

**Nacobbodera chitwoodi, n. gen., n. sp., (Nacobbidae:
Nematoda) on Douglas Fir in Oregon¹**

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Abstract: *Nacobbodera chitwoodi*, n. gen., n. sp., representing Nacobboderinae n. subfam. in the Nacobbidae, is described and illustrated from roots of Douglas fir, *Pseudotsuga menziesii* near Florence Oregon. This new species, having characters common to Nacobbidae, Heteroderidae, and Meloidogynidae, appears to represent a connecting link between these three families of the Heteroderoidea. Especially, a distinct tail on swollen adult females, vermiform shape of juvenile females, and the shape and sclerotization of the head of the various stages, indicate a Nacobbidae relationship. Certain other characteristics present in this new species are of the Heteroderidae and Meloidogynidae type as follows: Gross shape of adult female in posterior half of body, two ovaries, anterior position of excretory pore as in *Meloidogyne* females, absence of a bursa, and development of male within a sausage-shaped cuticle as in root-knot and cyst nematodes. **Key Words:** taxonomy, morphology, new taxa.

A soil sample taken by the second author from a forested area along the Pacific Ocean shore at Cape Meares, Oregon in February 1963 contained males and larvae of an undescribed nematode. This collection and several more taken in the same vicinity and along the Oregon coast during the next few months frequently contained males, various larval stages and occasionally vermiform juvenile females. Adult females and host associations were not discovered at that time. In early July 1965, nematode specimens from roots and mycorrhizae of Douglas fir [*Pseudotsuga menziesii* (Mirb.) Franco] in Oregon were sent via John Ruehle, Forest Service, USDA, Athens, Georgia to the senior author for identification. The material, which had been collected in late June 1965, by B. Zak, Forest Service, USDA, Corvallis, Oregon, was identified as a distinctively different taxon that might best be placed tentatively in *Meloidodera* Chitwood, Hannon & Esser, 1956. With this information, Zak (4) in 1967 reported the finding of a *Meloidodera* species on Douglas fir in Oregon, and also, kindly sent additional material for use in describing the form.

Since then we have studied this nematode in much greater detail and found certain characters typical of Nacobbidae, and other characters that occur in Heteroderidae and

Meloidogynidae. We, therefore, propose herein a new genus and new subfamily for this new species. In order to better accommodate these new taxa, the family Nacobbidae is emended slightly. Procedures used in describing this nematode, including fixing, drawing, and photographing specimens, were essentially the same as those recently given by Golden and Birchfield (2).

SYSTEMATICS

Family Nacobbidae (Chitwood & Chitwood, 1950) Golden, 1971 *Diagnosis Emended:* Superfamily

Heteroderoidea (Filipjev, 1934) Golden, 1971. Body cuticle with distinct annules. Head of both sexes with sclerotized cephalic framework. Marked sexual dimorphism evident; adult females saccate, or much swollen, at least on part of body, and males vermiform. Juvenile females also vermiform. Esophageal glands lobed, overlapping anterior portion of intestine. Lateral field present. Vulva postequatorial or subterminal, not terminal. Females with tail, which may be only vestigial. One or 2 ovaries. Bursa simple, not lobed if present.

TYPE SUBFAMILY: Nacobbinae Chitwood & Chitwood, 1950 (in part) (as emended by Golden, 1971)

TYPE GENUS: *Nacobbus* Thorne & Allen, 1944.

Other subfamilies included:

Rotylenchulinae Husain & Kahn, 1967
Nacobboderinae n. subfam.

The family Nacobbidae can be readily distinguished from the other families (Heteroderidae and Meloidogynidae) in the Heteroderoidea by the vermiform shape of the juvenile females and also the presence of a tail or tail-like protuberance on adult females.

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Nacobboderinae n. subfam.

Diagnosis – Nacobbidae: Strong sexual dimorphism present. Adult female enlarged, with 2 ovaries, and vulva in posterior portion, though not terminal. Males vermiform, without bursa.

TYPE GENUS: *Nacobbodera* n. gen.

