each molted cuticle with prorhabdion 9 μm long.

Holotype: Female, collected by C. M. Heald on January 22, 1973, slide number 1446, UCNS Collection, Davis, California.

Allotype: Male, same data as holotype, slide number 1447, UCNS Collection, Davis, California.

Paratypes: 40 females, 104 swollen females, 8 males, 87 juveniles, same data as holotype, deposited as follows: 11 females, 43 swollen females, 1 male, 45 juveniles in UCNS Collection, Davis, California; 22 females, 53 swollen females, 3 males, 37 juveniles in USDA Nematode Collection, Beltsville, Maryland; 4 females, 2 swollen females, 1 male, 5 juveniles in National Nematode Collection, IARI, New Delhi, India; 1 female, 2 swollen females, 1 male each at Nematology Department, Rothamsted Experimental Station; Plantenziektenkundige Dienst, Wageningen, The Netherlands; UCNS Collection, Riverside, California.

Type host: Mesquite, *Prosopis* sp.

Type locality: Weslaco, Texas.

Diagnosis: This species is most closely related to *G. aculeata* from which it differs in longer stylet [58 (51-66) μm for *G. aculeata*] and length of esophagus ($b = 2.4-4.1$ in *G. aculeata*).

Distribution: 9 females, 3 males and 2 juveniles found in soil about roots of *Mesembryanthemum* sp. at Dillon Beach, Marin County, California; 7 females, 2 males and 3 juveniles from soil about strawberry, Noyo, Mendocino County, California.

Gracilacus costata n. sp.
(Fig. 9-15)

Paratypes (13 females): $L = .31$ (.29-.34) mm; $a = 25$ (22-29); $b = 2.4$ (2.3-2.6); $c = 11$ (11-12); $V = 15$ (12-18) 70 (67-72); stylet = 77 (70-87) μm ; prorhabdion = 69 (63-78) μm ; excretory pore = 69 (56-79) μm .

Paratypes (4 males): $L = .34$ (.32-.35) mm; $a = 28$ (26-31); $c = 11$ (11-12); spicules = 20 (18-22) μm ; gubernaculum = 5 (4-6) μm ; $T = 37$ (33-41); excretory pore = 66 (62-72) μm .

Holotype (female): $L = .31$ mm; $a = 26$; $b = 2.3$; $c = 11$; $V = 17$ 71; stylet = 79 μm ; prorhabdion = 70 μm ; excretory pore = 64 μm . Body strongly curved almost a closed 'C' shape after fixation. Body narrows gradually anteriorly to a rounded head. Submedian lobes or lips not set off;

rounded anteriorly to same level as lateral lobes; produce a somewhat flat or truncate anterior surface. Sclerotization light; stylet guiding apparatus appears as two dark lines slightly curved at level of retracted stylet tip. Stylet slender; knobs rounded; apparently slightly anteriorly directed. Length of stylet shaft plus knobs 9 μm (7-9 μm in paratypes). Excretory pore anterior to base of stylet (Fig. 9). Hemizonid inconspicuous, immediately posterior to excretory pore. Esophago-intestinal valve small, rounded. Ovary outstretched (Fig. 13); spermatheca inconspicuous (Fig. 10), without sperm. Vulva lips slightly rounded and protruding; lateral vulvar membranes lacking. Tail long, slender-conoid; annules very fine but visible; subacute, to finely rounded terminus. Body annules average about 1.0 μm in width; lateral field with 3 incisures equally spaced; center line less distinct than outer 2 (Fig. 11-12).

Allotype (male): $L = .32$ mm; $a = 28$; $c = 12$; spicules = 18 μm ; gubernaculum = 5 μm ; $T = 37$; excretory pore = 63 μm . Body an open 'C' shape after fixation. Body narrows gradually anteriorly to rounded head. Submedian lobes slightly rounded, not set off; lateral area slightly depressed; give concave anterior outline. Sclerotization light. Stylet lacking, esophagus degenerate; only remnants identifiable (Fig. 14). Excretory pore immediately anterior to hemizonid which extends about 3 body annules in length. Testis outstretched; anterior third with large developing cells; posterior portion filled with small sperm. Spicules slightly curved; cloacal sheath short without projecting posterior margin. Tail slender conoid; annules visible almost to acute terminus (Fig. 15). Body annules average about 1.0 μm in width; lateral field with 3 incisures equally spaced; center line less distinct than outer 2.

Juveniles (3 fourth stage?): $L = .28$ (.26-.30) mm; $a = 18$ (15-22); $b = 3.6$ (3.6-3.7); stylet = 11 (10-13) μm ; prorhabdion = 7 (6-7) μm ; excretory pore = 69 (64-73) μm . Head rounded with submedian lobes or lips as in female; rounded but not set off. Stylet very weakly developed; knobs small swellings. Excretory pore at level of isthmus. Developing gonad not distinct. Tail subacute to rounded.

Holotype: Female, collected by L. H.

