Taxonomic Limits of the Genus Nagelus (Thorne and Malek, 1968) Siddiqi, 1979 with a Description of Nagelus borealis n.sp. from Alaska[1]

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Abstract: The genus *Nagelus* (Thorne and Malek, 1968) Siddiqi, 1979 is modified and a new species from Alaska is described. The combination of scanning electron microscopy and light microscopy permits the characterization of *Nagelus* spp. as having a broadly oval face pattern, no longitudinal striations on the lip region, deirids surrounded by six incisures, and an irregularly tapering tail with a large hyaline region. *Nagelus leptus* (Allen, 1955) Siddiqi, 1979, *N. alpensis* Doucet and Luc, 1981, *N. camelliae* (Kheiri, 1972) Siddiqi, 1979, *N. jamelensis* (Nesterov, 1973) Siddiqi, 1979, and *N. obscurus* (Allen, 1955) n. comb. are retained on this basis. *Nagelus borealis* n. sp. is characterized by a stylet length of 30 μm or more, an irregularly scalloped perioral disc, and a proportionately larger basal bulb. *Nagelus abalosi* (Doucet, 1978) Doucet, 1980 and *N. virginalis* (Doucet, 1978) Doucet, 1980 are synonymized with *N.* leptus. Nine other species from *Nagelus* are transferred to *Merlinius* Siddiqi, 1970. *Key words:* Merliniinae, taxonomy, Tylenchorhynchidae, scanning electron microscopy.

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The tylenchorhynchids are a widely distributed group of plant parasitic nematodes, frequently encountered in soil samples but seldom considered the sole source of plant disease. Biologically, they are not well known, in part, perhaps, because of their presumed innocuous role in crop production, but more likely owing to the effort required to identify them. Many of their diagnostic characters are unobservable by standard light microscopy.

This difficulty with identification is perhaps responsible for classifications that have stressed the ease of identification rather than phylogenetic relationship. Indeed, Tarjan in commenting on the creation of the genus *Merlinius* Siddiqi, 1970 states, "Although there can be reluctance to accept a new genus based on only one character, viz. six incisures, the character is consistent and easily recognizable. Since the objective of such action is to make the unwieldy genus *Tylenchorhynchus* less cumbersome, creation of the genus *Merlinius* is justifiable" (12). Recently, Siddiqi (11) proposed further changes by amending the other Tylenchorhynchid genera with six incisures (*Nagelus* Thorne and Malek, 1968, *Geocenamus* Thorne and Malek, 1968, *Scutylenchus* Jairajpuri, 1971) and included them along with *Amplimerlinius* Siddiqi, 1976 and *Merlinius* Siddiqi, 1970 in the subfamily Merliniinae Siddiqi, 1971.

Nagelus Thorne and Malek, 1968 was erected to accommodate one species, *N. aberrans* Thorne and Malek, 1968. It was considered distinct from *Tylenchorhynchus* Cobb, 1913 on the basis of an asymmetrical lip region without framework, angular spear knobs, protractor muscles attached to the inner wall of the labial cavity, and the presence of an epiptygma. *Nagelus* remained monotypic until 1979 when Siddiqi rediagnosed the subfamily Merliniinae. *Nagelus* received 11 species transferred from *Merlinius,* and *N. aberrans* was synonymized with *Merlinius leptus* (Allen, 1955) Siddiqi, 1970. The emended *Nagelus* (Thorne and Malek, 1968) Siddiqi, 1979 was characterized by lip annules without longitudinal striations, an offset lip region, and robust spicules and stylet. Subsequently, three new species of *Nagelus* were described: *N. abalosi* (Doucet, 1978) Doucet, 1980; *N. virginalis* (Doucet, 1978) Doucet, 1980; and *N. alpensis* Doucet and Luc, 1981 (1,2,3,4).

Following an examination of type specimens of 13 of 15 nominal species and 13 populations of *Nagelus leptus,* we have reevaluated the generic limits of *Nagelus,* transferred back to *Merlinius* those species not within those limits, synonymized *N.*

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abalosi and *N. virginalis* with *N. leptus*, and described one new species from Alaska.

MATERIALS AND METHODS

All specimens we collected for examination were obtained through the Cobb sieving technique and the modified Baermann funnel. Specimens were killed and fixed in hot formalin, processed into glycerin, and mounted on Cobb slides. Individual specimens were examined first by light microscopy (LM), then the slides were dismantled and the nematodes were mounted for scanning electron microscopy (SEM). Nematodes used for SEM were processed according to the methods of Sher and Bell, 1975 (10).

The following specimens were examined by SEM: *Nagelus leptus* from Mt. San Gorgonio, California; Bridger Mountains, Montana; Farmington Flats and Soldier Canyon, Utah. *N. affinis* (Allen, 1955) Siddiqi, 1979 from Dripping Springs and Santa Cruz Island, California. *N. borealis* n.sp. from Aligun and Chena Hot Springs, Alaska. *N. conicus* (Allen, 1955) Siddiqi, 1979 from Canyon de Chelly, Arizona; Cedar Valley, Curlew Valley, and Soldier Canyon, Utah. *N. grandis* (Allen, 1955) Siddiqi, 1979 from Mentone and Victorville, California; Mercury, Nevada; Las Cruces, New Mexico. *N. hexagrammus* (Sturhan, 1966) Siddiqi, 1979 from Mittenburg Main, Germany. *N. lineatus* (Allen, 1955) Siddiqi, 1979 from Bridger Mountains, Montana. *N. macrodens* (Allen, 1955) Siddiqi, 1979 from Bridger Mountains, Montana. *N. superbus* (Allen, 1955) Siddiqi, 1979 from Mt. San Jacinto and Santa Cruz Island, California. *Merlinius obscurus* (Allen, 1955) Siddiqi, 1979 from Hampshire and Wales, England; Wyszoqrad Dist., Poland. *M. parobscurus* (Mulvey, 1969) Tarjan, 1973 from Prudhoe Bay, Alaska.