The subfamily Nacobboderinae can be distinguished from Nacobbinae by the presence of two ovaries in females and lack of bursa in males; and from Rotylenchulinae, by the shape of females, the subterminal position of the vulva, and location of the outlet of the dorsal esophageal gland.

Nacobbodera n. gen.

Diagnosis – Nacobboderinae: with characters of the subfamily. Stylet well developed with strong knobs in both sexes and the developmental stages. Adult females swollen, heavily so in at least posterior half, with distinct tail and subterminal vulva. Both adult females and vermiform juvenile females with 2 ovaries. Lateral field present. Males vermiform, without bursa, and, at least in known species, development being the same as is common in males of root knot and cyst nematodes.

TYPE SPECIES: *Nacobbodera chitwoodi* n. sp.

Nacobbodera n. gen. can be distinguished from *Nacobbus* Thorne & Allen, 1944 and *Rotylenchulus* Linford & Oliveira, 1940, the only other genera in Nacobbidae, by the same characters as for the subfamilies above.

The name *Nacobbodera* is a combination of *Nacobbus* and the Latinized form of the Greek *deros* = "skin", being of the feminine gender as for *Heterodera* Schmidt, 1871.

The species name is given in honor of the late eminent nematologist, B. G. Chitwood.

Nacobbodera chitwoodi n. gen., n. sp.

Females: (20): Total length, 1,944 μ m (1,311-2,601); width, 552 μ (306-765); L/W ratio 3.6 (2.8-4.4); "neck" length, 1,163 μ m (816-1,580); ratio of total length/"neck" length, 1.70 (1.5-1.9); stylet, 31 μ m (30-32); outlet of dorsal esophageal gland from base of stylet, 4.6 μ m (4.4-5.2).

Holotype (Female): Length, 1,960 μ m; width, 310 μ m; stylet, 31 μ m; outlet of dorsal esophageal gland from base of stylet, 4.5 μ m; tail length, 19 μ m; distance from vulva to anus, 80 μ m; distance from anus to tail terminus, 45 μ m.

Description: Body pearly white, turning yellowish to light brown in old specimens, and in posterior half or more, being markedly swollen

to almost pear-shaped (Fig. 3, 4, 5). Thick cuticle with transverse annules which are wider on swollen part of body. Head slightly set off, bearing 3-4 annules arranged about as illustrated (Fig. 1D). Head 12 μ m (11-13) wide and 5 μ m (4-5) high, giving a head width/height ratio of 2.7 (2.2-3.0). Cephalic sclerotization prominent. Stylet strong, with well developed knobs, and anterior part of stylet longer, 19 μ m (18-19), than posterior portion, 12 μ m (11-13). Anterior portion of female and esophageal glands appearing commonly as illustrated (Fig. 1E), with excretory pore generally at anterior of the prominent median bulb. Ovaries 2, convoluted. Vulva oval (Figs. 6, 7), without perineal pattern except for usual body striae, located 82 μ m (52-122) from anus, and 138 μ m (87-175) from tail terminus. Vulva slit 45 μ m (37-62) in length. Anus distinct (Figs. 8, 9, 10, 11), and 54 μ m (35-74) from tail terminus. Phasmids conspicuous (Fig. 8, 9, 10), measuring 8 μ m (7-10) in diameter, and located about half way between tail terminus and anus. Protruding portion of tail appearing pointed to nipple-like (Fig. 8, 9, 10, 11), averaging 15 μ m in length.

Males (22): Length, 2,517 μ m (1,964-2,922); a=43 (32-55); b=10 (9-12); c=95 (70-137); stylet, 39 μ m (34-40); outlet of dorsal esophageal gland from base of stylet, 5.2 μ m (4.9-6.2); head width at base, 16 μ m (13-18); head height, 6.7 μ m (6.2-7.3); ratio of head width/head height = 2.5 (2.2-2.8); spicules, 57 μ m (50-64); gubernaculum, 16 μ m (14-17).

Allotype (Male): Length, 2,688 μ m; a = 44; b = 10; c = 96; stylet, 39 μ m; outlet of dorsal esophageal gland from base of stylet, 5 μ m; ratio of head width/head height = 2.4; spicules, 64; gubernaculum, 17 μ m.