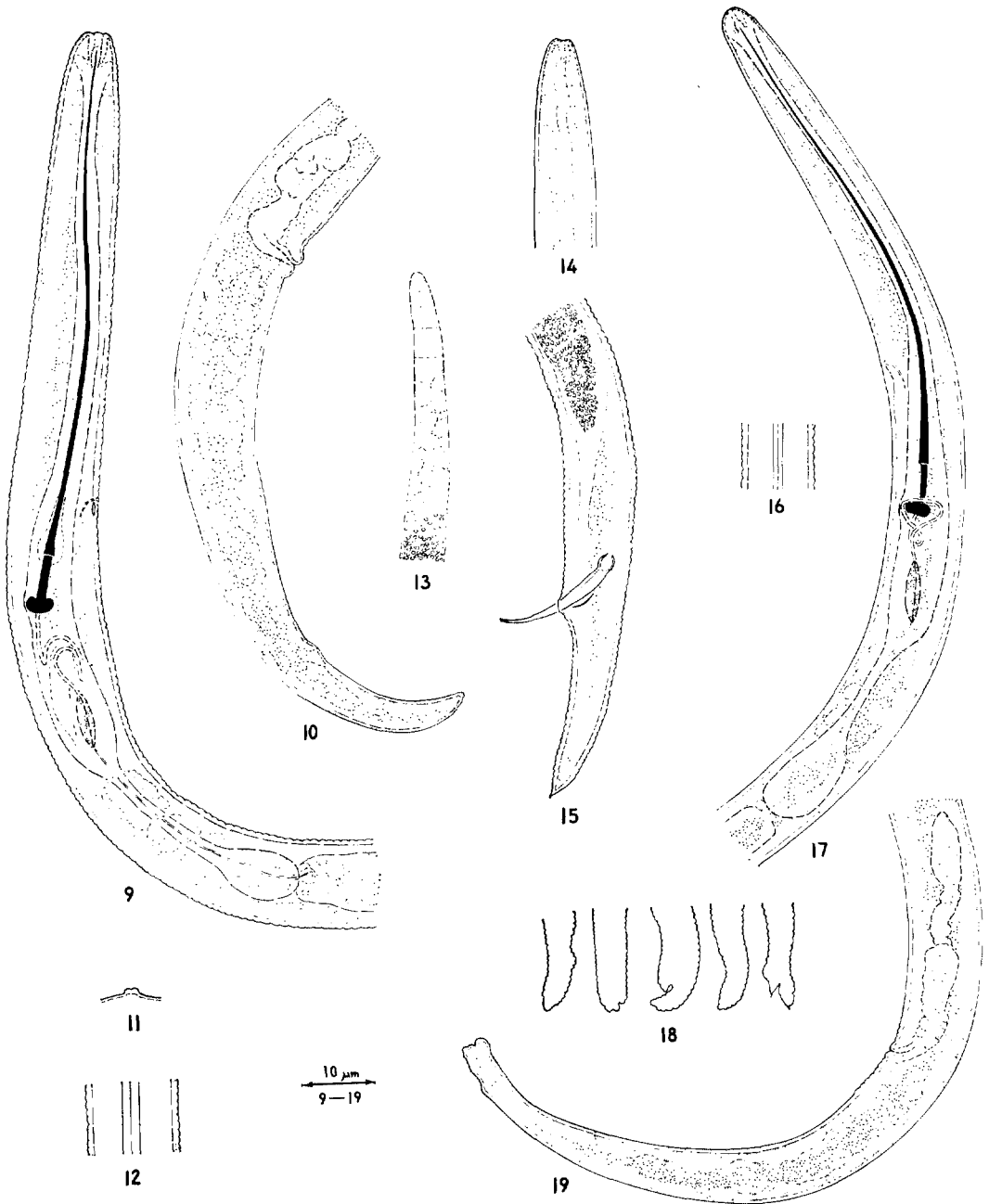


FIG. 9-19. 9-15) *Gracilacus costata* n. sp. 16-19) *Gracilacus solivaga* n. sp.

Wang on May 21, 1967, slide number 1442, UCNS Collection, Davis, California.

Allotype: Male, same data as holotype, slide number 1443, UCNS Collection, Davis, California.

Paratypes: 11 females, 8 males, 9 juveniles, same data as holotype plus 2 females, 10 males, 1 juvenile, same data as

holotype except these were collected on May 15, 1967, deposited as follows: 8 females, 13 males and 10 juveniles in UCNS Collection, Davis, California; 1 female, 1 male each at USDA Nematode Collection, Beltsville, Maryland; National Nematode Collection, IARI, New Delhi, India; Nematology Department, Rothamsted Experimental Station, Harpenden, England;

Plantenziektenkundige Dienst, Wageningen, The Netherlands; UCNS Collection, Riverside, California.

Type habitat: Noncultivated loam soil.

Type locality: Mt. Yangmin, Taipei, Taiwan.

Diagnosis: This species is most closely related to *G. solivaga* n. sp. from which it differs in its greater length [$L = .24$ (.21-.25) mm for *G. solivaga*] and slender-conoid subacute tail (tail mostly deformed in *G. solivaga*). *G. costata* is also related to *G. latescens* from which it differs also in larger size [$L = .27$ (.22-.29) mm for *G. latescens*] and subacute tail (tail is bluntly rounded in *G. latescens*).

Distribution: 11 females, 2 males and 20 juveniles from soil about *Manihot utilisima* Pohl., at the property of Rafael Navarro A. in Colombia, South America.

Gracilacus solivaga n. sp.
(Fig. 16-19)

Paratypes (5 females): $L = .24$ (.22-.25) mm; $a = 24$ (22-25); $b = 2.1$ (2.0-2.1); $c = ?$; $V = 14$ (13-14) 73 (71-75); stylet = 71 (69-75) μm ; prorhabdion = 64 (60-69) μm ; excretory pore = 54 (52-56) μm .

Holotype (female): $L = .25$ mm; $a = 25$; $b = 2.1$; $c = ?$; $V = 14$ 71; stylet = 74 μm ; prorhabdion = 69 μm ; excretory pore = 52 μm . Body an open 'C' shape after fixation. Body gradually narrows anteriorly to a rounded head. Sclerotization very light; stylet guiding apparatus appears as two slightly arcuate, darker lines at tip of retracted stylet. Stylet slender; slightly arcuate ventrad (Fig. 17). Knobs small, rounded; slightly posteriorly directed. Stylet shaft plus knobs 5 μm (6-7 in paratypes). Excretory pore about 2 body widths anterior to stylet knobs. Hemizonid immediately posterior to excretory pore. Isthmus slender, relatively short. Esophago-intestinal valve small, rounded. Ovary outstretched; spermatheca indefinite; no sperm seen (Fig. 19). Vulva inconspicuous; lateral vulvar membranes lacking. Tail long, slender-conoid; narrows gradually; annules distinct to misshapen; lobed terminus [paratypes variously misshapen, two subacute-conoid (Fig. 18)]. Body annules fine; less than 1 μm in width. Lateral field with 3 incisures (Fig. 16), center one lighter than outer 2.

