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MORPHOLOGY AND MORPHOMETRICS OF ITALIAN POPULATIONS OF *BURSAPHELENCHUS* SPECIES¹

by

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Summary. Observations are reported on the morphology and morphometrics of Italian populations of *Bursaphelenchus* spp. associated with *Pinus* spp. In *Bursaphelenchus leoni* males a small ventral preanal papilla was detected, that had not previously observed; SEM revealed the presence of a knob-like appendage on the spicule distal end of *B. sexdentati*, a morphological character that had not previously been described. *B. teratospicularis*, recorded for the first time in Italy, is described in details. Selected morphometric characters are described of two populations of *B. leoni*, seven of *B. mucronatus*, three of *B. sexdentati* and two of *B. teratospicularis*.

A survey of the pine wood nematodes, *Bursaphelenchus* spp., was started in 1992 to determine their association with the decline and death of trees observed in coniferous plantations.

Bursaphelenchus xylophilus (Steiner *et* Buhner) Nickle was never detected but four other species of *Bursaphelenchus* were found which were more or less widely distributed in the regions sampled (Marinari Palmisano *et al.*, 1992; Caroppo *et al.*, 1998).

Morphological characteristics of *Bursaphelenchus* species occurring in Italy, namely *B. mucronatus*, *B. leoni* and *B. sexdentati*, have been reported previously (Marinari Palmisano *et al.*, 1992; 1994; Marinari Palmisano and Ambrogioni, 1994). These observations have been extended with further detailed examination of the morphometric variation of the species.

Materials and methods

Studies were undertaken on seven population of *B. mucronatus*, three of *B. sexdentati* and two each of *B. leoni* and *B. teratospicularis* (Table I) extracted from pine trees in selected localities in northern and central western Italy (Caroppo *et al.*, 1998). Specimens were killed and fixed in FP 4:1 hot solution, processed by the glycerol-ethanol method (Seinhorst, 1959) and mounted in anhydrous glycerin. Measurements were made with the aid of a camera lucida.

For scanning electron microscope (SEM) studies, made only on the population IT 2 (w) of *B. sexdentati*, specimens were fixed in 4% glutaraldehyde for two hours, postfixed overnight in 2% OsO₄, then dehydrated in ethanol, critical point dried and sputter coated with gold (Eisenbach, 1991) for observation in a Philips SEM.

¹ The study has been carried out with financial support from the Commission of the European Communities, Agriculture and Fisheries (FAIR) specific RTD programme, CT 95-0083, "Pest Risk Analysis of pine wood nematode-related *Bursaphelenchus* species in view of South European pine wilting and wood imports from Asia".

TABLE I - Populations of *Bursaphelenchus* species used for the description of morphometrical characters.

Species	Isolate No	Region	Locality (district)	Host
◇ <i>B. leoni</i>	IT1 (w)	Tuscany	Marina di Massa (MS)	<i>P. pinaster</i>
◇ <i>B. leoni</i>	IT10 (w)	Tuscany	Piombino (LI)	<i>P. halepensis</i>
◆ <i>B. mucronatus</i>	IT4 (w)	Piedmont	Fenestrelle (TO)	<i>P. sylvestris</i>
◆ <i>B. mucronatus</i>	IT5 (w)	Piedmont	Oulx (TO)	<i>P. sylvestris</i>
◆ <i>B. mucronatus</i>	IT6 (w)	Piedmont	Variselle (TO)	<i>P. nigra austriaca</i>
◆ <i>B. mucronatus</i>	IT7 (w)	Piedmont	Dronero (CN)	<i>P. strobus</i>
◆ <i>B. mucronatus</i>	IT8 (w)	Piedmont	Monte Calvario (CN)	<i>P. sylvestris</i>
◆ <i>B. mucronatus</i>	IT12 (i)*	Liguria	Prati di Prà (GE)	<i>P. pinaster</i>
◆ <i>B. mucronatus</i>	IT13 (w)	Tuscany	Marina di Massa (MS)	<i>P. pinaster</i>
◆ <i>B. sexdentati</i>	IT2 (w)	Tuscany	Marina di Massa (MS)	<i>P. pinaster</i>
◆ <i>B. sexdentati</i>	IT9 (w)	Tuscany	Piombino (LI)	<i>P. halepensis</i>
◇ <i>B. sexdentati</i>	I15 (w)**	Piedmont	Mond'Ovile (AL)	<i>P. pinaster</i>
◇ <i>B. teratospicularis</i>	IT3 (w)	Tuscany	Marina di Massa (MS)	<i>P. pinaster</i>
◇ <i>B. teratospicularis</i>	IT11 (w)	Tuscany	Piombino (LI)	<i>P. halepensis</i>

◇ Natural population.

◆ *In vitro* reared population.

* Population isolated from *Monochamus galloprovincialis galloprovincialis* in a previous survey (Marinari Palmisano *et al.*, 1992).

** Population isolated in a previous survey carried out in Piedmont.

Descriptions

BURSAPHELENCHUS LEONI Baujard, 1980

(Table II; Fig. 1)

Morphology and morphometrics of the Italian populations generally agree with the original description (Baujard, 1980).

Cuticle finely annulated. Lip region frontally rounded, set off from the rest of the body by a deep constriction. Stylet with basal thickenings weakly developed. Median bulb elongate-ovoid in shape. Excretory pore just anterior to hemizonid at the level of or just behind the nerve ring. Number of incisures on the lateral field not discernible.

Female - Body long with inflexion at vulva when killed by heat. Ovary long and outstretched. Vulva with a cuticular flap, covering and extending until 3.6 µm posterior to vulval opening; area posterior to vulval flap often swollen (Fig. 1A). Post-uterine branch long, of-

ten filled with sperm. Tail very long, conoid in shape with slight ventral curvature and finely rounded terminus (Fig. 1B), sometimes ending in a very small digitate process or constriction. Its width varies considerably.

Male - Body J-shaped when killed by heat. Testis usually long and outstretched, reaching almost the posterior end of oesophageal glands, in one specimen also the base of the median bulb, reflexed apically in some specimens as much as two body widths. Spicules of the same shape as the original description of the species (Baujard, 1980), but at the end of the lamina there is a slight posterior hook-like process (Fig. 1C), previously not reported for *B. leoni*. Three pairs of caudal papillae are present, one subventral adanal, one ventral postanal at 55% of tail length from cloaca and one ventral pair of papillae, smaller than the others, at the beginning of the bursa. A single ventral preanal papilla is present at 3.6 µm anterior to cloaca, but obscure in most specimens; it has not previ-

TABLE II - *Measurements of two Italian populations of Bursaphelenchus leoni.*

	IT1 (w)		IT10 (w)	
	10 ♀♀	10 ♂♂	10 ♀♀	10 ♂♂
n				
Body length	811.2±69.0 (707.9-900.2)	674.2±69.9 (569.9-778.0)	720.1±63.1 (643.7-837.3)	633.8±80.6 (534.8-757.5)
Body width	8.5 21.3±2.0 (18.2-23.0)	10.4 18.9±2.2 (14.5-21.8)	8.8 18.5±1.3 (16.9-20.6)	12.7 16.0±1.9 (13.3-19.4)
a	9.3 38.2±1.3 (35.8-39.6)	11.9 36.0±3.5 (29.3-40.2)	7.1 39.2±1.2 (38.0-40.7)	11.9 39.7±2.1 (37.2-42.6)
Distance from anterior end to junction of oesophagus and intestine	3.3 78.5±5.5 (71.4-90.8)	9.6 75.9±3.6 (72.6-84.7)	3.0 70.9±2.5 (67.8-75.0)	5.3 71.8±6.5 (65.3-85.9)
b	7.1 10.3±0.5 (9.7-11.1)	4.7 8.8±0.9 (7.7-10.1)	3.5 10.3±0.8 (7.7-10.1)	9.1 8.8±0.7 (8.1-10.0)
Distance from anterior end to posterior end of oesophageal glands	4.8 148.7±12.7 (133.1-169.4)	9.6 140.4±11.3 (121.0-154.9)	9.6 138.4±11.3 (125.8-152.5)	7.8 128.6±7.5 (121.0-145.2)
b'	8.5 5.5±0.6 (4.9-6.5)	8.0 4.8±0.7 (3.7-6.1)	7.5 5.3±0.7 (4.2-6.2)	5.8 4.9±0.6 (4.1-5.9)
Distance from anterior end to base of median bulb	10.1 73.6±5.1 (66.6-85.9)	15.1 70.9±3.8 (64.1-78.7)	13.4 68.2±2.2 (65.3-72.6)	11.1 66.1±4.1 (61.7-75.0)
b1	7.0 11.1±0.8 (10.1-12.7)	5.4 9.5±1.0 (8.2-11.6)	3.2 10.7±1.0 (8.9-12.4)	6.2 9.4±0.7 (8.7-10.4)
Oesophageal glands overlapping intestine length	6.8 69.9±11.8 (52.0-90.8)	10.9 63.1±10.7 (47.2-81.1)	9.7 66.7±12.2 (44.5-84.7)	7.0 59.3±5.6 (52.0-67.0)
Oesophageal glands overlapping intestine length/Body width to junction of oesophagus and intestine	16.9 4.0±0.8 (2.9-5.4)	17.0 3.9±0.9 (2.8-5.6)	18.3 4.9±0.9 (3.7-6.4)	5.5 4.3±0.5 (3.6-5.0)
Stylet length	20.9 14.7±0.9 (13.3-16.9)	23.4 14.4±0.7 (13.3-15.7)	17.7 14.6±0.8 (13.3-15.7)	11.1 14.6±1.0 (13.3-15.7)
Distance from anterior end to excretory pore	6.1 97.1±6.8 (84.7-106.5)	5.1 94.1±6.4 (87.1-106.5)	5.6 89.3±4.7 (84.7-96.8)	6.6 86.3±8.2 (78.7-104.1)
Distance from anterior end to hemizonid	7.0 102.3±6.2 (95.6-110.1)	6.8 98.4±5.0 (92.0-107.7)	5.2 97.2±4.1 (88.3-102.9)	9.6 91.6±7.3 (84.7-106.5)
V	6.0 70.2±1.6 (66.3-71.8)	5.1	4.3 70.3±1.0 (68.4-71.1)	8.0
	2.2		1.4	