Description: Body vermiform, slender, averaging 59 μ m at widest part, and tapering gradually at both ends. Cuticle relatively heavy, measuring about 4 μ m in thickness with distinct annules; subcuticular annulation less distinct but twice as numerous. Lateral field with 5 lines (Fig. 1-C). Head set off, with 3-4 annules generally arranged as illustrated (Fig. 1B). Cephalic framework very heavily sclerotized (Fig. 12). Stylet, knobs, guide ring and cephalids commonly appearing as shown (Fig. 1B). As in females and other stages, anterior part of stylet longer than posterior portion. Median bulb prominent and distinctive (Fig. 1A), with its center averaging 123 μ m from anterior end. Excretory pore about 5 annules in front of distinct hemizonid. Testis 1. Spicules

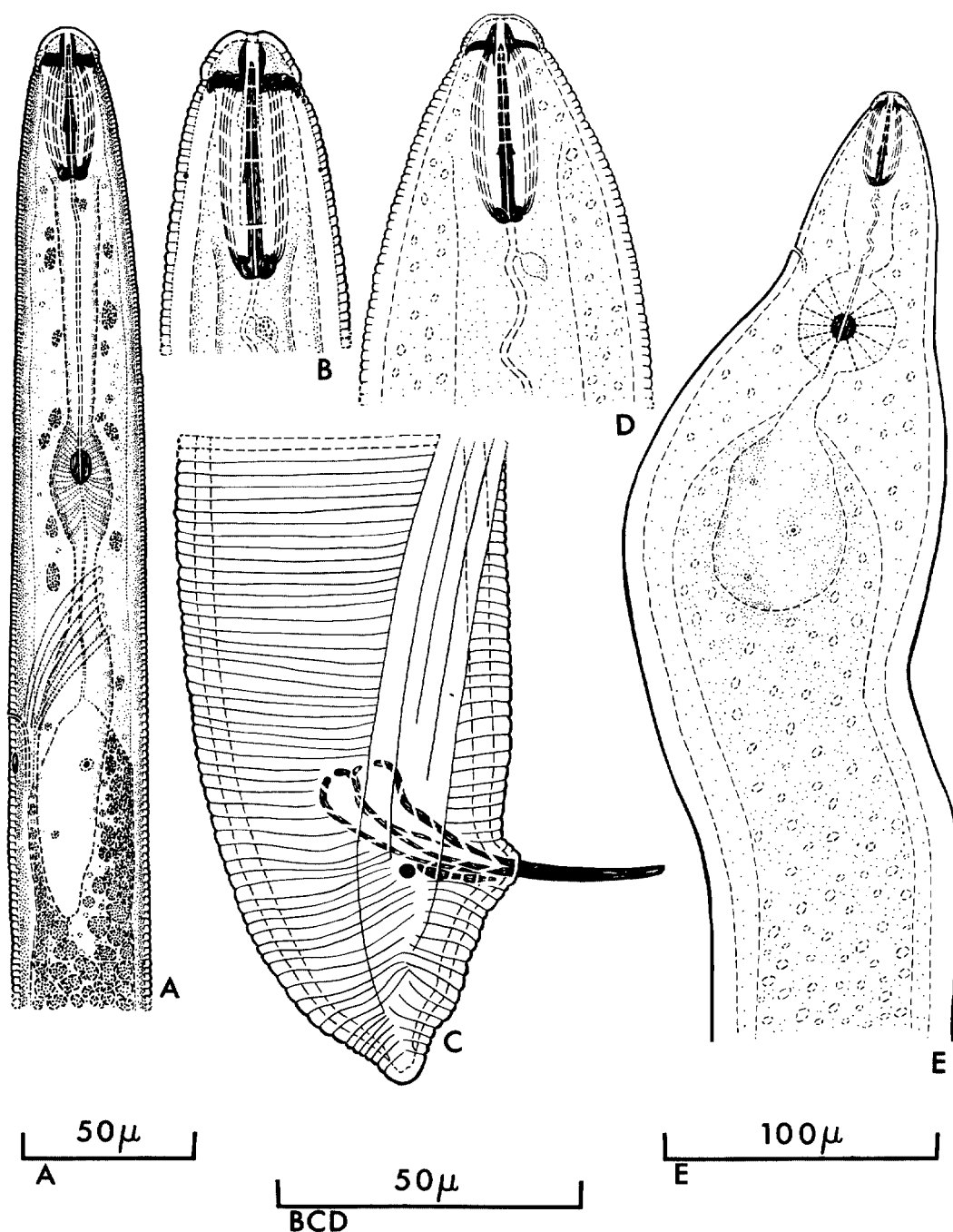


FIG. 1. Drawings of *Nacobbodera chitwoodi* n. gen., n. sp. Male: A = Anterior. B = Enlargement of part of "A". C = Posterior. Adult Female: D = Enlarged extreme anterior. E = Anterior.

slightly arcuate, with rounded tips. Phasmids prominent, located in vicinity of cloaca or just posterior to it (Fig. 1C). Tail commonly twisted as in *Meloidogyne*, generally appearing with nipple-like terminus about as shown (Fig. 1C),

and measuring 28 μm (20-34).

Juvenile Females (8): Length, 1,747 μm (1,284-2,128); a=39 (35-43); b=5.6; c=53 (46-59); stylet, 34 μm (32-36); outlet of dorsal esophageal gland from base of stylet, 4.6 μm