Male: Unknown.

Holotype: Female, collected by M. T. Hutchinson on March 22, 1962, slide number 1448, UCNS Collection, Davis, California.

Paratypes: 5 females, same data as holotype, deposited in UCNS Collection, Davis, California.

Type habitat: Upper jungle soil.

Type locality: Mooloya, Hewaheta, Sri Lanka.

Diagnosis: This species is most closely related to *G. costata* from which it differs in its smaller size [.31 (.29-.34) mm for *G. costata*] and its variously misshapen tail (uniformly subacute in *G. costata*).

Also present in this soil sample were 13 females, 2 males, and 1 juvenile of *Paratylenchus minutus*.

Gracilacus pandata n. sp.
(Fig. 20-24)

Paratypes (10 females): $L = .38$ (.33-.42) mm; $a = 26$ (23-32); $b = 3.1$ (2.8-3.2); $c = 11$ (9-12); $V = 27$ (19-31) 74 (70-76); stylet = 66 (63-70) μm ; prorhabdion = 55 (53-59) μm ; excretory pore = 103 (94-119) μm .

Paratypes (3 males): $L = .39$ (.36-.42) mm; $a = ?$; $c = 10$; spicules = 20 (19-22) μm ; gubernaculum = 4 (4-5); $T = 36$ (34-40); excretory pore = 89 (83-94) μm .

Holotype (female): $L = .40$ mm; $a = 28$; $b = 3.1$; $c = 11$; $V = 29$ 75; stylet = 68 μm ; prorhabdion = 55 μm ; excretory pore = 102 μm . Body only slightly curved ventrad after fixation. Body gradually narrows slightly to rounded head. Submedian lobes small rounded; protrude only very slightly beyond round contour of head. Sclerotization light; stylet guiding apparatus appears as two dark, slightly curved lines at tip of retracted stylet. Stylet slender, slightly curved; knobs large, rounded, slightly posteriorly directed. Excretory pore at level of anterior end of isthmus (opposite nerve ring in some paratypes). Hemizonid 2 body annules in length at level of excretory pore. Esophago-intestinal valve small, rounded. Ovary outstretched; spermatheca narrow, elongate (7 x 25 μm); filled with large sperm (Fig. 22). Vulva inconspicuous; only a slight notch in ventral outline. Lateral vulvar membrane rounded, prominent. Tail long, slender-conoid ending in narrow, finely rounded, almost acute

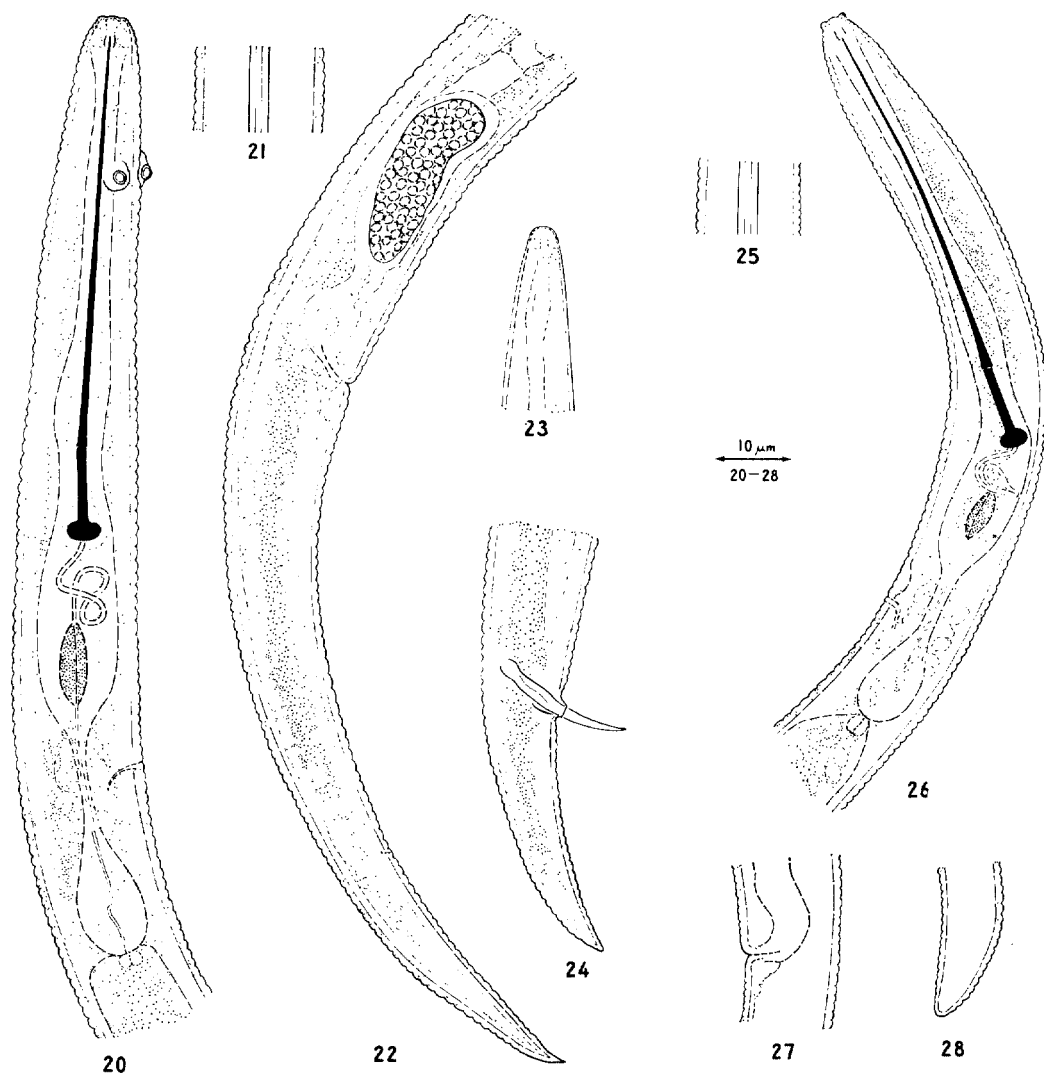


FIG. 20-28. 20-24) *Gracilacus pandata* n. sp. Fig. 20) Two specimens of *Bacillus penetrans* present on anterior end of female. 25-28) *Gracilacus parvula* n. sp.