Type specimens of all *Nagelus* species were examined by LM with the exception of *N. kirjanovae* (Sagitov, 1973) Siddiqi, 1979 and *N. jamalensis* (Nesterov, 1973) Siddiqi, 1979.

SYSTEMATICS

Nagelus (Thorne and Malek 1968) Siddiqi, 1979

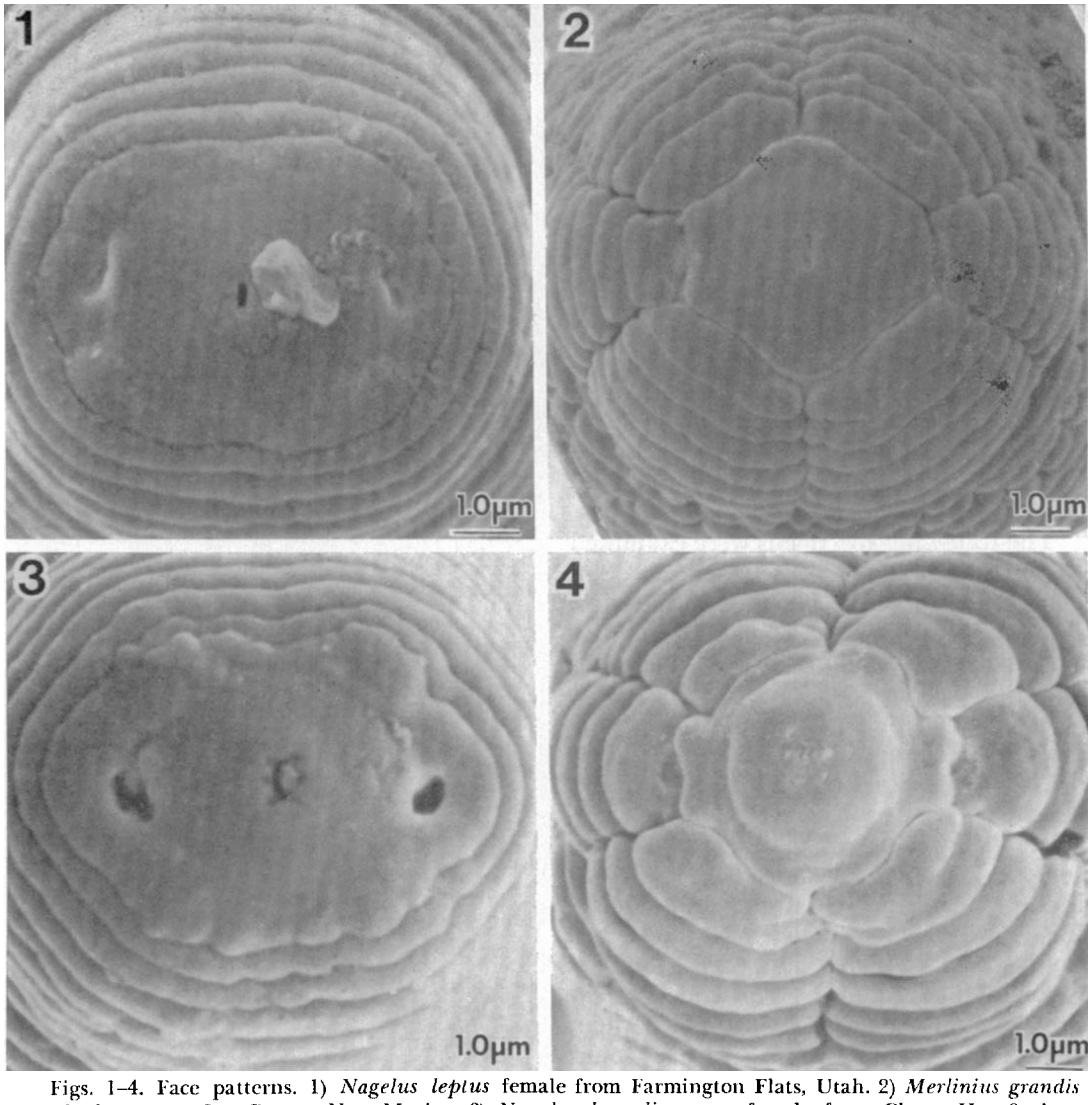
Nagelus—Type species: *Nagelus aberrans* Thorne and Malek, 1968 by monotypy (junior subjective synonym of *Nagelus leptus* [Allen, 1955] Siddiqi, 1979).

As noted by Siddiqi, 1979, Thorne and Malek's original description of *Nagelus* was vague and inaccurate in a few respects. The cephalic framework is moderately sclerotized rather than "absent." The protractor muscles do not attach to the inner wall of the labial cavity and the vulval structures are not sclerotized. These three characteristics are of minor taxonomic importance. The fourth, lateral elongation of the head, bears special attention. This trait, visible from a face view of *Nagelus leptus* (Fig. 1) (the senior synonym of *N. aberrans*), results in a somewhat broadly oval shape. No longitudinal striae interrupt the head annules, and the amphid apertures lie within the boundary of the first annule. It is the lateral elongation of the head that is responsible for confusion concerning the degree of "offsetness" in *N. leptus*. Depending on the orientation of the head, it may appear continuous, asymmetrical, or distinctly offset. When the head and body are laterally aligned, the head seems slightly offset. Obviously, this character must be interpreted with caution.

None of the species transferred to *Nagelus* by Siddiqi, 1979 that we have observed by SEM show a similar face view. Generally in these species the first annule is discontinuous (broken into smaller segments), and the boundary of the first annule is coincident with the amphid apertures (Figs. 2,4).