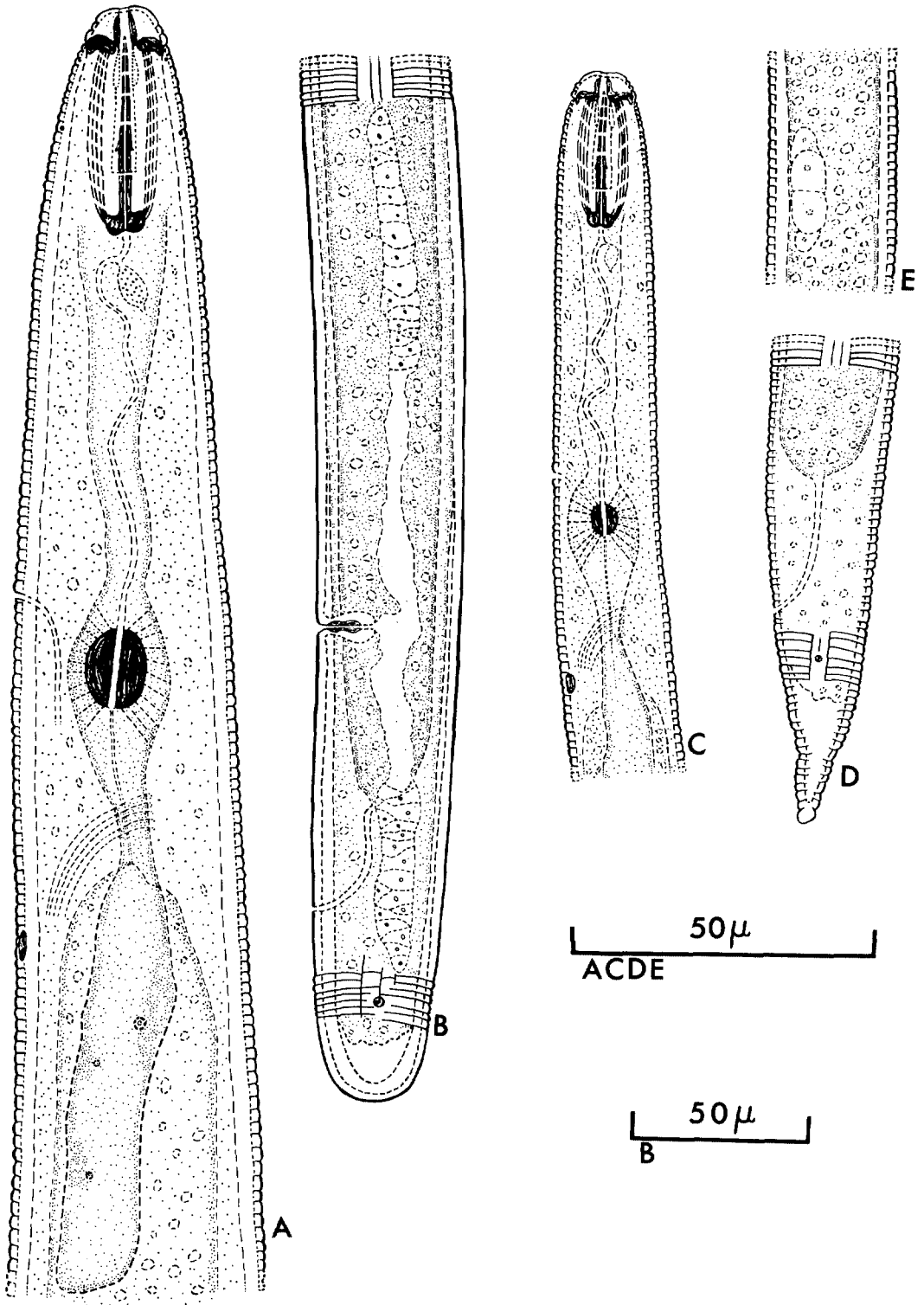


FIG. 2. Drawings of *Nacobbodera chitwoodi* n. gen., n. sp. Juvenile Female: A = Anterior. B = Posterior. Larva (probably second-stage): C = Anterior. D = Posterior. E = Body section with genital primordium.



FIG. 3-5. Photomicrographs of adult females of *Nacobbodera chitwoodi* n. gen., n. sp. 3. Gross shape of specimens (portion of "neck", or anterior part, on some specimens is broken off). 4. Gross shape at higher magnification (portion of "neck" of one specimen is broken off and not shown). 5. Adult female attached to a piece of Douglas fir root. [Note intact head (arrow) and portion of neck protruding from root].