terminus. Body annules average $1.3\text{--}1.8\text{ }\mu\text{m}$ wide. Lateral field with 4 incisures (Fig. 21); inner 2 lighter than outer 2 [several paratype females had conspicuous, infections of *Bacillus penetrans* (syn. *Dubosquia penetrans*) on cuticle, especially on anterior end (Fig. 20)].

Allotype (male): $L = .36\text{ mm}$; $a = ?$; $c = 10$; spicules = $18\text{ }\mu\text{m}$; gubernaculum = $4\text{ }\mu\text{m}$; $T = 31$; excretory pore = $87\text{ }\mu\text{m}$. Body an open 'C' shape after fixation. Body narrows gradually to slender, rounded head. Sclerotization very light; stylet lacking (Fig. 23). Testis outstretched. Spicules slightly curved, ventrad. Cloacal sheath

short, inconspicuous, without projection of posterior margin. Tail slender, conoid; terminus finely rounded (Fig. 24).

Holotype: Female, collected by F. E. Caveness on August 31, 1964, slide number 1399, UCNS Collection, Davis, California.

Allotype: Male, collected by F. E. Caveness on July 10, 1964, slide number 1400, UCNS Collection, Davis, California.

Paratypes: 26 females, same data as holotype, and 1 female, 3 males, same data as allotype, deposited as follows: 22 females, 3 males in UCNS Collection, Davis, California; 1 female each in National Nematode Collection, IARI, New Delhi, India;

USDA Nematode Collection, Beltsville, Maryland; Nematology Department, Rothamsted Experimental Station, Harpenden, England; Plantenziektenkundige Dienst, Wageningen, The Netherlands; UCNS Collection, Riverside, California.

Type host: Grapefruit (holotype); water yam, *Dioscorea alata* L. (allotype).

Type locality: 1 mile north of Katsina Twp., Katsina Province, Nigeria (holotype); 8 miles southwest of Jebba, Ilorin Province, Nigeria (allotype).

Diagnosis: This species is most closely related to *G. goodeyi* from which it is distinguished by its longer stylet (63-70 μm vs. 48-56 μm for *G. goodeyi*) and rounded head (conoid in *G. goodeyi*).

Gracilacus parvula n. sp.
(Fig. 25-28)

Paratypes (4 females): L = .35 (.34-.37) mm; a = 28 (27-29); b = 3.3 (3.2-3.4); c = 16; V = ²⁵ (23-28) 79 (78-80); stylet = 58 (56-60) μm ; prorhabdion = 46 (45-48) μm ; excretory pore = 91 (86-96) μm .

Holotype (female): L = .35 mm; a = 28; b = 3.3; c = 17; V = ²⁸ 79; stylet = 59 μm ; prorhabdion = 47 μm ; excretory pore = 89 μm . Body an open 'C' shape after fixation. Head narrows with rounded outline, distinct annules, to constriction setting off rounded, protruding submedian lobes or lips, truncate or flattened at anterior surface. Sclerotization light; stylet guiding apparatus appears as two dark lines, slightly arcuate, near tip of retracted stylet (Fig. 26). Stylet slender; knobs relatively large, directed slightly posteriad. Excretory pore opposite isthmus. Hemizonid 3 body annules in length immediately anterior to excretory pore. Length of stylet shaft plus knobs 12 μm (11-12 μm in paratypes). Isthmus slender, relatively short. Esophago-intestinal valve small, lobate. Ovary outstretched; spermatheca small, ovate, without sperm. Vulva inconspicuous; lateral vulvar membranes distinct, rounded (Fig. 27). Tail conoid; narrows gradually to bluntly rounded terminus (Fig. 28). Lateral field with 4 incisures about equally spaced; inner 2 lighter than outer 2 (Fig. 25).

Male: Unknown.

Juvenile (4 third stage ?): L = .26 (.25-

.29) mm; a = 22 (22-23); b = 2.6 (2.0-3.2); stylet = 40 (38-42) μm ; prorhabdion = 32 (30-34) μm ; excretory pore = 70 (61-80) μm . Head with distinct set-off lips as in female. Stylet knobs large, backwardly directed. Excretory pore opposite isthmus. Gonad about 21 μm long, 66-68 μm from terminus. Tail bluntly rounded.

Holotype: Female, collected May 15, 1967, slide number 1449, UCNS Collection, Davis, California.

Paratypes: 4 females, 11 juveniles, same data as holotype, deposited in UCNS Collection, Davis, California.

Type habitat: Noncultivated loam soil.

Type locality: Mt. Yangmin, Taipei, Taiwan.

Diagnosis: This species is most closely related to *G. mutabilis* but differs in the set-off protruding lips of *G. parvula* (in *G. mutabilis* the head outline is continuous, not set off, but with submedian lobes rounded anteriorly). The stylet is longer in *G. mutabilis* [58 (56-60) μm vs. 48-57 μm for *G. mutabilis*]; stylet knobs of *G. parvula* larger than in *G. mutabilis*.

Additional collection: After this manuscript was submitted for publication but before it was set for printing, another collection of this species was provided by C. S. Huang. The collection held 10 males, 5 juveniles, and 7 females from soil about roots of Sunki orange rootstock near Chiayi, Taiwan in May 1975. Measurements of males and females and a description of the male by C. S. Huang are:

12 females (Chiayi): L = .35 (.32-.37) mm; a = 24 (19-30); b = 3.4 (3.0-3.8); c = 16 (15-19); V = 82 (81-84).