TABLE II - *Continued.*

	IT1 (w)		IT10 (w)	
Anterior genital branch length	320.8±68.1 (233.5-425.9)	455.0±90.3 (284.4-532.4)	302.5±90.7 (150.0-442.9)	366.3±74.0 (284.4-544.5)
G1	21.2 39.5±7.3 (29.9-51.4)	19.9	30.0 41.5±11.0 (19.4-52.9)	20.2
Post-uterine branch length	18.5 111.2±9.3 (96.8-127.1)		26.4 93.2±8.4 (78.7-104.1)	
G2	8.4 13.8±0.9 (11.7-15.2)		9.1 12.9±1.5 (10.8-14.6)	
T	6.6	67.6±11.7 (38.3-80.2)	11.9	58.0±10.3 (43.9-81.2)
Vulval - anus distance	174.1±21.1 (151.3-217.8)	17.3	152.4±16.6 (127.1-181.5)	17.8
Post-uterine branch length % / Vulval - anus distance	12.1 64.3±5.1 (55.6-72.0)		10.9 61.8±8.3 (50.0-74.3)	
Body diameter at vulva	8.0 20.5±2.0 (18.2-24.2)		13.5 17.4±1.7 (15.7-19.4)	
Post-uterine branch length / Body diameter at vulva	9.7 5.5±0.3 (4.9-5.9)		9.5 5.4±0.6 (4.4-6.0)	
Tail length	6.0 67.6±8.9 (53.2-85.9)	32.1±1.6 (29.0-33.9)	10.6 63.6±8.3 (50.8-78.7)	7.6 29.4±2.2 (26.6-33.9)
c	13.1 12.1±1.2 (10.5-13.8)	5.1 21.1±2.3 (17.8-24.4)	13.0 11.6±1.3 (9.9-13.6)	7.6 21.5±1.7 (19.2-24.1)
Body width at anus	9.7 11.9±1.8 (8.5-14.5)	11.0 14.6±0.8 (13.3-15.7)	10.8 10.5±0.7 (9.7-11.2)	8.0 13.7±1.1 (12.1-15.7)
c'	14.9 5.8±0.8 (5.1-7.7)	5.6 2.2±0.1 (2.0-2.4)	6.5 6.0±0.9 (4.7-7.2)	8.3 2.2±0.1 (2.0-2.4)
Spicules (chord)	14.0	19.0±1.0 (18.2-20.6)	14.1	6.5 17.3±1.2 (15.7-19.4)
		5.2		6.8

All measurements are in μm . The measurements are given as: arithmetic mean \pm standard deviation, (minimum - maximum) and coefficient of variation.

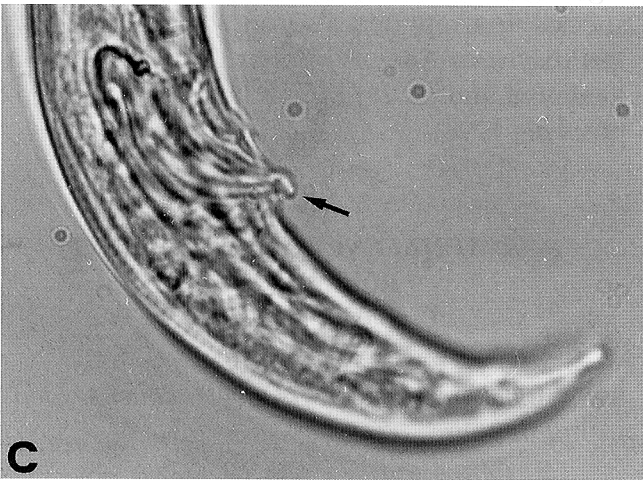
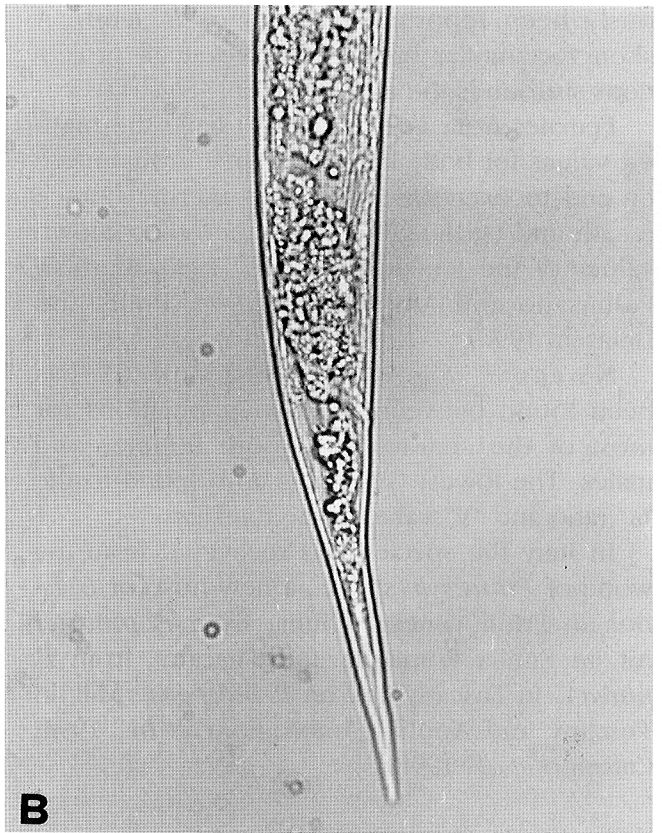
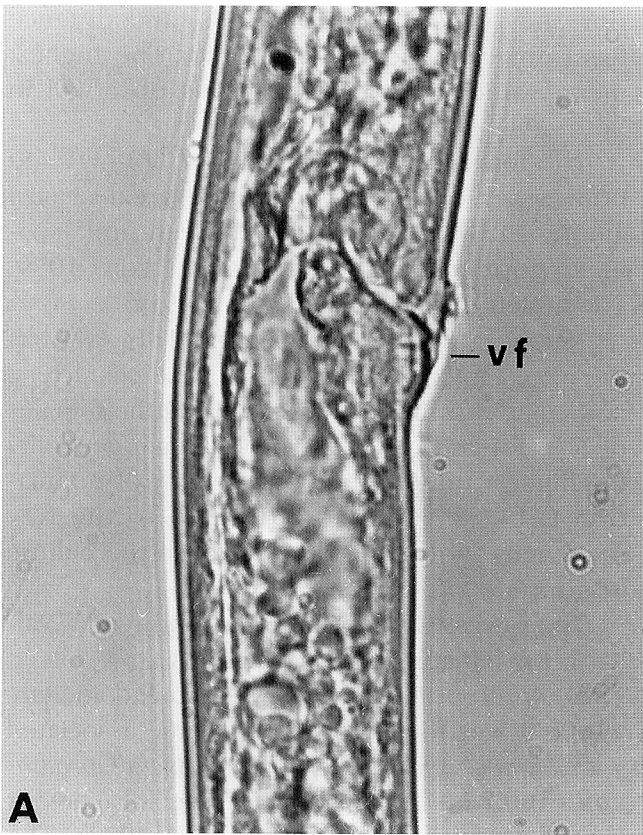


Fig. 1 - Photomicrographs of *Bursaphelenchus leoni*: A, female vulval region (vf = vulval flap), lateral; B, female posterior region, lateral; C, male tail with spicules ending with a hook-like process (→), lateral; D, male tail with bursa, subventral.

ously been reported in males of *B. leoni*. A short rectangular bursa with two small projections surrounds the end of the tail (Fig. 1D).