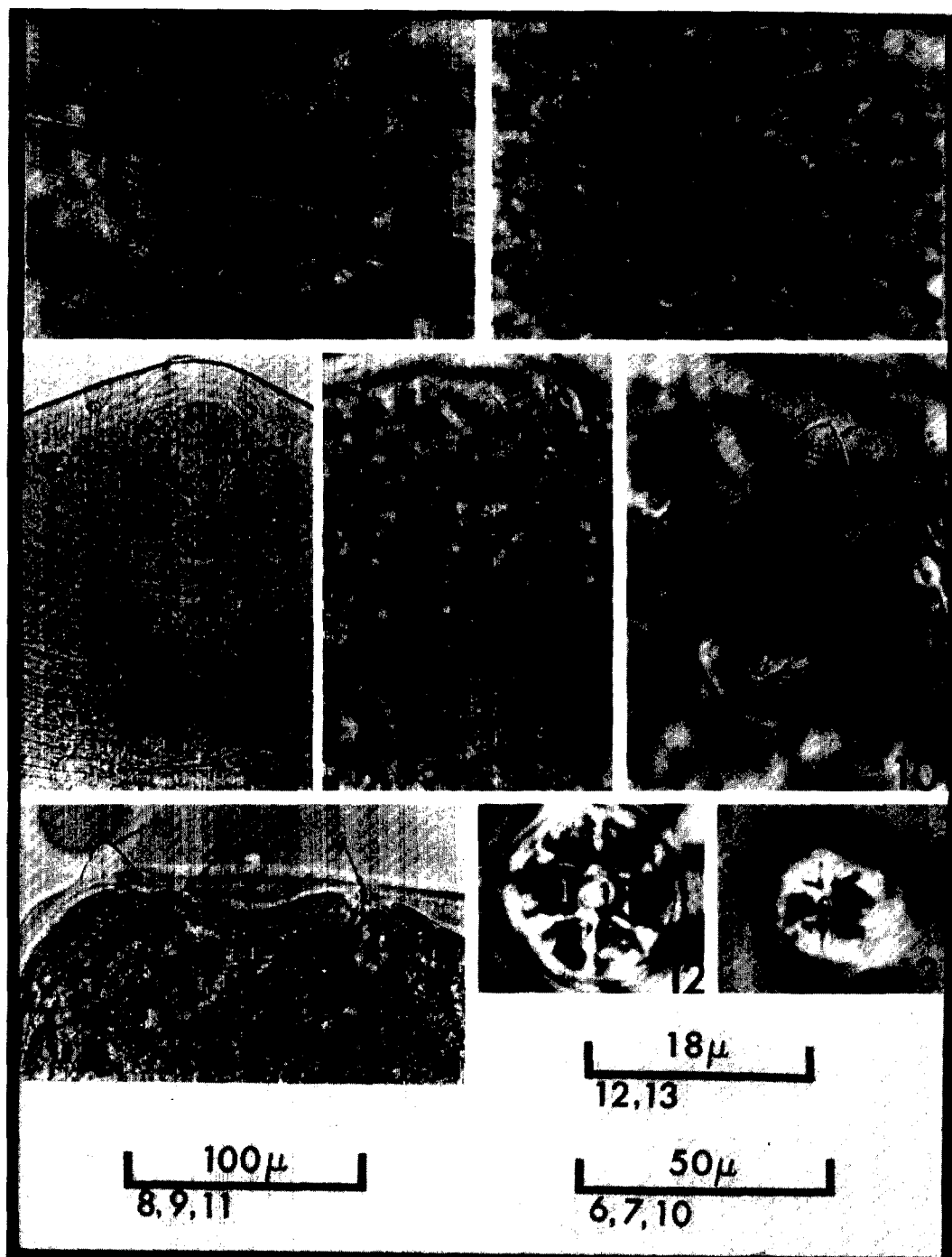


FIG. 6-13. Photomicrographs of specimens of *Nacobbodera chitwoodi* n. gen., n. sp. 6. Adult female vulva at surface, showing some annulation also. 7. Same as Fig. 6, but deeper focus. 8. Ventral view of posterior portion of adult female, with small tail folded anteriorly toward anus. 9. Ventral view of posterior portion of another adult female with tail extending posteriorly. 10. A view of part of 9 at higher magnification (Vulva not included). 11. Lateral view of posterior portion of adult female. 12. En face view of male. (Note slit-like amphid openings at left and right of oral aperture). 13. Deep-focus, en face view of a larva. (a = anus; p = phasmids; t = tail, v = vulva).

(4.4-5.2); head width, 13 μ m (11-14); head height, 5 μ m (4.4-5.2); ratio of head width/head height = 2.7 (2.6-2.8); V=90-92%; tail, 35 μ m (30-39); tail terminal, 16 μ m (10-22); caudal ratio A=0.67 (0.53-0.81); caudal ratio B=1.2 (1.0-1.7).

Description: Body vermiform, slender, tapering only slightly at each extremity, and measuring 45 μ m (34-56) at widest part. Cuticle distinctly annulated, with twice as many annules on subcuticle. Lateral field with 4 lines, usually reducing to 3 near anus, and terminating about as shown (Fig. 2B) near the prominent phasmids. Head slightly set off, with generally 2 annules appearing about as illustrated (Fig. 2A). Cephalic framework heavily sclerotized. Stylet, knobs, guide ring, cephalids, and esophageal region commonly appearing as in Fig. 2A. Anterior part of stylet longer, 21 μ m (19-23), than posterior portion, 13 μ m (12-14). Center of distinct, valvated median bulb 105 μ m (94-114) from anterior end. Valve of median bulb unusually large. Excretory pore located near middle or upper part of median bulb while hemizonid is several annules posterior to nerve ring. Anterior ovary (Fig. 2B) longer than posterior on which was seen in some specimens to be distally recurved. Tail rounded.