9 males (Chiayi): L = .31 (.29-.35) mm; a = 29 (27-30); c = 14 (11-16); spicules = 19 (17-20) μm .

Male (Chiayi): Body shape after fixation variable. Some an open 'C' shape; others tightly curved; tail overlapping body. Body gradually narrows anteriorly, then more abruptly at rounded head. Sclerotization delicate. Stylet lacking. Hemizonid anterior to excretory pore; occupies about 3 body annules in length. Testis outstretched. Cloacal opening with prominent sheath and hooked posterior margin. Spicules slender, curved. Caudal alae not observed. Tail narrows gradually with slender

conoid shape; terminus finely rounded, almost acute.

Gracilacus enata n. sp.
(Fig. 29-35)

Paratypes (16 females): L = .31 (.25-.35); a = 26 (23-28); b = 2.3 (2.1-2.4); c = 12 (11-13); V = ¹⁷ (15-20) 78 (74-80); stylet = 94 (82-104) μ m; prorhabdion = 83

(72-92) μ m; excretory pore = 90 (80-110) μ m.

Paratypes (2 males): L = .34-.35 mm; a = 33-34; c = 10; spicules = 17-18 μ m; gubernaculum = 3 μ m; T = 31-38; excretory pore = 75-80 μ m.

Holotype (female): L = .35 mm; a = 27; b = 2.4; c = 12; V = ¹⁷ 77; stylet = 104 μ m; prorhabdion = 92 μ m; excretory

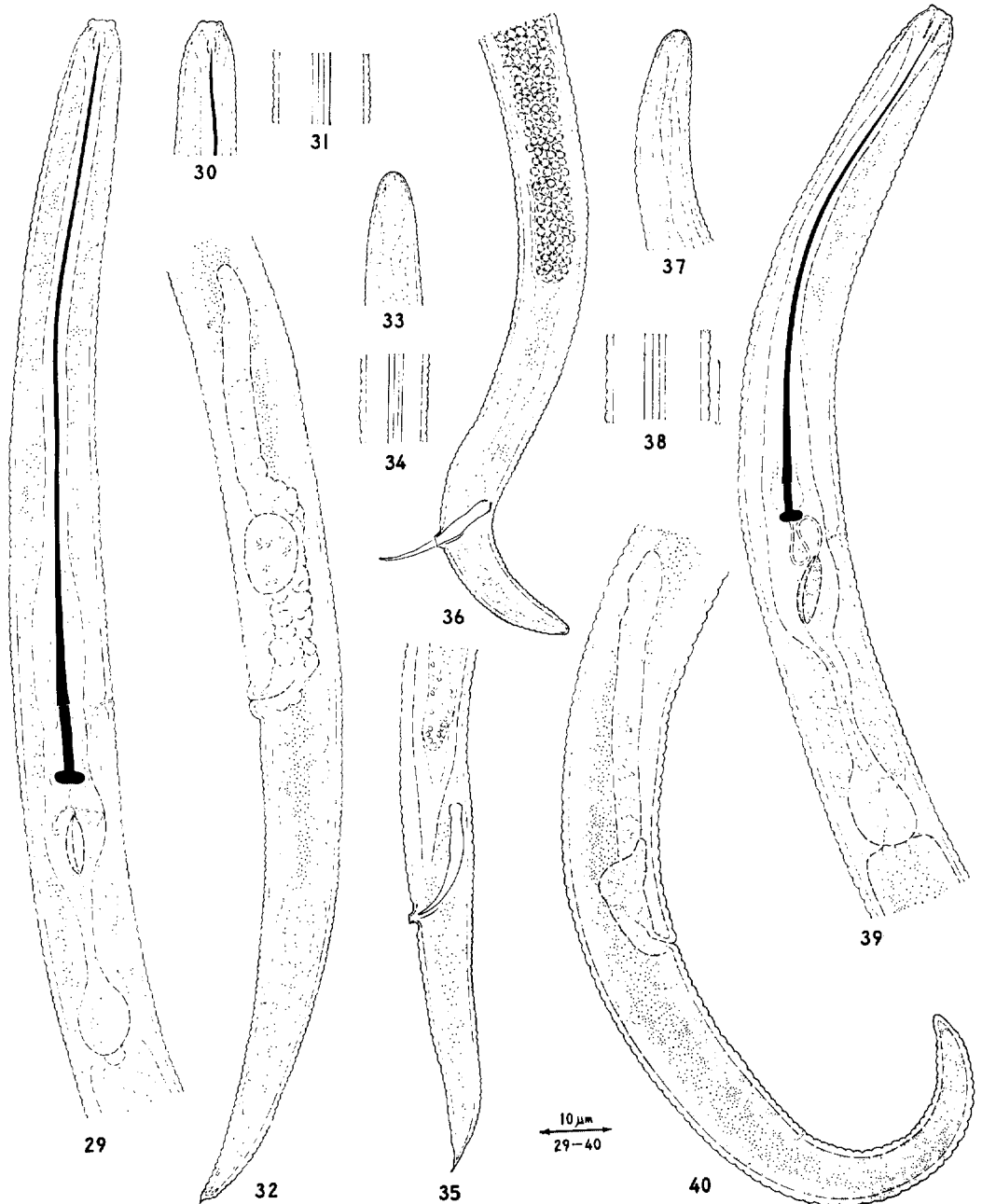


FIG. 29-40. 29-35) *Gracilacus enata* n. sp. 36-40) *Gracilacus teres* n. sp.

pore = 97 μm . Body only slightly curved ventrally after fixation. Body gradually narrows anteriorly; ends in a constriction or depression setting off sub-median lobes or lips which are rounded and protrude forward. Sclerotization light; stylet guiding apparatus appears as two dark lines, slightly curved, near tip of retracted stylet (Fig. 29, 30). Stylet slender, with rounded knobs. Length of stylet shaft plus knobs 12 μm (8-14 μm in paratypes). Excretory pore anterior to stylet knobs. Ovary outstretched (Fig. 32); spermatheca spherical (spherical to slightly ovate in paratypes). Rounded vulvar lips protrude slightly. Lateral vulvar membranes absent. Tail slender conoid; annules distinct up to narrow, acute terminus. Body annules average less than 1 μm in width. Lateral field with 4 incisures equally spaced and distinct (Fig. 31).