Females from isolate IT1 (w) have the highest values for body length, distance from anterior end to excretory pore, post-uterine branch length and tail length, among the other known values of the females (Baujard, 1980; Marinari Palmisano and Ambrogioni, 1994; Philis and Braasch, 1996).

No appreciable difference for the CV has been found between the two populations for most of the characters in both females and males. The lowest CV values correspond to the "a" ratio and "V" value in the females.

In Italy the species was recovered from the wood of *Pinus sylvestris* L., a new host for *B. leoni*, in Friuli Venezia Giulia; from *P. pinaster* Ait. in Emilia Romagna and Tuscany; from *P. pinea* L. in Tuscany and on *P. halepensis* Mill. in Tuscany and Apulia (Ambrogioni *et al.*, 1994; Caroppo *et al.*, 1998).

BURSAPHELENCHUS MUCRONATUS

Mamyra et Enda, 1979

(Tables III and IV)

Italian populations were previously described (Marinari Palmisano *et al.*, 1992; Marinari Palmisano *et al.*, 1994; Marinari Palmisano and Ambrogioni, 1994). Their morphometrics generally agree with those reported for specimens of various geographical regions (Mamyra and Enda, 1979; Mc Namara and Støen, 1988; Tomminen *et al.*, 1989; Braasch, 1991).

Females of populations IT6 (w) and IT8 (w) have the highest values for most of the morphometric characters among all Italian populations of the species and the females of IT5 (w) and IT12 (i) show the lowest values (Tables III - IV). The males of the population IT6 (w) can be differentiated by the highest values of body length, oesophageal glands overlapping intestine length, distance from anterior end to poste-

rior end of oesophageal glands, and distance from anterior end to hemizonid. The highest mean value of stylet length was observed in both sexes of the population IT4 (w).

The females of the population IT8 (w) and both sexes of IT6 (w) have the greatest size among those of all other European and Japanese populations (Mamyra and Enda, 1979; Tomminen *et al.*, 1989; Braasch, 1991).

Among the other populations, IT13 (w) has the lowest CV values for most of the characters, particularly in the females, whereas the females of IT6 (w) and males of IT5 (w) have generally the highest values. The homogeneity of population IT13 (w) may be attributed to the few specimens (n = 4) used to establish the culture (Caroppo *et al.*, 1998).

The lowest CV values correspond to "V" value in the females of all populations.

B. mucronatus appears widespread in Italy where it was found for the first time associated with *Monochamus galloprovincialis galloprovincialis* (Ol.) on *P. pinaster* in three localities of Liguria (Marinari Palmisano *et al.*, 1992). The species was reported also on *P. pinaster*, *P. nigra austriaca* Arn., *P. strobus* L., *P. sylvestris* in Piedmont and on *P. pinaster* in Tuscany (Caroppo *et al.*, 1998).

BURSAPHELENCHUS SEXDENTATI

Rühm, 1960

(Table V; Figs. 2-4)

Syn.: *Aphelenchoides* (*Bursaphelenchus*) *sexdentati* Rühm, 1960

B. bakeri Rühm, 1964 (= junior objective synonym)

B. naujaci Baujard, 1980

The Italian populations of the species are morphologically very similar to the original description (Rühm, 1960), with the exception of some biometrical characters.

TABLE III - Measurements of four Italian populations of *Bursaphelenchus mucronatus*.