Larvae, probably second-stage (25): Length, 645 μ m (526-739); a=29 (24-35); b=4 (3.6-4.5); c=17 (15-23); stylet, 24 μ m (23-25); outlet of dorsal esophageal gland from base of stylet 3.4 μ m (2.6-3.5); head width at base 8 μ m (7-10); head height 3.4 μ m (3.1-3.5); ratio of head width/head height = 2.5; tail, 36 μ m (31-40); tail terminal, 21 μ m (16-23); caudal ratio A=2.0 (1.6-2.3); caudal ratio B=6.4 (4.6-8.8).

Description: Body vermiform, averaging 21 μ m at widest part, and tapering slightly at extremities except markedly so on tail. Cuticle distinctly annulated, with annules twice as numerous on subcuticle. Lateral field (Fig. 2D) with 4 lines, non-areolated. Head offset, usually with 3-4 annules appearing about as shown (Fig. 2C), and with heavy sclerotization (Fig. 13). Stylet, knobs, cephalids, and median bulb appearing as illustrated (Fig. 2C). Excretory pore at level of median bulb, and hemizonid a few annules posterior to nerve ring. Genital primordium (Fig. 2E) composed of 4 cells, on ventral side, and located about 70% of body from anterior end. Phasmids distinct, located at 75% of tail from posterior end. Tail tapering to a rather rounded terminus, and often appears

pinched or crinkled at about 2/3 of its length (Fig. 2D).

Eggs: Length, 152 μ m; width 66 μ m; L/W ratio = 2.3. Egg shell hyaline, without visible markings. Eggs are deposited in a large gelatinous matrix, which might be five or more times the diameter of the swollen adult female.

HOLOTYPE (female): Collected by B. Zak from Douglas fir in the Coastal Range near Florence, Oregon on July 19, 1965. Slide T-224t, United States Department of Agriculture Nematode Collection, Nematology Laboratory, ARS, Beltsville, Maryland 20705.

ALLOTYPE (male): Slide T-225t, same data and Collection as holotype.

PARATYPES: Various stages: United States Department of Agriculture Nematode Collection, Beltsville, Maryland. Additional specimens at California Nematode Survey Collection, Davis; and Oregon State University Nematode Collection, Corvallis.

TYPE HOST AND LOCALITY: Roots of Douglas fir, *Pseudotsuga menziesii* (Mirb.) Franco, in the Coastal Range near Florence, Oregon. [Although Zak (4) reported this nematode as being on the mycorrhizae, our dissection of infected material showed the nematode's head to be actually in the root which was, however, commonly coated with mycorrhizae. This was confirmed by E. Hacskeylo, Forest Physiology Laboratory, Forest Service, Beltsville, Maryland].

DIAGNOSIS: *Nacobbodera* with the above specific characters. No other described species.

DISCUSSION: This remarkable new species seems to provide a connecting link between the families Nacobbidae, Heteroderidae, and Meloidogynidae. In the following respects *N. chitwoodi* is similar to Nacobbidae: Presence of a tail on adult females and relationship of vulva and anus; presence of vermiform juvenile females, and absence of swollen intermediate stages in development of females; and the shape and nature of the sclerotization in the heads. On the other hand, the following characteristics suggest a close relationship to Heteroderidae and Meloidogynidae. Gross shape of the females in posterior half of body; forward location of excretory pore as in *Meloidogyne*; presence of two ovaries; absence of a bursa; and development of males through the sausage-shaped stage and retention within the cuticle as in root-knot and cyst nematodes.

The taxonomic position and best placement of *N. chitwoodi* could, of course, be debated. However, the characteristics given above,

especially the vermiform juvenile females and the tail on adult females, both of which are always present in Nacobbidae, seem to warrant our present course of action. Also, the nature of *N. chitwoodi* as described herein further justifies the action of Golden (1) in establishing the superfamily Heteroderoidea for the distinctive but closely related families, Nacobbidae, Heteroderidae, and the recently established Meloidogynidae (3).

Presence of a tail-like protuberance on *Meloidogyne coffeicola*, *M. poghossianae*, and *Meloidodera armeniaca* is recognized, and a need for further study of these forms, especially the various stages, seems evident for investigating the possible relationship to the present new species from Douglas fir.

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