Allotype (male): L = .34 mm; a = 36; c = 9; spicules = 17 μm ; gubernaculum = 4 μm ; T = 31; excretory pore = 75 μm . Body an open 'C' shape; curved dorsally after fixation. Body gradually narrows anteriorly to a slender rounded head. Sclerotization light; stylet lacking (Fig. 33). Hemizonid at level of excretory pore. Testis outstretched; sperm small. Testicular gland prominent. Spicules curved slightly; cloacal sheath short, without protrusion of posterior margin. Caudal alae not observed. Tail slender, conoid; terminus finely rounded, almost acute (Fig. 35). Body annules average less than 1 μm in width. Lateral field with 4 incisures equally spaced and distinct (Fig. 34).

Juveniles (4 second stage ?): L = .23 (.18-.29) mm; a = 20 (18-23); b = 2.6 (2.1-3.2); stylet = 49 (45-51) μm ; prorhabdion = 41 (38-43) μm ; excretory pore = 70 (64-77) μm . Body narrows at head to set-off protruding lips or submedian lobes similar to female. Stylet slender; distinct and well-developed knobs directed posteriad. Excretory pore at level of isthmus. Gonad 7 (6-8) μm long, 59 (55-65) μm from terminus. Tail slender, conoid; ends in finely rounded terminus.

Juveniles (6 fourth stage): L = .31 (.27-.34) mm; a = 24 (21-27); b = 3.3 (3.1-3.6); excretory pore = 81 (66-89) μm . Body narrows at head to set-off protruding lips or submedian lobes similar to females. Stylet lacking. Procorpus elongate. Excretory pore

at level of isthmus. Gonad 39 (29-50) μm long, 70 (65-77) μm from terminus. Tails slender, conoid; some narrow abruptly near terminus and give hook-like or digitate appearance. Terminus finely rounded to acute.

Holotype: Female, collected by A. Lizana on September 26, 1968, slide number 1444, UCNS Collection, Davis, California.

Allotype: Male, same data as holotype, slide number 1445, UCNS Collection, Davis, California.

Paratypes: 24 females, 2 males, 18 juveniles, same data as holotype, deposited as follows: 17 females, 2 males, 12 juveniles in UCNS Collection, Davis, California; 3 females, 1 juvenile in USDA Nematode Collection, Beltsville, Maryland; 1 female, 4 juveniles in National Nematode Collection, IARI, New Delhi, India; 1 female, 1 juvenile in Nematology Department, Rothamsted Experimental Station, Harpenden, England; 1 female each in Plantenziektenkundige Dienst, Wageningen, The Netherlands, and UCNS Collection, Riverside, California.

Type host: Custard apple, or Chirimoya var. Concha Temarana, *Annona cherimola* Mill.

Type locality: Quillota, Chile.

Diagnosis: This species is most closely related to *G. teres* n. sp. from which it differs in the longer stylet [74 (72-75) μm for *G. teres*] and acute tail (rounded in *G. teres*).

Gracilacus teres n. sp. (Fig. 36-40)

Paratypes (14 females): L = .31 (.29-.35) mm; a = 21 (19-25); b = 2.6 (2.4-2.7); c = 13 (10-15); V = ¹⁸ (15-20) 74 (72-75); stylet = 74 (69-83) μm ; prorhabdion = 68 (64-77) μm ; excretory pore = 77 (70-85) μm .

Paratypes (6 males): L = .35 (.29-.38) mm; a = 30 (29-31); b = 3.9; c = 16 (15-17); spicules = 18 (16-19) μm ; gubernaculum = 4 μm ; T = 35 (34-37); excretory pore = 71 (55-80) μm .

Holotype (female): L = .30 mm; a = 21; b = 2.4; c = 13; V = ²⁰ 74; stylet = 73 μm ; prorhabdion = 67 μm ; excretory pore = 78 μm . Body after fixation an open 'C' shape; more strongly curved posterior

to vulva. Body very gradually narrows anteriorly, with distinct annules up to slight constriction which sets off small, rounded, submedian lobes or lips. Lateral lips rounded, at same level with submedian lobes, give tri-lobed outline which is rounded (almost truncate outline in some paratypes). Sclerotization of head, light; stylet guiding apparatus appears as two dark straight lines near tip of retracted stylet (Fig. 39). Stylet slender; curves dorsad more than curvature of body; knobs small, rounded. Length of stylet shaft plus knobs $6\text{ }\mu\text{m}$ ($5\text{--}7\text{ }\mu\text{m}$ in paratypes). Dorsal gland orifice not visible because esophageal lumen coils. Excretory pore at level between stylet knobs and valve of median bulb. Small hemizonid at level of excretory pore. Isthmus slender, elongate. Esophago-intestinal valve distinct, small, lobate. Ovary outstretched; spermatheca inconspicuous, without sperm (Fig. 40). Vulva inconspicuous without lateral vulvar membranes. Tail conoid; narrows gradually, with distinct annules almost to bluntly rounded terminus. Body annules average $1.0\text{--}1.5\text{ }\mu\text{m}$ in width. Lateral field with 4 incisures, equally spaced about $1\text{ }\mu\text{m}$ apart, inner 2 lighter than outer 2 (Fig. 38).