	IT4 (w)		IT5 (w)		IT6 (w)		IT7 (w)	
n	10 ♀♀	10 ♂♂	10 ♀♀	10 ♂♂	10 ♀♀	10 ♂♂	10 ♀♀	10 ♂♂
Body length	861.4±71.6 (757.5-966.8)	832.7±66.6 (735.7-963.2)	733.9±63.9 (605.0-824.0)	740.6±83.0 (578.4-860.3)	967.3±113.0 (749.0-1103.5)	952.0±93.4 (818.0-1137.4)	864.1±92.6 (735.7-997.0)	797.3±5.6 (715.1-905.1)
Body width	23.6±2.3 (20.6-27.8)	18.6±0.8 (16.9-19.4)	17.9±1.7 (15.7-21.8)	16.8±2.4 (14.5-22.4)	22.9±1.4 (20.6-25.4)	19.2±1.5 (15.7-21.8)	20.8±2.0 (16.9-23.0)	15.8±0.9 (14.5-16.9)
a	36.6±1.6 (33.8-39.2)	45.0±3.3 (40.5-49.8)	41.2±3.9 (33.3-45.1)	44.7±6.2 (31.1-51.6)	42.4±4.7 (32.6-47.5)	50.0±5.4 (42.3-58.8)	41.8±4.7 (33.8-49.4)	50.3±2.1 (47.7-53.4)
Distance from anterior end to junction of oesophagus and intestine	79.7±2.1 (77.4-83.5)	80.3±3.3 (72.6-84.7)	76.2±4.0 (70.2-82.3)	72.3±6.5 (66.6-88.3)	79.6±6.0 (70.2-87.1)	77.5±2.6 (72.6-82.3)	77.1±3.9 (71.4-82.3)	74.5±2.0 (71.4-77.4)
b	10.9±1.0 (9.6-12.3)	10.4±1.2 (9.1-13.3)	9.8±0.8 (8.2-10.8)	10.3±1.2 (8.2-11.5)	12.2±1.3 (10.7-14.3)	12.3±1.1 (10.7-14.5)	11.2±0.8 (9.7-12.2)	10.7±0.5 (9.7-11.7)
Distance from anterior end to posterior end of oesophageal glands	147.8±10.8 (133.1-173.0)	135.9±7.2 (127.1-152.5)	137.4±11.1 (118.6-154.9)	128.0±8.2 (112.5-136.7)	147.2±14.8 (127.1-165.8)	144.5±13.8 (124.6-171.8)	146.6±6.5 (139.2-156.1)	134.1±10.8 (124.6-152.5)
b'	7.3 (5.9±0.6)	8.1 (6.1±0.6)	5.3 (4.5-6.4)	6.4 (5.7-7.6)	11.2 (9.5-13.3)	10.6 (9.3-12.3)	8.6 (7.5-9.7)	5.0 (4.5-5.5)
Distance from anterior end to base of median bulb	73.3±1.6 (71.4-76.2)	74.4±2.8 (67.8-78.7)	69.6±3.6 (64.1-76.2)	66.8±7.1 (60.5-84.7)	74.1±5.2 (65.3-81.1)	72.1±2.6 (67.8-76.2)	71.4±3.4 (66.6-76.2)	69.4±2.5 (66.6-72.6)
b1	11.8±1.0 (10.4-13.3)	11.2±1.2 (9.8-14.2)	10.5±0.6 (9.4-11.6)	11.2±1.3 (8.5-12.5)	13.1±1.3 (11.5-15.0)	13.2±1.1 (11.8-15.7)	12.1±0.9 (10.7-13.3)	11.5±0.5 (10.6-12.5)
Oesophageal glands overlapping intestine length	63.9±8.1 (48.4-72.6)	55.7±5.8 (46.0-67.8)	61.7±10.0 (44.8-78.7)	55.8±8.0 (42.4-67.0)	70.5±10.8 (53.2-84.7)	67.0±12.8 (48.4-93.2)	69.5±3.9 (62.9-75.0)	59.5±9.3 (50.8-76.2)
Oesophageal glands overlapping intestine length / Body width to junction of oesophagus and intestine	2.7 (3.1-4.3)	3.0 (2.7-4.3)	3.5 (2.9-5.4)	3.4 (2.3-4.6)	3.2 (3.2-5.2)	3.5 (2.7-5.5)	3.4 (3.9-4.8)	3.7 (3.5-5.2)
Stylet length	16.5±0.5 (15.7-16.9)	16.7±0.4 (15.7-16.9)	14.7±0.5 (13.9-15.7)	14.6±0.9 (13.3-16.9)	15.1±1.0 (13.3-16.9)	14.8±0.8 (13.3-15.7)	15.0±0.7 (14.5-16.3)	14.7±0.5 (13.9-15.7)
Distance from anterior end to excretory pore	76.6±6.3 (70.2-84.7)	79.7±7.5 (67.8-88.3)	72.8±6.6 (64.1-81.1)	58.9±7.5 (52.0-75.0)	82.3±6.4 (76.2-93.2)	77.1±7.9 (66.6-88.3)	69.9±12.5 (52.0-90.8)	62.5±4.9 (56.9-72.6)
Distance from anterior end to hemizonid	94.3±3.3 (88.3-99.2)	96.8±2.6 (94.4-101.6)	89.9±4.0 (84.7-94.4)	87.3±8.3 (78.7-102.9)	100.3±5.3 (94.4-108.9)	98.2±9.3 (84.7-108.9)	93.9±5.3 (85.9-102.9)	94.2±2.5 (90.8-98.0)
V	74.4±1.6 (72.2-77.2)	74.4±1.0 (72.5-75.6)	74.4±1.0 (72.5-75.6)	75.9±1.5 (73.2-77.9)	75.9±1.5 (73.2-77.9)	75.9±1.5 (73.2-77.9)	73.6±1.8 (71.7-78.1)	73.6±1.8 (71.7-78.1)
Flap length	2.1 (1.0-2.0)	1.3 (1.0-2.0)	1.3 (1.0-2.0)	2.0 (1.0-2.0)	2.0 (1.0-2.0)	2.0 (1.0-2.0)	2.5 (1.0-2.0)	2.5 (1.0-2.0)
Anterior genital branch length	418.7±66.9 (302.5-490.1)	507.1±49.4 (435.6-580.8)	304.3±57.3 (205.7-381.2)	399.2±85.4 (227.5-481.6)	420.9±120.8 (290.4-677.6)	504.5±167.2 (318.2-834.9)	365.8±89.8 (260.2-490.1)	471.0±53.9 (399.3-553.0)
Post-uterine branch length	139.1±11.0 (121.0-156.1)	139.1±11.0 (121.0-156.1)	104.9±12.7 (84.7-127.1)	121.4 (84.7-127.1)	140.0±23.1 (115.0-188.8)	140.0±23.1 (115.0-188.8)	130.3±11.7 (121.0-157.3)	11.5
T	7.9	61.1±6.1 (49.4-71.4)	12.1	53.5±8.0 (39.3-64.5)	16.5	53.2±17.5 (31.9-81.7)	9.0	59.1±6.2 (51.2-68.3)
Vulval - anus distance	189.7±17.0 (160.9-220.2)	189.7±17.0 (160.9-220.2)	158.4±14.0 (129.5-177.9)	15.0	201.0±25.4 (160.9-239.6)	32.8	202.3±20.8 (169.4-242.0)	10.6
Post-uterine branch length % / Vulval - anus distance	73.5±3.5 (65.9-78.2)	73.5±3.5 (65.9-78.2)	66.5±7.8 (56.0-76.9)	8.8	69.5±8.3 (59.8-84.8)	12.7	64.8±5.4 (57.6-71.4)	10.3
Body diameter at vulva	21.4±1.6 (18.2-23.0)	21.4±1.6 (18.2-23.0)	16.6±2.2 (14.5-21.8)	11.7	20.7±1.6 (18.2-24.2)	12.0	19.9±1.6 (16.9-21.8)	8.4
Post-uterine branch length / Body diameter at vulva	6.5±0.6 (5.7-8.0)	6.5±0.6 (5.7-8.0)	6.4±0.7 (5.4-7.6)	13.0	6.9±1.6 (5.3-10.4)	12.4	6.6±0.8 (5.7-8.1)	8.2
Tail length	31.1±2.4 (27.8-35.1)	29.9±2.1 (26.6-33.9)	30.8±2.5 (25.4-33.9)	8.2	28.1±3.4 (24.2-33.9)	32.0±3.3 (26.6-36.3)	32.8±4.3 (26.6-39.9)	28.4±1.9 (24.2-30.3)
c	27.9±2.8 (22.4-31.4)	28.0±2.2 (24.3-32.5)	24.0±2.7 (20.0-28.4)	12.2	26.5±2.1 (23.9-31.0)	30.3±2.8 (26.6-34.7)	26.5±1.7 (24.4-28.9)	28.1±2.1 (26.0-33.3)
Body width at anus	15.2±1.0 (14.2-16.9)	15.3±0.8 (14.5-16.9)	8.9±0.8 (8.5-10.9)	11.4	13.4±1.3 (10.9-15.7)	10.4±0.6 (9.7-10.9)	16.7±1.5 (13.3-18.2)	15.0±0.8 (14.5-16.9)
c'	3.1±0.3 (2.6-3.6)	3.6±0.4 (3.2-4.3)	3.5±0.4 (2.7-4.0)	9.0	2.1±0.3 (1.6-2.6)	3.1±0.3 (2.7-3.8)	3.4±0.4 (2.8-4.1)	1.9±0.1 (1.7-2.0)
Mucron length	2.6±0.5 (1.8-3.6)	2.6±0.5 (1.8-3.6)	2.7±0.4 (2.4-3.6)	12.5	13.2	10.3	12.3	4.8
Spicules	18.9	30.6±1.0 (29.0-31.5)	15.6	27.2±1.5 (24.2-30.3)	16.7	30.6±1.8 (27.8-32.7)	19.4	27.7±1.6 (25.4-30.3)
Spicules (chord)		3.3 (2.7-4.2)	7.0	5.7 (4.8-6.6)	2.8	5.7 (4.8-6.6)	6.6	5.6 (4.8-6.6)

TABLE IV - *Measurements of three Italian populations of B. mucronatus.*

	IT8 (w)		IT12 (i)		IT13 (w)	
n	10 ♀♀	10 ♂♂	10 ♀♀	10 ♂♂	10 ♀♀	10 ♂♂
Body length	942.8±87.4 (847.0-1124.1)	758.2±88.0 (619.5-865.2)	722.1±66.2 (621.9-810.7)	670.4±50.4 (597.4-740.5)	805.0±26.7 (764.7-845.8)	737.4±60.2 (667.9-844.6)
	9.3	11.6	9.2	7.5	3.3	8.2
Body width	25.8±3.2 (23.0-33.9)	19.3±2.1 (16.9-23.0)	19.9±2.5 (16.9-24.2)	17.3±1.2 (15.7-19.4)	18.3±1.2 (15.7-19.4)	16.2±1.2 (14.5-18.2)
	12.3	10.8	12.6	6.8	6.7	7.2
a	36.8±2.6 (33.2-42.2)	39.5±3.6 (34.1-46.5)	36.7±3.7 (31.7-44.3)	38.8±2.5 (35.3-43.7)	44.2±2.9 (40.0-49.9)	45.5±1.9 (43.1-48.2)
	7.0	9.0	10.1	6.4	6.6	4.2
Distance from anterior end to junction of oesophagus and intestine	74.2±4.5 (66.6-82.3)	70.2±3.1 (65.3-76.2)	73.0±4.0 (66.6-77.4)	73.2±5.7 (60.5-79.9)	75.3±2.8 (70.2-78.7)	73.9±3.0 (66.6-76.2)
	6.0	4.4	5.5	7.8	3.8	4.1
b	12.7±0.9 (11.4-13.8)	10.8±1.1 (8.7-12.5)	9.9±1.0 (8.9-12.1)	9.2±0.8 (8.0-10.6)	10.7±0.5 (10.2-11.8)	10.0±0.7 (8.9-11.1)
	7.1	10.5	9.8	8.7	4.7	7.4
Distance from anterior end to posterior end of oesophageal glands	145.9±9.5 (127.1-156.1)	132.4±8.1 (121.0-146.4)	130.3±7.9 (115.0-141.6)	129.7±3.8 (124.6-134.3)	135.8±5.0 (128.3-146.4)	132.5±6.1 (127.1-144.0)
	6.5	6.1	6.1	2.9	3.7	4.6
b'	6.5±0.6 (5.8-7.4)	5.7±0.5 (4.8-6.5)	5.5±0.3 (5.1-6.1)	5.2±0.4 (4.7-5.7)	5.9±0.3 (5.6-6.4)	5.6±0.6 (4.6-6.6)
	9.0	8.7	5.3	6.8	4.4	10.6
Distance from anterior end to base of median bulb	68.1±5.5 (60.5-77.4)	64.5±3.4 (59.3-71.4)	67.6±2.7 (64.1-71.4)	68.6±3.9 (60.5-72.6)	71.0±2.6 (65.3-73.8)	69.0±3.1 (64.1-72.6)
	8.0	5.3	4.0	5.7	3.6	4.5
b1	13.9±1.0 (12.2-15.4)	11.8±1.2 (9.5-13.4)	10.7±1.0 (9.5-12.6)	9.8±0.7 (8.6-11.1)	11.4±0.6 (10.8-12.6)	10.7±0.8 (9.5-12.0)
	7.4	10.3	9.1	7.4	4.9	7.5
Oesophageal glands overlapping intestine length	71.7±6.7 (60.5-81.1)	62.2±5.8 (53.2-72.6)	56.6±5.4 (46.0-65.3)	56.5±5.5 (48.4-66.6)	60.5±4.4 (54.5-67.8)	58.6±8.2 (50.8-72.6)
	9.4	9.3	9.5	9.7	7.2	13.9
Oesophageal glands overlapping intestine length / Body width to junction of oesophagus and intestine	4.0±0.3 (3.5-4.4)	3.8±0.3 (3.5-4.3)	3.6±0.2 (3.2-3.9)	3.8±0.4 (3.3-4.6)	4.0±0.4 (3.5-4.7)	3.9±0.5 (3.2-5.0)
	7.6	7.2	6.1	11.1	9.6	14.0
Stylet length	15.8±0.8 (14.5-16.9)	15.3±0.5 (14.5-15.7)	14.3±0.6 (13.3-15.1)	13.7±0.6 (13.3-14.5)	15.1±0.6 (14.5-15.7)	15.1±0.6 (14.5-15.7)
	4.9	3.3	4.4	4.2	3.7	4.2
Distance from anterior end to excretory pore	71.8±4.3 (66.6-78.7)	72.5±5.8 (66.6-84.7)	74.1±7.0 (58.1-81.1)	75.8±4.5 (66.6-82.3)	75.1±4.7 (66.6-80.0)	71.9±5.6 (62.9-79.9)
	6.0	8.0	9.5	6.0	6.3	7.7
Distance from anterior end to hemizonid	91.0±1.8 (88.3-94.4)	90.5±4.1 (83.5-96.8)	90.4±6.6 (78.7-96.8)	92.8±5.5 (85.9-101.6)	91.7±3.5 (84.7-98.0)	90.4±2.9 (85.9-94.4)
	2.0	4.5	7.3	6.0	3.4	3.2
V	76.0±1.5 (73.1-78.7)		73.5±1.1 (71.6-75.0)		73.2±1.4 (71.7-76.3)	
	2.0		1.5		1.9	