The absence of longitudinal striae on the lip region, a generic character in *Nagelus* sensu Siddiqi, is the exception rather than the rule. *Nagelus conicus, N. grandis, N. macrodens,* and *N. superbus* possess six complete longitudinal striations on the lip region (Figs. 6,7,8). *Nagelus affinis* and *N. lineatus* have at least partial longitudinal striations on the lip region. These striations may be reduced in length, extending only a few annules, or reduced in number with the absence of the dorsal and ventral striae. This range of striation patterns in the lip region is also observed in *Merlinius*.

Additional characters emphasize the distinction between *N. leptus* and putative "*Nagelus*" species but indicate affinities with other Merliniinae. The deirids of *N.*

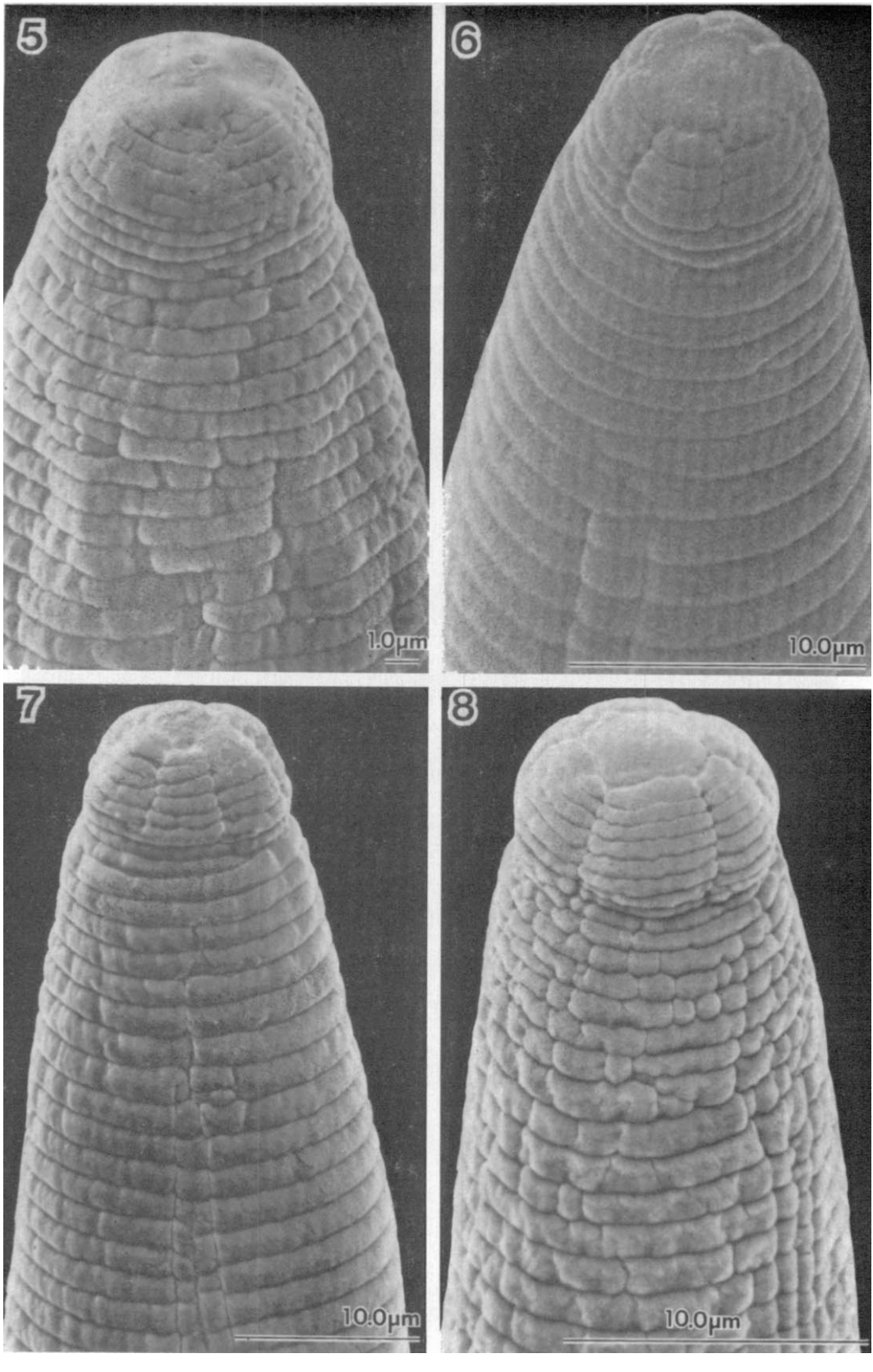


Figs. 1–4. Face patterns. 1) *Nagelus leptus* female from Farmington Flats, Utah. 2) *Merlinius grandis* female from near Las Cruces, New Mexico. 3) *Nagelus borealis* n. sp. female from Chena Hot Springs Rd., Alaska. 4) *Merlinius superbus* female from Santa Cruz Island, California.

leptus lie in the part of the lateral field where there are six incisures (Fig. 9). This is also the condition of *N. abalosi, N. alpensis, N. camelliae* (Kheiri, 1972) Siddiqi, 1979, and *N. virginalis,* but not for other *"Nagelus"* species. The deirids of *N. affinis, N. alpinus,* (Allen, 1955) Siddiqi, 1979, *N. conicus, N. grandis, N. hexagrammus, N. lineatus, N. macrodens,* and *N. superbus* lie in the part of the lateral field where there are four incisures (Fig. 10). The deirids of *Merlinius* spp. are similarly located at the four-incisure points.

The presence of a relatively long hyaline region on the tail terminus and an irregularly tapering tail further characterize *N. leptus* and those related species with the deirid at the six-incisure point. Those *"Nagelus"* with a deirid at the four-incisure point have a shorter hyaline region relative to tail length and a more regularly annulated tail.