Allotype (male): $L = .38\text{ mm}$; $a = 31$; $c = 15$; spicules = $18\text{ }\mu\text{m}$; gubernaculum = $4\text{ }\mu\text{m}$; $T = 36$; excretory pore = $80\text{ }\mu\text{m}$. After fixation, body coils tightly, especially in posterior portion. Body gradually narrows anteriorly, then narrows more abruptly near lips to set-off small protruding lips or submedian lobes which are somewhat like holotype head but lips do not protrude so distinctly. Sclerotization delicate; stylet lacking (Fig. 37). Hemizonid 2 body annules posterior to excretory pore. Testis outstretched, surrounded in posterior portion by prominent testicular gland. Spicules curved slightly. Cloacal sheath distinct, without hook-like extension of posterior margin. Tail narrows gradually to conoid outline, with bluntly rounded terminus (Fig. 36). Body annules average $1.0\text{--}1.5\text{ }\mu\text{m}$ in width. Lateral field very faint, with 4 incisures equally spaced; inner 2 lighter than outer 2.

Juveniles (5 fourth stage ?): $L = .34$ ($.30\text{--}.36$) mm ; $a = 21$ ($17\text{--}25$); $b = 4.1$ ($3.9\text{--}4.2$); stylet = 16 ($15\text{--}19$) μm ; prorhabdion = 13 ($11\text{--}15$) μm ; excretory pore = 78 (72--

84) μm . Head rounded similar to female. Stylet much reduced, knobs slight swellings. Excretory pore near posterior end of metacarpus. Developing gonad $16\text{--}41\text{ }\mu\text{m}$ long, $72\text{--}104\text{ }\mu\text{m}$ from bluntly rounded terminus.

Holotype: Female, collected by R. D. Sharma in 1973, slide number 1450, UCNS Collection, Davis, California.

Allotype: Male, same data as holotype, slide number 1451, UCNS Collection, Davis, California.

Paratypes: 14 females, 6 males, 19 juveniles, same data as holotype, deposited as follows: 6 females, 1 male, 17 juveniles in UCNS Collection, Davis, California; 2 females, 1 male, 1 juvenile in National Nematode Collection, IARI, New Delhi, India; 2 females, 1 male in USDA Nematode Collection, Beltsville, Maryland; 1 female, 1 male, 1 juvenile in Nematology Department, Rothamsted Experimental Station, Harpenden, England; 1 female, 1 male each at Plantenziektenkundige Dienst, Wageningen, The Netherlands, and UCNS Collection, Riverside, California.

Type host: *Theobroma cacao* L.

Type locality: Linhares, Espirito Santo, Brazil.

Diagnosis: This species is most closely related to *G. steineri* and *G. enata* n. sp. It differs from *G. steineri* in its set-off, protruding lips (head rounded in *G. steineri*) and longer stylet [67 ($65\text{--}69$) μm for *G. steineri*]. It differs from *G. enata* by its rounded tail (acute in *G. enata*) and shorter stylet [94 ($82\text{--}104$) μm in *G. enata*].

Distribution: Four other collections, all from *T. cacao*, were identified as this species. One is from Linhares, the type locality of *G. teres*; two others are from the same general area of Espirito Santo; and the fourth is from Mutuipe at Fazenda do Dr. Rui.

SPECIES INQUIRENDAE

Paratylenchus strenzkei (Volz, 1951)

Oostenbrink, 1960

syn. *Hemicycliophora*

(= *Procriconema*) *strenzkei*

Volz, 1951

There are no type specimens of *P. strenzkei*. Volz (13) described his specimens as juveniles, but undoubtedly the vulva was mistaken for the anus, and they were indeed females.

In 1952, Volz sent one specimen for examination which he had identified as *P. strenzkei*. This was a juvenile with measurements as follows: L = .19 mm; a = 15; b = 2.4; stylet = 42 μ m; prorhabdion = 32 μ m. Adhering to the specimen was part of the previous cuticle with a molted prorhabdion measuring 30 μ m. There is no way of determining whether the juvenile was third- or fourth-stage.

Geraert (6) probably was correct in judging this species to be synonymous with *P. straeleni*, but in the absence of designated type specimens from the type locality, it is best to assign this species to *species inquirendae*.

KEY TO SPECIES OF *GRACILACUS*

1. Lateral field with 2 incisures 2.
Lateral field with 3 incisures 3.
Lateral field with 4 incisures 8.
2. Female stylet = 68-76 μ m
..... *peperpolli* Schoemaker, 1963.
Female stylet = 100-119 μ m
..... *elegans* Raski, 1962.
3. Lateral vulvar membranes small
..... *idalima* Raski, 1962.
Lateral vulvar membranes lacking 4.
4. Female tail bluntly rounded 5.
Female tail subacute to finely rounded or deformed 6.
5. Female stylet = 58 (48-68) μ m; b = 2.7 (2.3-4.1) *aculeata* (Brown, 1959).
Female stylet = 75 (63-80) μ m; b = 2.2 (1.7-2.5) *latescens* n. sp.
6. Female stylet = 61-69 μ m
..... *acicula* (Brown, 1959).
Female stylet >69 μ m 7.
7. Female length = .24 (.21-.25) mm; tail mostly deformed, some subacute
..... *solivaga* n. sp.
Female length = .31 (.29-.34) mm; tail subacute *costata* n. sp.
8. Lateral vulvar membranes present 9.
Lateral vulvar membranes absent 24.
9. Female head with submedian lobes or lips prominent and/or protruding 10.
Female head conoid to rounded 12.
10. Female stylet = 92 (86-95) μ m
..... *peratica* Raski, 1962.
Female stylet <60 μ m 11.
11. Female stylet = 48-57 μ m; knobs delicate; submedian lobes prominent but not set off *mutabilis* (Colbran, 1969).
Female stylet = 56-60 μ m; knobs strongly developed; submedian lobes set off by slight constriction *parvula* n. sp.
12. Excretory pore at isthmus or more posterior 13.
Excretory pore near valve of median bulb or more anterior 21.
13. Spermatheca absent; spermagonium present, round *robusta* Wu, 1974.
Spermatheca present 14.