TABLE IV - *Continued.*

	IT8 (w)		IT12 (i)		IT13 (w)	
Flap length	10.2±1.3 (7.3-11.5) 13.0		8.3±1.6 (6.1-10.3) 18.6		8.6±0.6 (7.3-9.7) 6.9	
Anterior genital branch length	532.2±73.2 (429.6-635.3)	537.4±69.8 (405.3-632.8)	309.7±78.2 (205.7-429.6)	378.4±49.8 (296.5-457.4)	271.3±41.7 (213.0-347.3)	341.6±29.9 (273.5-381.2)
Post-uterine branch length	13.8 153.1±13.4 (127.1-173.0) 8.8		13.0 25.3 115.2±17.1 (84.7-133.1) 14.8		15.4 130.7±11.9 (102.9-145.2) 9.1	
T		71.1±7.5 (61.7-85.9) 10.6		56.3±3.8 (49.3-63.4) 6.8		46.6±5.8 (37.4-54.6) 12.4
Vulval - anus distance	196.6±20.2 (167.0-239.6) 10.3		162.2±13.6 (136.7-183.9) 8.4		182.3±7.4 (169.4-198.4) 4.0	
Post-uterine branch length % / Vulval - anus distance	78.1±4.7 (71.8-83.9) 6.0		71.3±10.5 (55.2-83.7) 14.7		71.6±5.1 (60.7-80.0) 7.1	
Body diameter at vulva	23.1±1.9 (20.6-27.8) 8.3		17.6±1.7 (14.5-19.4) 9.2		17.8±0.9 (16.9-19.4) 4.8	
Post-uterine branch length / Body diameter at vulva	6.6±0.6 (5.8-8.0) 9.5		6.6±0.9 (5.3-7.9) 14.3		7.3±0.6 (6.1-8.0) 7.5	
Tail length	31.6±1.8 (29.0-33.9) 5.7	29.4±1.2 (27.8-31.5) 4.0	29.1±2.3 (25.4-32.7) 8.0	27.3±1.3 (25.4-29.0) 4.7	33.2±2.1 (30.3-36.3) 6.4	28.2±1.0 (26.6-30.3) 3.6
c	29.9±2.1 (25.2-33.2) 7.0	25.8±2.5 (21.3-29.1) 9.8	25.0±2.8 (22.0-30.2) 11.0	24.6±2.0 (20.6-26.8) 8.3	24.4±2.1 (21.8-27.3) 8.7	26.2±2.1 (24.0-30.3) 7.9
Body width at anus	10.3±0.6 (9.7-10.9) 6.1	16.1±0.8 (14.5-16.9) 5.0	9.1±1.0 (7.3-10.9) 11.1	14.1±1.0 (12.1-15.7) 6.9	8.7±0.7 (7.3-9.7) 8.0	14.4±0.9 (13.3-15.7) 6.1
c'	3.1±0.3 (2.7-3.5) 9.4	1.8±0.1 (1.7-1.9) 4.9	3.2±0.2 (2.9-3.6) 7.1	1.9±0.1 (1.7-2.1) 7.3	3.9±0.4 (3.3-4.7) 10.6	2.0±0.1 (1.8-2.2) 7.1
Mucron length	4.4±0.5 (3.6-4.8) 11.1		2.5±0.5 (1.8-3.6) 18.7		3.4±0.6 (2.4-4.2) 18.4	
Spicules		29.5±1.5 (27.8-31.5) 4.9		26.2±0.9 (25.4-27.8) 3.4		28.8±1.6 (25.4-31.5) 5.6
Spicules (chord)		25.5±2.1 (21.8-29.0) 8.1		22.3±1.2 (20.6-24.2) 5.4		23.8±1.7 (21.8-26.6) 7.1

Medium to long nematodes (Table V). Cuticle finely annulated. Head rounded relatively high, offset by a shallow constriction (Fig. 2A). En face SEM view of head region shows six labial lobes with four slightly elevated cephalic papillae located on each subdorsal and subventral cephalic sectors and two pore-like amphidial apertures dorso-medially located on lateral cephalic sectors (Fig. 3A). A distinct labial disc is visible within a ring of inner papillae (frequently obscured) closely surrounding a well defined circular stomatal aperture. SEM revealed only four sublateral inner papillae. Six larger protuberances encircling the inner papillae, and corresponding to the outer labial papillae, are present. Stylet with moderately developed basal thickenings. Median bulb oval. Excretory pore anterior to hemizonid, the position varying between the junction of oesophagus and intestine and the hemizonid.

Lateral field with four incisures (Fig. 3D), beginning midway between anterior extremity and start of metacarpus (Fig. 3C), extending posteriorly to the tail tip, but reduced to three incisures below the anus in the female (Figs. 3E-G) and to the level of preanal papilla in the male. In the latter the lateral field is less distinct from the preanal papilla to the bursal flap.

Female - Body ventrally slightly arcuate when killed by heat and with a postvulval constriction. Vulva with anterior lip extending about 2 μm posterior to the opening (Figs. 4A-B). Exposed area posterior to vulval flap swollen (Fig. 2C). Post-uterine branch long and wide usually filled with sperms. Tail gradually tapering, conical conoid in shape with variable terminus, rounded or slightly digitate (Figs. 3E-G). Anus sometimes a dome-shaped slit in ventral view (Fig. 3F).

Male - Body ventrally arcuate, C shaped when heat killed, with tail curled, the extent of curl variable (Figs. 2E; 4C-D). Testis not always outstretched, sometimes reaching posterior end

of oesophageal glands or beyond. Basic shape of the spicules similar to original description (Rühm, 1960), but differing in the lamina being more curved and with a knob-like appendage at the distal end, not described before (Figs. 2D-E; 4D-E). Seven preanal and postanal papillae present (Figs. 4C-D): one preanal ventromedian at the level of cloaca, smaller than others and obscure in most specimens (visible with SEM); one pair of subventral adanal papillae, one pair of postanal papillae at 35-48% of tail length from cloaca, one ventral pair of papillae at 48-60% of tail length, behind cloaca at level of bursal flap. Bursa relatively long, usually oval shaped in ventral view, with two small projections at the sides of the terminal margin (Fig. 4F).