Figs. 5–8. Head regions. 5) Lateral view, *Nagelus leptus* female from Farmington Flats, Utah. 6) Lateral view, *Merlinius affinis* female from Santa Cruz Island, California. 7) Lateral view, *Merlinius superbus* female from Santa Cruz Island, California. 8) Sublateral view, *Merlinius grandis* female from near Las Cruces, New Mexico.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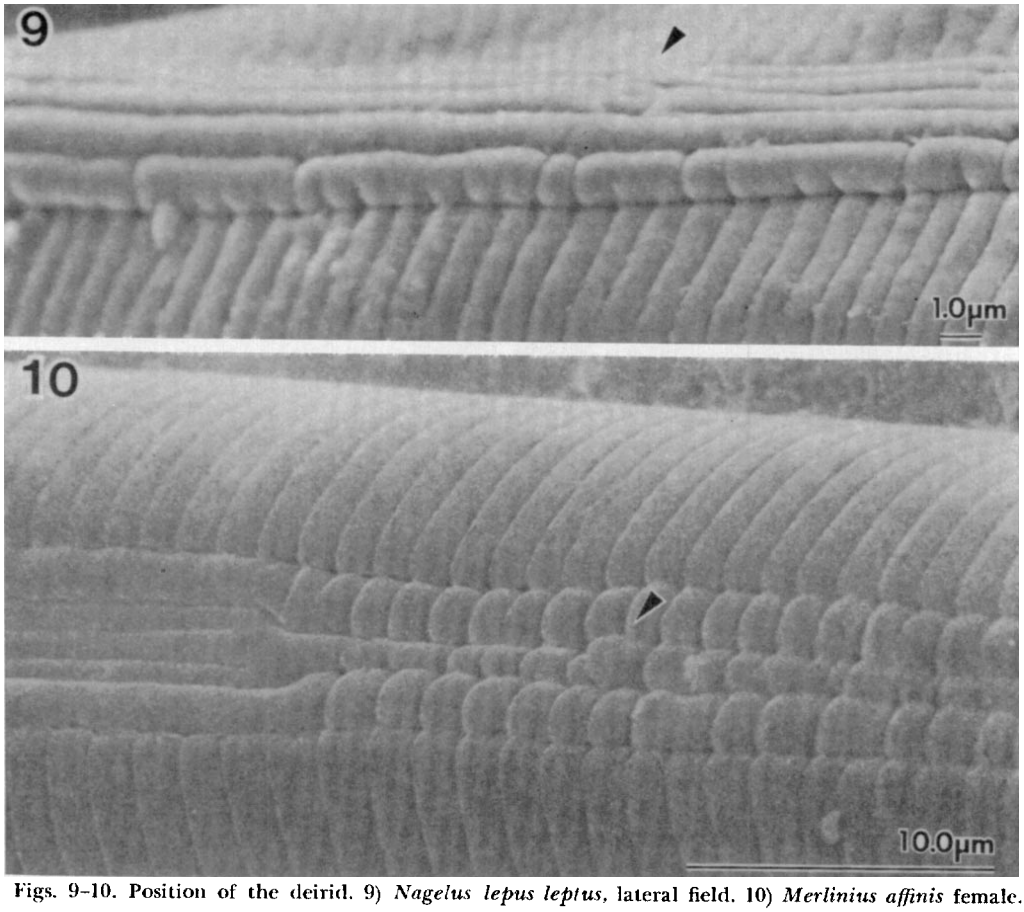


Figs. 9–10. Position of the deirid. 9) *Nagelus lepus leptus*, lateral field. 10) *Merlinius affinis* female.

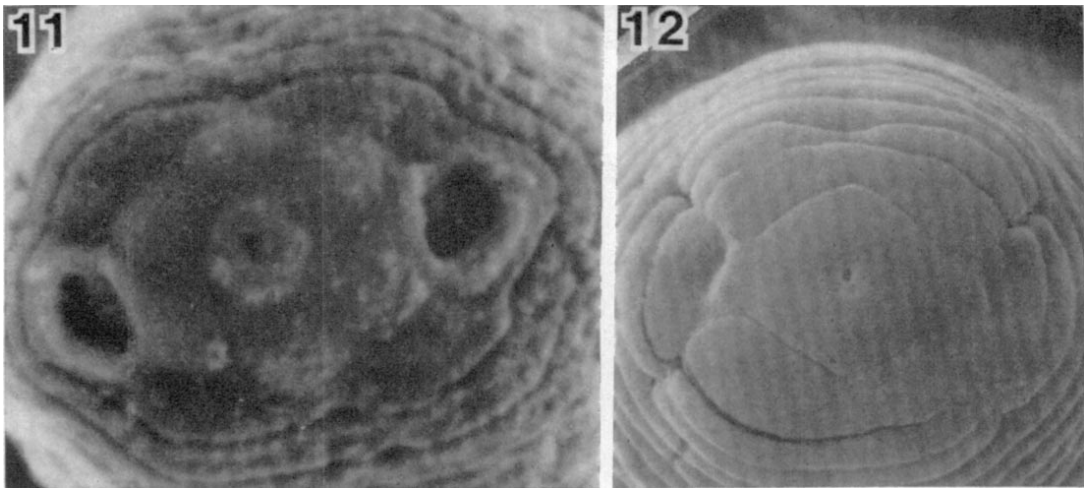
It seems, therefore, that *Nagelus* can be better characterized by the following four features: 1) a somewhat broadly oval face, laterally elongated, with amphid apertures well within the continuous boundary of the first annule, 2) no longitudinal striations interrupting the lip annules, 3) deirid surrounded by six longitudinal incisures, and 4) an irregularly tapering tail with a long hyaline region. On this basis, *Merlinius obscurus* (Allen, 1955) Siddiqi, 1970 is herein transferred to *Nagelus* (Fig. 11) and *N. affinis, N. alpinus, N. conicus, N. grandis, N. hexagrammus, N. kirjanovae, N. lineatus, N. macrodens,* and *N. superbus* are removed from *Nagelus* and tentatively returned to *Merlinius*. Characteristics used by Siddiqi to differentiate those species from *Merlinius* are either size related—i.e., open vs. closed vulva, robust vs. not robust spear, spicules robust vs. relatively slender, modified vs. unmodified gubernaculum—or inaccurate (discussed above). The taxonomic placement of these species will be dealt with more fully in a following paper.