14. Spermatheca ovoid to ovoid-elongate 15.
Spermatheca spherical 17.
15. Female head conical with rounded apex; stylet = 48-56 μ m
..... *goodeyi* (Oostenbrink, 1953).
Female head rounded or a truncated cone; stylet >55 μ m 16.
16. Female length = .25-.31 mm; stylet = 53-65 μ m; male length = .28-.34 mm
..... *aonli* Misra and Edward, 1971.
Female length = .38 (.33-.42) mm; stylet = 66 (63-70) μ m; male length = .36-.42 mm *pandata* n. sp.
17. Posterior edge of annules on females crenate *crenata* (Corbett, 1966).
Posterior edge of annules on females smooth 18.
18. Female head a truncated cone
..... *marylandica* (Jenkins, 1960).
Female head rounded 19.
19. Female head smooth; corpus swells markedly in posterior half *abietis* (Eroshenko, 1974).
Female head with fine annulations; corpus without marked swelling in posterior half 20.
20. V = 73-77; b = 2.8-3.2
..... *ivorensis* (Luc and de Guiran, 1962).
V = 79-85; b = 3.0-4.5
..... *straeleni* (de Coninck, 1931).
21. Female tail bluntly rounded
..... *epacris* (Allen and Jensen, 1950).
Female tail subacute to finely rounded 22.
22. Female stylet = 97 (91-102) μ m
..... *anceps* (Cobb, 1923).
Female stylet <92 μ m 23.
23. Female tail subacute to rounded; stylet = 89 (83-92) μ m *intermedia* Raski, 1962.
Female tail finely rounded, almost acute; stylet = 77 (70-85) μ m *mira* Raski, 1962.
24. Female stylet = 41-46 μ m
..... *micoletzkyi* (Edward, Misra and Singh, 1967).
Female stylet >63 μ m 25.
25. Female head rounded to conoid but submedian lobes not set off 26.
Female head with submedian lobes set off or protruding 28.
26. Female stylet = 67 (65-69) μ m
..... *steineri* (Golden, 1961).
Female stylet >72 μ m 27.
27. Female length = .25-.28; excretory pore at isthmus, opposite nerve ring
..... *oostenbrinki* Misra and Edward, 1971.
Female length = .33-.39; excretory pore near knobs of stylet
..... *macroдора* (Brzeski, 1963).
28. Female stylet = 74 (69-83) μ m; tail bluntly rounded *teres* n. sp.
Female stylet = 94 (82-104) μ m; tail acute *enata* n. sp.

LITERATURE CITED

1. ALLEN, M. W., and S. A. SHER. 1967. Taxonomic problems concerning the phytoparasitic nematodes. *Annu. Rev. Phytopathol.* 5: 247-264.
2. BROWN, G. L. 1959. Three new species of the genus *Paratylenchus* from Canada (Nematoda: Criconeematidae). *Proc. Helminthol. Soc. Wash.* 26:1-8.

3. COLBRAN, R. C. 1969. Studies of plant and soil nematodes. 14. Five new species of *Tylenchorhynchus* Cobb, *Paratylenchus* Micoletzky, *Morulaimus* Sauer and *Hemicyclophora* de Man (Nematoda: Tylenchoidea). Queensl. J. Agric. Anim. Sci. 26:181-192.
4. DEMENT'EVA, S. P. 1972. *Thornenema* uniformis, sp. n., and *Paratylenchus* longistylusa, sp. n., new species of plant nematodes from the rhizosphere of tobacco. IZV Akad. Nauk. Mold. SSR Ser. Biol. Khim. Nauk. 4:62-64.
5. EROSHENKO, A. S. 1974. A new nematode from coniferous forests in the Far East of the USSR. Parazitologiya 8:220-222.
6. GERAERT, E. 1965. The genus *Paratylenchus*. Nematologica 11:301-334.
7. GOLDEN, A. M. 1971. Classification of the genera and higher categories of the Order Tylenchida (Nematoda). Pages 191-232, in B. M. Zuckerman, W. F. Mai and R. A. Rohde, eds. Plant parasitic nematodes. Academic Press, New York.
8. MISRA, S. L. and J. C. EDWARD. 1971. Two new species of the genus *Paratylenchus* with description of their larval stages and a note on *P. nawadus* a synonym of *P. nainianus*. Allahabad Fmr. 45:345-351.
9. OOSTENBRINK, M. 1953. A note on *Paratylenchus* in the Netherlands with the description of *P. goodeyi* n. sp. (Nematoda: Criconematidae). Tijdschr. Plantenziekten. 59: 207-216.
10. RASKI, D. J. 1962. *Paratylenchidae* n. fam. with descriptions of five new species of *Gracilacus* n. g. and an emendation of *Cacopaurus* Thorne, 1943, *Paratylenchus* Micoletzky, 1922 and *Criconematidae* Thorne, 1943. Proc. Helminthol. Soc. Wash. 29:189-207.
11. SIDDIQI, M. R., and J. B. GOODEY. 1963. The status of the genera and subfamilies of the Criconematidae (Nematoda); with a comment on the position of *Fergusobia*. Nematologica 9:363-377.
12. THORNE, G., and R. B. MALEK. 1968. Nematodes of the Northern Great Plains. Part I. Tylenchida (Nemata: Secernentea). S. D. Agric. Exp. Stn. Tech. Bull. 31:1-111.
13. VOLZ, P. 1951. Untersuchungen über die Mikrofauna des Waldbodens. Zool. Jahrb. 79 (5/6):514-566.
14. WU, L. Y. 1974. *Paratylenchus robustus* n. sp. (*Paratylenchinae*: Nematoda) from forest soil in Ontario. Can. J. Zool. 52:1423-1425.