No appreciable differences were found in the morphological characters in both females and males among the Italian populations of *B. sexdentati*.

Some morphometrical characters show differences from the values given by other authors for *B. sexdentati*, *B. bakeri* and *B. naujaci* (Rühm, 1960; Baujard, 1980; Tarjan and Aragón, 1982; Marinari Palmisano and Ambrogioni, 1994). The ranges observed for most of the measurements of the females and males from I15 (w) are narrower than those known for *B. sexdentati* and synonyms of the species. Both sexes of the population IT9 (w) are more slender than in other descriptions (Rühm, 1960; Baujard, 1980).

In the Italian populations the lowest CV values correspond to "V" value, the highest CV values for the characters of both sexes is shown by the population IT2 (w).

B. sexdentati was reported for the first time in Italy on *P. pinaster* in Emilia Romagna (Ambrogioni *et al.*, 1994). The species also occurs on *P. pinaster* in Piedmont and on *P. pinaster*, *P. halepensis* and *P. pinea* in Tuscany (Caroppo *et al.*, 1998). The two last coniferous species, to the best of our knowledge, are new hosts for *B. sexdentati*.

TABLE V - *Measurements of three Italian populations of Bursaphelenchus sexdentati.*

	IT2 (w)		IT9 (w)		I15 (w)	
	10 ♀♀	10 ♂♂	10 ♀♀	10 ♂♂	10 ♀♀	10 ♂♂
n						
Body length	886.5±193.9 (613.5-1171.3)	859.0±98.9 (703.0-1049.1)	1106.2±99.6 (983.7-1314.1)	960.6±113.2 (749.0-1154.3)	704.8±78.4 (599.0-838.5)	653.0±50.2 (540.9-724.8)
Body width	21.9 22.2±3.5 (15.7-27.8)	11.5 19.1±4.1 (12.1-24.2)	9.0 21.8±2.4 (18.2-26.6)	11.8 18.9±2.9 (13.3-23.0)	11.1 17.5±1.9 (15.7-20.6)	7.7 13.9±0.6 (13.3-14.5)
a	15.6 39.9±4.5 (32.4-44.7)	21.5 46.2±7.7 (36.0-58.6)	11.0 51.0±4.2 (43.6-57.2)	15.1 51.6±2.8 (46.9-56.3)	11.1 40.3±3.6 (35.9-45.8)	4.5 47.0±3.2 (40.6-50.6)
Distance from anterior end to junction of oesophagus and intestine	11.2 69.7±3.9 (62.9-75.0)	16.6 67.3±5.3 (58.1-72.6)	8.2 76.2±2.8 (72.6-79.9)	5.3 72.5±4.4 (66.6-82.3)	9.1 72.3±2.9 (66.6-75.0)	6.8 70.3±4.8 (64.1-78.7)
b	5.6 12.8±2.8 (8.5-17.3)	7.9 12.8±1.3 (11.0-15.2)	3.6 14.2±1.1 (12.7-15.7)	6.0 13.3±1.6 (10.0-16.2)	3.4 9.5±1.0 (8.5-11.4)	6.8 9.5±0.9 (8.2-10.9)
Distance from anterior end to posterior end of oesophageal glands	21.9 137.0±8.0 (123.4-147.6)	9.9 133.0±13.6 (106.5-150.0)	7.6 156.6±9.1 (142.8-170.6)	12.1 140.6±15.6 (123.4-164.6)	10.2 137.0±5.9 (127.1-147.6)	9.4 133.0±8.9 (112.5-141.6)
b'	5.8 6.4±1.2 (4.7-7.9)	10.3 6.6±0.8 (5.2-7.7)	5.8 6.9±0.6 (6.1-8.0)	11.1 7.1±0.9 (6.1-8.5)	4.3 5.2±0.5 (4.6-6.2)	6.7 5.1±0.5 (4.5-6.1)
Distance from anterior end to base of median bulb	17.9 63.3±2.6 (59.3-69.0)	12.1 60.9±4.2 (53.2-67.8)	9.0 72.0±6.4 (62.9-87.1)	12.8 68.9±4.4 (62.9-78.7)	10.5 61.2±1.8 (56.9-62.9)	10.1 62.3±3.7 (54.5-66.6)
b1	4.0 14.0±3.0 (9.4-19.0)	7.0 14.0±1.4 (12.2-16.7)	9.0 15.4±1.4 (13.5-17.8)	6.4 14.1±1.7 (10.5-17.1)	3.0 11.5±1.2 (9.9-13.3)	5.9 10.5±0.7 (9.4-11.3)
Oesophageal glands overlapping intestine length	21.3 67.3±8.5 (56.9-79.9)	10.2 64.6±9.9 (48.4-78.7)	9.2 80.3±8.5 (67.8-92.0)	12.3 68.4±14.2 (53.2-94.4)	10.6 66.4±6.7 (56.9-75.0)	6.4 62.7±6.3 (48.4-70.2)
Oesophageal glands overlapping intestine length / Body width to junction of oesophagus and intestine	12.7 4.4±0.6 (3.6-5.5)	15.3 4.4±0.8 (3.6-5.9)	10.6 5.3±0.8 (3.7-6.0)	20.3 4.8±1.1 (3.5-6.4)	10.1 5.5±0.7 (3.9-6.2)	10.1 5.6±0.5 (4.7-6.2)
Stylet length	13.2 15.2±0.6 (14.5-15.7)	18.5 15.0±0.6 (14.5-15.7)	14.8 15.9±0.7 (14.5-16.9)	22.8 15.7±0.6 (14.5-16.9)	13.4 13.5±0.6 (12.7-14.5)	8.6 13.7±0.9 (12.1-15.7)
Distance from anterior end to excretory pore	3.9 79.0±6.4 (73.8-90.8)	3.9 75.3±7.5 (60.5-87.1)	4.4 85.5±4.9 (78.7-92.7)	4.0 87.7±7.3 (75.0-102.9)	4.7 72.7±3.7 (67.8-78.7)	7.0 73.9±3.3 (67.8-78.7)
Distance from anterior end to hemizonid	8.1 86.9±8.9 (78.7-101.6)	9.9 83.9±8.7 (66.6-95.6)	5.7 94.0±4.3 (88.3-100.4)	8.4 94.5±7.4 (85.9-111.3)	5.1 81.3±6.6 (72.6-90.8)	4.4 81.7±3.6 (75.0-87.0)
V	10.2 74.1±2.2 (67.9-75.4)	10.4	4.6 74.1±3.1 (71.9-82.5)	7.8	8.1 74.5±1.4 (71.1-76.6)	4.4
	3.0		4.1		1.9	