Nagelus abalosi, N. virginalis, and *N. leptus*

We were unable to see any difference between *N. abalosi, N. virginalis,* and *N. leptus*. They are nearly identical morphometrically (Table 1). The tenuous differentiating character of slightly offset head vs. not offset head was discussed above.

Contrary to the statement by Doucet that a "well-developed double epiptygma projected above the level of the body surface" is an "unusual character in the genus," and therefore helps differentiate *N. virginalis,* Thorne used this character to diagnose the genus and included two illustrations of it (11). Furthermore, epiptygmas are found throughout Merliniinae, ranging from barely conspicuous cuticular projections within the vulva to long cuticular "flaps" which protrude a few micrometers from the vulva.

Intraspecific variation in lateral incisure



Figs. 11–12. Face patterns. 11) *Nagelus obscurus* n. comb. Courtesy of D. J. Hooper. 12) *Merlinius parobscurus* female from Prudhoe Bay seashore tundra, Alaska.

spacing (lateral field width) obscures any interspecific differences in this character. Measurements from paratype specimens from all three species show that lateral field width is usually 6–7.5 μm at the level of the deirid, widens to 8–9 μm midbody, and narrows to 6–7.0 μm at anal level.

Tail annule number of both species, 64–84 in *N. abalosi* and 59–68 in *N. virginalis,* is subsumed by the range of *N. leptus* which was found to be as large as 55–88 ($\bar{x}$ = 67) in one population (Farmington Flats, Utah). Further information on variation of tail annule number is presented in Table 2. Therefore, *N. abalosi* and *N. virginalis* are synonymized with *N. leptus.*

Merlinius parobscurus

Merlinius parobscurus (Mulvey, 1969) Tarjan, 1973 appears to occupy an intermediate position between *Nagelus* and *Merlinius.* The female tail and position of the deirids are the same as *Nagelus,* and the spear is similar to that of *N. obscurus.* Yet the face view more nearly conforms to *Merlinius* spp. If fusion of cuticular labial segments and loss of longitudinal cephalic striations are interpreted as the direction of evolution, then *M. parobscurus* has lost most of its cephalic striations, retaining only partial lateral striae, occasional dorsal or ventral indentations, and a somewhat faint impression of the labial disc (Fig. 12). A more complete systematic analysis of *Merlinius* is needed before placement of this species is evident.

Diagnosis—Nagelus (emended): Merliniinae. Body generally C-shaped when fixed, 1 mm or less, cuticle without longitudinal striae. Lip region slightly offset, annules continuous, not marked by longitudinal striations. Perioral disc broadly oval, laterally elongated, amphid apertures lie within the boundary of the first annule. Deirids conspicuous, surrounded by six incisures. Lip sclerotization light to moderate, stylet usually greater than 20 μm, knobs often laterally elongated and sloping posteriorly. Epiptygma conspicuous. Female tail conoid, irregularly tapering with annulated terminus and long hyaline region. Phasmids usually anterior to middle of tail. Spicules and gubernaculum characteristics of Merliniinae. Spicules somewhat cylindroid with characteristic notched tip, gubernaculum trough shaped in lateral view. Fourth-stage juveniles possess six lateral lines.

Species of *Nagelus*

Nagelus leptus (Allen, 1955) Siddiqi, 1979
- syn. *Tylenchorhynchus leptus* Allen, 1955
- *Merlinius leptus* (Allen, 1955) Siddiqi, 1970
- *Nagelus aberrans* Thorne and Malek, 1968
- *Merlinius abalosi* Doucet, 1978
- *Nagelus abalosi* (Doucet, 1978) Doucet, 1980, new synonymy
- *Nagelus virginalis* (Doucet, 1978) Doucet, 1980, new synonymy

Table 1. Measurements* (um) of *Nagelus leptus* Females.

Species	reference	n	L	a	b	C	c′	Spear	H (hyaline region of the tail)	V
N. leptus										
Original description	(1)	14	... (640–960)	... (26–34)	... (4.5–5.7)	... (11–12)	... (3.4–4.2)	... (23–27)	... ...	... (51–56)
Farmington Flats, Utah	(**)	38	850 (730–980)	32 (27–37)	5.2 (4.5–5.7)	12.2 (10.4–13.8)	4.3 (3.8–5.2)	27 (25.0–29.5)	11 (9.5–15.0)	54 (52–57)
Mt. San Gorgonio, California	(**)	20	910 (730–1,145)	33 (26–40)	5.4 (4.7–6.2)	13.3 (11.6–15.1)	4.2 (3.2–5.2)	27.5 (26.5–29.0)	12.5 (9.0–15.0)	53 (50–57)
Steese Hwy., Alaska	(**)	10	860 (730–970)	30 (28–33)	6.0 (5.2–6.7)	11.2 (9.9–12.9)	4.1 (3.8–4.8)	27 (25.5–28.0)	15 (13.0–16.5)	53 (51–55)
Spitzbergen Island	(7)	30	790 (640–910)	28 (25–31)	5.5 (5.0–6.2)	11.6 (10.4–12.8)	3.5 (3.2–3.9)	26 (24–28)	... ...	54 (51–58)
Sweden	(9)	12	... (840–1,030)	... (32–37)	... (5.4–6.2)	... (11.2–13.6)	... (4–5)	... (25–28)	... ...	... (51–55)
N. (aberrans) syn. *leptus*										
Original description	(13)	...	900	31	5.8	15	...	27	...	62
Authors measurements of paratypes	(**)	6	785 (760–820)	23.5 (23–25)	5.5 (5.2–5.9)	11.7 (10–13)	3.5 (2.8–3.9)	26 (24.0–28.5)	12.5 (11–13)	53 (52–54)
N. (abalosi) syn. *leptus*	(2)	10	880 (830–930)	29 (28–31)	5.5 (5.3–5.7)	13 (12–14)	3.6 (3.2–3.9)	28 (28)	... ...	54.4 (53–56)
N. (virginalis) syn. *leptus*	(2)	15	970 (880–1,000)	33 (30–38)	5.5 (5.0–5.8)	14.3 (13.2–15.1)	3.0 (3.4–4.2)	28 (27–29)	... ...	54 (52–56)

*Averages outside parentheses; ranges within parentheses.
**Authors' measurements.