TABLE V - *Continued.*

	IT2 (w)		IT9 (w)		I15 (w)	
Anterior genital branch length	306.8±95.2 (163.4-520.3)	484.5±119.1 (288.0-641.3)	475.3±71.7 (350.9-592.9)	640.5±95.7 (471.9-744.2)	289.7±70.4 (211.8-411.4)	392.8±60.9 (266.2-459.8)
G1	31.1 35.7±12.3 (21.9-59.0)	24.6	15.1 43.2±7.2 (35.1-55.3)	15.0	24.3 40.9±7.8 (33.3-59.2)	15.5
Post-uterine branch length	34.4 140.3±35.6 (100.4-209.3)		16.7 162.8±17.1 (145.2-193.6)		19.1 109.3±14.9 (90.8-139.2)	
G2	25.4 15.9±2.2 (12.9-20.7)		10.5 14.8±1.8 (11.3-17.2)		13.7 15.6±1.9 (13.3-19.6)	
T	13.8	56.6±13.2 (35.2-76.0)	12.3	67.0±9.1 (51.9-76.3)	12.4	60.5±10.5 (39.0-77.2)
Vulval - anus distance	191.1±39.1 (144.0-246.8)	23.3	241.9±25.4 (193.6-286.8)	13.6	139.7±15.1 (115.0-158.5)	17.4
Post-uterine branch length % / Vulval - anus distance	20.5 73.0±6.7 (63.2-84.8)		10.5 67.6±6.9 (55.7-76.9)		10.8 76.5±10.6 (63.0-93.6)	
Body diameter at vulva	9.1 20.1±3.0 (15.7-24.2)		10.2 20.3±2.1 (18.2-24.2)		13.9 15.4±1.8 (13.3-18.2)	
Post-uterine branch length / Body diameter at vulva	14.8 7.0±1.2 (4.8-8.7)		10.5 8.1±0.8 (6.8-9.7)		11.8 7.2±1.2 (5.7-9.4)	
Tail length	17.7 36.5±6.3 (27.8-50.8)	27.5±1.5 (25.4-30.3)	10.1 42.7±4.1 (36.3-48.4)	30.0±1.9 (26.6-32.7)	16.9 33.6±3.1 (27.8-37.5)	7.2 25.0±1.8 (20.6-26.6)
c	17.2 24.3±3.2 (18.1-27.8)	5.5 31.2±3.3 (25.3-36.1)	9.6 26.2±4.0 (21.8-36.2)	6.3 32.0±3.2 (26.9-36.1)	9.3 21.2±3.3 (16.5-26.2)	7.2 26.1±1.7 (22.6-28.5)
Body width at anus	13.0 12.1±2.0 (9.7-15.7)	10.6 12.8±1.7 (9.7-15.7)	15.1 12.0±0.9 (10.9-13.3)	9.9 13.3±1.6 (10.9-15.7)	15.7 9.4±0.9 (8.5-10.9)	6.5 10.7±0.8 (9.7-12.1)
c'	16.1 3.2±0.2 (2.9-3.5)	13.3 2.2±0.3 (1.8-2.9)	7.4 3.6±0.2 (3.0-3.9)	12.0 2.3±0.3 (1.8-2.7)	10.0 3.6±0.6 (2.9-4.4)	7.0 2.4±0.3 (1.9-2.8)
Spicules (chord)	7.0	13.3 15.5±1.3 (13.3-18.2)	6.5	11.3 16.0±1.4 (13.3-18.2)	15.4	11.4 14.5±1.4 (13.3-16.9)
		8.2		8.7		9.9



Fig. 2 - Photomicrographs of *B. sexdentati*: A, female anterior region, lateral; B, female posterior region, ventral; C, female vulval region with a swollen area posterior to vulval flap (→), lateral; D, male tail with spicules and bursa, subventral; E, male tail with spicules ending with a knob-like appendage (→), lateral.

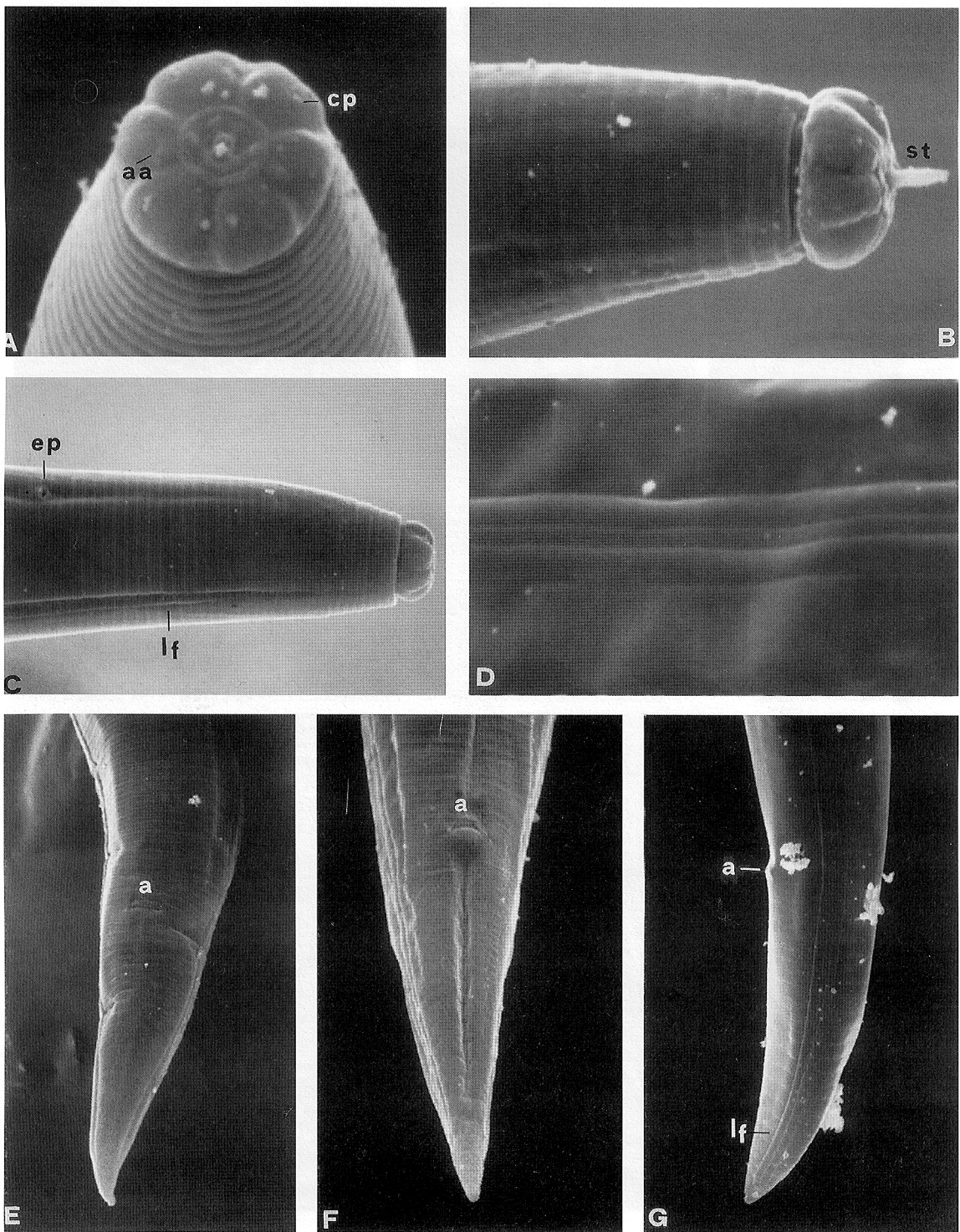


Fig. 3 - SEM photomicrographs of *B. sexdentati*; A, female anterior region (aa = amphid aperture; cp = cephalic papilla), face view. x 8,000; B, female anterior region (st = protracted stylet), ventral. x 6,500; C, female anterior region (ep = excretory pore; lf = lateral field), subventral. x 2,800; D, female lateral field; E, F, G, female variations in tail terminus (a = anus; lf = lateral field), ventral. x 2,600; ventral. 3,400; lateral. x 2,700.