Table 2. Variation of tail annule number in *Nagelus leptus*.

Population	n	Mean*	Range	Standard deviation
N. (abalosi) syn. *leptus* Cantal, France	10	74	64–84	...†
Steese Hwy, Alaska	10	71.4 a	60–82	6.52
N. (aberrans) syn. *leptus* Wilmot, South Dakota paratypes	6	70.5 ab	64–80	7.26
Farmington Flats, Utah	38	67.2 abc	55–88	8.06
San Gorgonio, California	20	64.8 bc	55–73	4.94
Trail Ridge, Colorado paratypes	10	64.1 c	59–70	3.60
N. (virginalis) syn. *leptus* Alpes-Maritimes, France	15	64	59–68	...†

*Data analyzed by Duncan's multiple-range test; numbers followed by the same letter are not significantly different at $P = 0.05\%$.

†Standard deviations not available for either French population.

Type locality: Trail Ridge, Colorado.

Type host: Moss and lichens.

Distribution: Holarctic.

Records. United States—Alaska: Steese Hwy., mi 77 on alder; California: Mt. San Gorgonio on *Lilium sp.* and *Juncus* sp.; Montana: Bridger Mountains in a meadow; New Mexico: Taos in Carson National Forest; North Dakota; Granville on prairie sod; South Dakota: Black Hills in a meadow near Sylvan Lake, Wilmot on hillside thicket; Utah: Boulder Mountain on aspen, Cedar Breaks National Monument on juniper, Farmington Flats on aspen and rose, Fish Lake on sod, Mt. Timpanogos on sod, Soldier Canyon on willow and birch; Wisconsin: Greenlake on grass. Canada: Lake Lenore and Mt. McGill. Austria: Lechtal, Gneis. Italy: Dolomites. Sweden: Spitzbergen Island. Switzerland: Briency, Furkastrasse, Dischmalal, Airolz. USSR: Kazakhstan.

N. alpensis Doucet and Luc, 1981

Type locality: Plan Caval, Commune de Peira Cava, Alpes maritimes, France.

Type host: soil from prairie with grass.

Distribution: known only from type locality.

N. camelliae (Kheiri, 1972) Siddiqi, 1979

Syn. *Merlinius camelliae,* Kheiri, 1972

Type locality: Lahidja and Shahsavar, Iran.

Type host: tea at Lahidja and orange at Shahsavar.

Distribution: known only from type locality in Iran and from Firuzkoy, Turkey around garlic.

N. jamalensis (Nesterov, 1973) Siddiqi, 1979

syn. *Tylenchorhynchus jamalensis* Nesterov, 1973

Merlinius jamalensis (Nesterov, 1973) Hooper, 1978

Type locality: Yamal Peninsula, North of Seyakhe, Siberia USSR

Type host: arctic vegetation.

Distribution: known only from type locality.

N. obscurus (Allen, 1955) n. comb.

syn. *Tylenchorhynchus obscurus* Allen, 1955

Tylenchorhynchus goodeyi Marinari, 1962

Quinisulcius goodeyi (Marinari, 1962) Siddiqi, 1971

Merlinius obscurus (Allen, 1955) Siddiqi, 1970

Type locality: Gendrigen, The Netherlands.

Type host: "soil."
Distribution: United States and Europe.
Records. United States—Alaska: Fairbanks on white spruce. England: Cambridgeshire on ryegrass, St. Albans in turf. France: St. Honorat Island on grass. Holland. Italy: Compiabbi, Florence in meadow. Poland: Vistulla riverbank, Wyszograd Dist., in sand.

N. borealis n. sp.
Type information: see below.

DISCUSSION

Nagelus and Amplimerlinius Siddiqi, 1976 both lack longitudinal striae of the lip region, possess deirids in the region of the cuticle with six incisures, and have an extensive hyaline region of the tail, all characteristics which we believe may be synapomorphic. *Amplimerlinius* differs from *Nagelus* in the face view which is more rounded, the continuous lip region, and the female tail which is cylindrical with a hemispherical, annulated terminus.

Presently the six species in *Nagelus* can be discriminated on the basis of spear, length, knob shape, SEM face view, and the presence of males (or sperm in the spermatheca) (Table 3). *N. leptus,* the sole parthenogenetic species, is distinguished by conspicuously offset spermatheca, which are devoid of sperm, and a spear which ranges from 23 to 29 μm. As is typical for uniparental organisms (5), *N. leptus* shows a slight interpopulation variation in certain characteristics, such as mean stylet length, tail length, and body length.

N. alpensis and *N. jamalensis* are morphometrically similar, apparently distinguishable by the C ratio and spear length: 12.3–16.2 and 23.5–25.5 μm in the former; 8.3–9.5 and 27.5–28.0 μm in the latter. Both species are morphologically close to *N. leptus,* and either one could be biparental progenitors.

N. obscurus, unlike any other *Nagelus* sp., has small, rounded spear knobs and a continuous lip region. *N. camelliae* is the smallest species of the genus with a spear that does not exceed 22 μm. *N. borealis* n. sp. has the longest spear of the genus (all populations measured averaged 30 μm or more) and is further distinguished by the proportionally larger basal bulb and the irregularly scalloped perioral disc.

Nagelus species are most often encountered at higher elevations and the more northern latitudes. Hosts are varied, but most species have been associated with grasses.

Nagelus borealis n. sp.
(Figs. 3,13 A–G)

Measurements. Holotype (♀): L = .91 mm, a = 34, b = 5.4, c = 11.2, c′ = 4.4, V = 51, spear = 29.0 μm, MB (anterior end to metacorpus valve/esophageal length) = .48, H (length of hyaline region) = 18.0 μm, basal bulb/esophageal length = .18.

Paratypes (18 ♀): L = 0.83–0.99 (0.91 = mean ± .046 = standard deviation); a = 29–38 (32 ± 2.7); b = 5.2–6.1 (5.6 ± 0.2); c = 10.2–13.8 (11.7 ± 0.4); c′ = 3.5–5.0 (4.2 ± 0.4); V = 51–54 (52 ± 1.0); spear = 29.0–33.0 (30.0 ± 1.1); MB = 0.44–0.52 (0.48 ±0.02); H = 10–20 (18 ± 2.9); P′ (anus to phasmid/tail length) = 0.31–0.51 (0.43 ± 0.06).

Paratypes (5 ♂): L = 0.85–0.92 (0.87 ± 0.29); a = 33–38 (35 ± 2.6); b = 5.0–5.6 (5.4 ±0.1); c = 10.3–11.6 (10.9 ± 0.5); c′ = 4.0–4.6 (4.2 ± 0.3); spear = 29.0–31.0 (30.0 ± 1.0); P′ = 0.40–0.55 (0.45 ± 0.6); MB = 0.50–0.52 (0.51 ± 0.01); spicules = 26.0–30.0 (28.0 ± 1.6); gubernaculum = 10.0–13.0 (11.0 ± 1.5).

Diagnosis. Female: Body C-shaped when fixed. Distinct body annulation unmarked by longitudinal striae. Lateral fields start anteriorly at level of stylet knobs, four incisures becoming six incisures about 10 annules anterior to deirid. Areolation at extreme ends of lateral field. Deirids conspicuous. Lip region slightly offset, usually with seven annules, without longitudinal striae. Perioral disc broadly oval, amphid apertures circumscribed by boundary of first lip annule, margin irregularly scalloped. Light cephalic sclerotization. Stylet well developed, knobs rounded with anterior surface sloping posteriorly. DEGO 2–3 μm behind knobs. Basal bulb elongate, cylindical, occupying 16–22% ($\bar{x}$ = 19) of esophagus length (base to anterior end). Hemizonid occupying 2–4 body annules.

Table 3. Measurements* (μm) of *Nagelus* spp. with males.

Species	Sex	Reference	n	L	a	b	C	c′	Spear	V	Spicule length	gubernaculum length
N. alpensis	♂	(4)	10	850 (800–900)	24 (22–29)	6.1 (5.3–8.7)	13.5 (12.2–16.2)	3.1 (2.8–3.7)	25 (23.5–25.5)	55.5 (52–61)	... ...	... ...
	♀	(4)	10	900 (730–970)	28 (25–30)	5.9 (5.2–6.4)	12.5 (11.5–14.0)	3.0 (2.5–3.4)	24.5 (23.5–25.0)	... ...	31.5 (29.5–36.5)	10.5 (7.5–12.5)
N. borealis Aligun, Alaska	♀	(**)	18	910 (830–990)	32 (29–38)	5.6 (5.2–6.1)	11.7 (10.2–13.8)	4.2 (3.5–5.0)	30.0 (28.5–32.5)	52 (51–54)	... ...	... ...
	♂	(**)	5	870 (850–920)	35 (33–38)	5.4 (5.3–5.6)	10.9 (10.3–11.6)	4.2 (4.0–4.6)	30.0 (29.5–31.0)	... ...	28.3 (26.0–30.0)	11.4 (10.0–13.0)
Sagwan, Alaska	♀	(**)	11	1,000 (920–1,090)	31 (28–34)	5.5 (5.1–5.8)	11.4 (10.3–12.1)	4.1 (3.7–4.6)	32.5 30.0–34.0)	52 (48–53)	... ...	... ...
	♂	(**)	3	990 (950–1,050)	35 (33–39)	5.3 (4.9–5.5)	10.7 (9.7–11.5)	4.1 (4.0–4.9)	34.5 (32.0–37.5)	... ...	31.7 (31.0–32.0)	13.0 (11.0–14.0)
N. camelliae	♀	(6)	2	... (600–610)	... (24–26)	... (4.3–4.9)	... (12–14)	... (2.7–3.3)	... (20–21)	... (55–58)	... ...	... ...
	♂	(6)	3	... (520–570)	... (26–28)	... (3.6–4.4)	... (10.5–12.0)	... (3.0–3.2)	20 (20)	... ...	... (25–27)	... (9–10)
N. jamalensis	♀	(8)	10	... (810–930)	... (27–32)	... (5.1–5.6)	... (8.3–9.5)	... ...	... (27.5–28)	... (51–53)	... ...	... ...
	♂	(8)	5	... (930–960)	... (30–31)	... (5.3–5.6)	... (9.8–10.2)	... ...	... ...	... ...	... ...	... ...
N. obscurus	♀	(1)	5	... (630–790)	... (26–37)	... (4.6–5.3)	... (13–16)	... ...	... (24–27)	... (53–58)	... ...	... ...
	♂	(1)	2	... (740-760)	... (30–33)	... (5.6–6.7)	12 (12)	... ...	... (25–26)	... ...	... ...	... ...

*Averages outside parentheses; ranges within parentheses.
**Author's measurements.

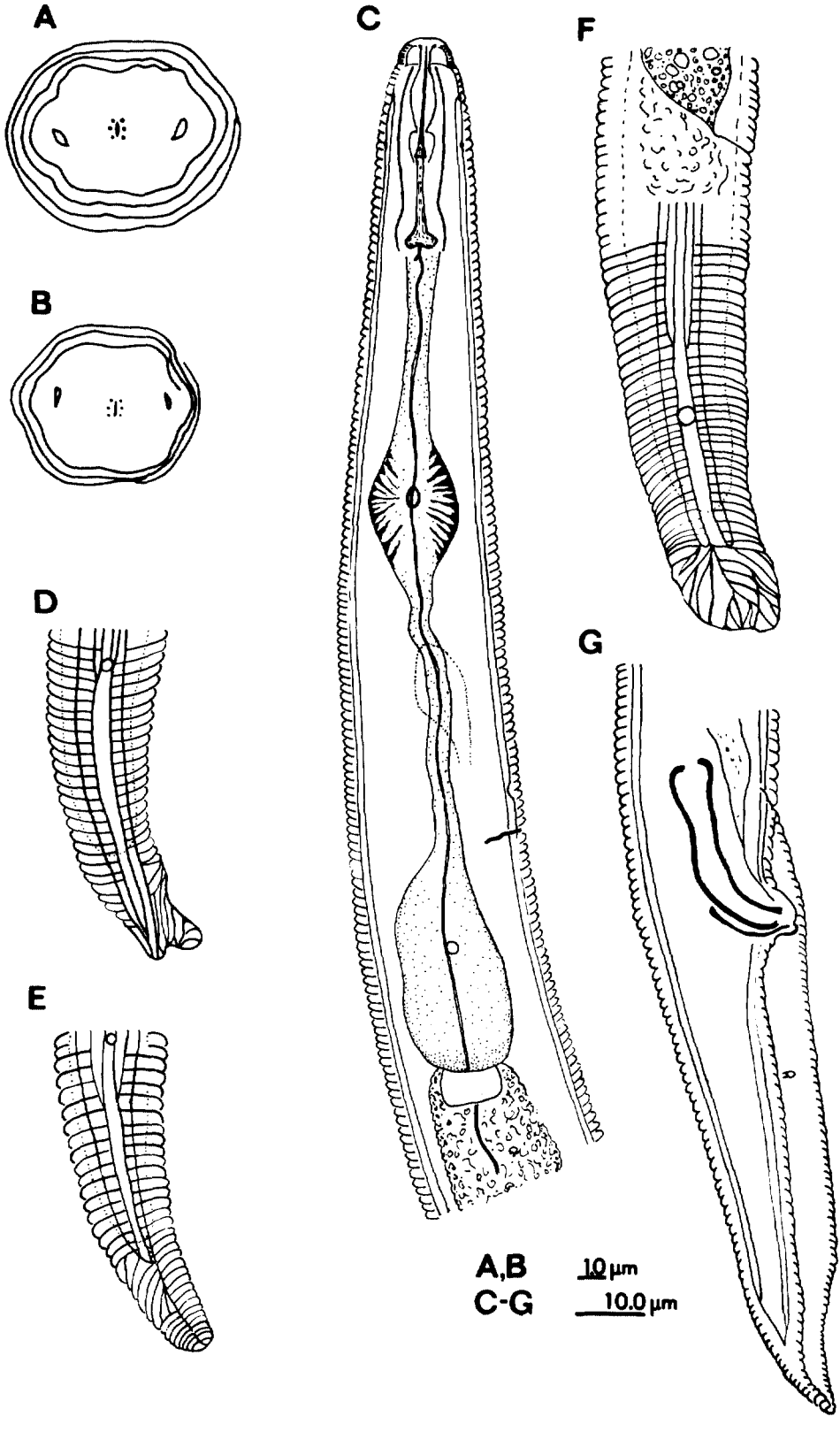


Fig. 13. *Nagelus borealis* n. sp. A) Face pattern of adult female. B) Face pattern of juvenile. C) Anterior region of adult female. D–F) Female tail shapes. G) Male tail.

Esophageal-intestinal valve large, rounded, almost as wide as base of esophageal basal bulb. Ovaries outstretched, oocytes usually in two rows. Spermatheca in line with ovary, sperm round. Large double epiptygma. Female tail conoid, irregular terminus often with notch. Hyaline region 11–27 μm. Phasmid generally anterior to middle of tail.

Male: Body, lip region, esophagus as in female. Spicules arcuate, with notched tip, average 31 μm over all populations; gubernaculum averages 13 μm over all populations. Lateral field of tail completely areolated. Bursa envelopes tail terminus.

Differential diagnosis: N. borealis has the longest spear (mean = 30 μm) of any *Nagelus* sp., an irregularly scalloped perioral disc, a basal bulb which proportionately occupies more of the total esophageal length than in other *Nagelus* sp. and the presence of males. Fifty percent of the female tails in most populations are notched. *N. borealis* appears closest to *N. jamalensis* from which it differs in spear measurement (27.5–28.0 μm for *N. jamalensis)* and in having a larger C ratio.

Type information: Holotype ♀ from Aligun, Alaska near pipeline 10 N on alpine tundra, mixture of grass tussocks and mosses. Collected 25 June 1977 by S. D. Van Gundy. Catalog #53. Nematode Collection, Department of Nematology, University of California, Riverside.

Paratypes: Specimens distributed in type collections as follows: 5 ♀ and 2 ♂ UCDNC, Division of Nematology, University of California, Davis; 4 ♀ and 2 ♂ USDA Nematology Investigations, Beltsville, Maryland; 4 ♀, 3 ♂ and 1 j Rothamsted Experimental Station, Harpenden, England; 11 ♀, 1 ♂, and 1 j UCNRC, Department of Nematology, University of California Riverside. All other specimens deposited in the Riverside Collection.

Distribution: known only from Alaska.

Records. United States—Alaska: Aligun, Barrow, Cape Thompson, Chena Hot Springs, Fort Yukon, Mead River, Prudhoe Bay, Sagwan, Steese Hwy (mi. 175), and Toolik. Grasses, willow, mosses, and alder were the reported hosts.

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