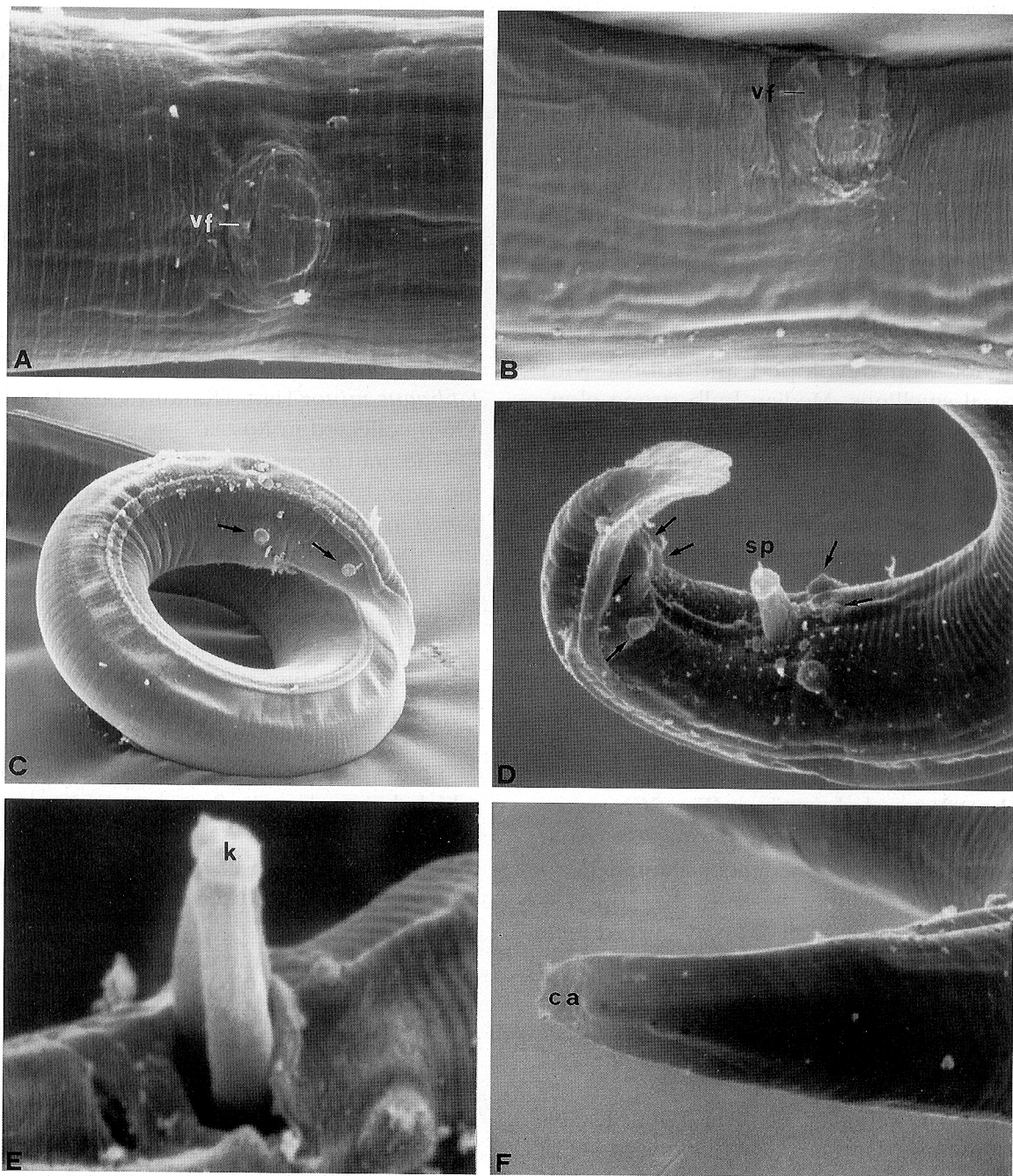


Fig. 4 - SEM photomicrographs of *B. sexdentati*: A, B, female vulval region (vf = vulval flap), ventral. x 3,800; subventral. x 5,500; C, male posterior region (arrows = caudal papillae), subventral. x 2,100; D, male tail region with protracted spicules (arrows = caudal papillae; sp. = spicules ending with a knob-like appendage), subventral. x 3,800; E, male protracted spicules (k = knob-like appendage), ventral. x 10,000; F, male tail terminus (ca = caudal ala), dorsal. x 4,400.

BURSAPHELENCHUS TERATOSPICULARIS

Kakuliya et Devdariani, 1965

(Table VI; Fig. 5)

The Italian populations are morphologically very similar to the original description (Kakuliya and Devdariani, 1965), with some minor differences.

Medium sized nematodes (Table VI). Cuticle marked by moderately prominent annules. Lip region slightly set off and slightly flattened frontally. Stylet well developed and robust with small basal swellings. Median bulb strong elongate-oval or rounded-rectangular (Fig. 5A). Oesophago-intestinal junction just posterior to the base of median bulb. Oesophageal gland lobes very long. Excretory pore anterior to the hemizonid consistently, between the hemizonid and the nerve ring. Three or four incisures in the lateral field, however, not readily visible.

Female - Body ventrally curved when killed by heat. Ovary outstretched. Vagina slopes posteriorly to vulval opening. Vulval lips slightly protruding (Fig. 5B); vulval flap absent. Post-uterine sac short (Fig. 5B). Tail conical in shape with a broad rounded terminus (Fig. 5C), sometimes ending in a very small process. Anal opening obscure on all specimens examined.

Male - Body forms a more or less open C when relaxed by heat. Tail strongly curved ventrally (Fig. 5D). Spicules of the same shape as the original description of *B. teratospicularis*. Two pairs of preanal and postanal papillae: one pair of subventral adanal papillae at the level of the spicule rostrum (when the spicules are not protracted), the other one subventral at 46-50% of tail length from cloaca, at the beginning of the bursa. Bursa small, usually oval shaped when viewed ventrally, with the outer edges semi-acute (Fig. 5E).

The ranges of body length of the Italian population IT11 (w) are wider than those of the original Russian population. Specimens of the two Italian populations examined are more slender, ranges of "a" ratio are between 33.6-

38.2 for females, 30.4-39.2 for males vs 29.0-33.8 for females and 27.2-30.0 for males of the Russian population. The females of both Italian populations differ from those of the original description in the posterior vulva (ranges between 78.1-81.1% vs 75.5-79.5%).

The Italian populations have very low CV values for most of the measurements. The lowest CV values applying to "V".

B. teratospicularis was described from specimens isolated from frass in the galleries of the beetles *Orthotomicus proximus* Eichb. and *Blastophagus minor* Hart. (Kakuliya and Devdariani, 1965) collected in Russia.

The Italian specimens were extracted from the wood of *P. pinaster*, *P. halepensis* and *P. pinea* in three localities of Tuscany (Caroppo *et al.*, 1998). A single male of the species was found at Scopeti (Florence). As far as we are aware *B. teratospicularis* has not previously been collected from these pines species.

This is the first report of *B. teratospicularis* from Italy.

Five species of *Bursaphelenchus*, one of which being described as a new species, have been found in Italy associated with forest trees (Marinari Palmisano *et al.*, 1992; 1994; Marinari Palmisano and Ambrogioni, 1994; Ambrogioni *et al.*, 1994).

B. mucronatus, the most common species, is limited in its distribution to the northern and central western Italian areas; *B. leoni* is reported also from southern Italy. In all cases few specimens were recovered from wood samples but frequently two, three or four species occurred together (Caroppo *et al.*, 1998). *B. mucronatus* is widely distributed in European pine forests; *B. leoni*, *B. sexdentati* and *B. teratospicularis* occur mainly in South Europe, where the climate is warmer.

Acknowledgements. We thank M. Cavalli, D. Coniglio and M. Michelassi for the technical assistance.

TABLE VI - *Measurements of two Italian populations of Bursaphelenchus teratospicularis.*

	IT3 (w)	IT3 (w)	IT11 (w)	IT11 (w)
n	4 ♀♀	2 ♂♂	10 ♀♀	10 ♂♂
Body length	603.2±26.4 (567.5-628.0)	(584.4-617.1)	673.3±31.8 (609.8-723.6)	606.4±24.2 (566.3-641.3)
Body width	4.4 17.0±1.4 (15.7-18.2)	15.7	4.7 18.7±1.2 (16.9-20.6)	4.0 17.8±0.9 (16.9-19.4)
a	8.5 36.6±1.6 (34.6-38.2)	(37.2-39.2)	6.3 36.2±1.5 (33.6-38.2)	4.8 34.2±1.9 (30.4-36.2)
Distance from anterior end to junction of oesophagus and intestine	4.4 72.0±5.4 (67.8-79.9)	69.0	4.0 79.4±3.8 (72.6-84.7)	5.6 76.5±4.6 (69.0-83.5)
b	7.5 8.7±0.9 (7.9-10.0)	(8.5-9.0)	4.7 8.6±0.5 (7.5-9.5)	6.1 7.9±0.3 (7.3-8.2)
Distance from anterior end to posterior end of oesophageal glands	10.9 215.4±10.1 (206.9-228.7)	(185.1-186.0)	6.9 227.4±7.3 (220.2-242.0)	3.5 192.8±11.2 (170.6-208.1)
b'	4.7 2.8±0.3 (2.3-3.1)	(3.1-3.3)	3.2 3.0±0.1 (2.8-3.2)	5.8 3.2±0.2 (3.0-3.5)
Distance from anterior end to base of median bulb	12.3 72.0±5.4 (67.8-79.9)	69.0	4.1 79.4±3.8 (72.6-84.7)	4.7 75.0±4.6 (67.8-82.3)
b1	7.5 8.7±0.9 (7.9-10.0)	(8.5-9.0)	4.7 8.5±0.5 (7.5-9.5)	6.2 8.1±0.3 (7.5-8.4)
Oesophageal glands overlapping intestine length	10.9 143.4±7.0 (136.7-150.0)	(116.2-118.6)	6.1 149.1±7.4 (139.2-158.5)	3.3 116.4±8.6 (96.8-127.1)
Oesophageal glands overlapping intestine length / Body width to junction of oesophagus and intestine	4.9 10.6±0.5 (10.3-11.3)	(8.7-8.9)	5.0 10.6±0.5 (9.7-11.6)	7.4 8.1±0.6 (6.7-8.8)
Stylet length	4.6 19.1±0.6 (18.2-19.4)	19.4	4.7 20.0±0.6 (19.4-20.6)	7.3 20.5±1.4 (18.2-23.0)
Distance from anterior end to excretory pore	3.2 94.4±4.7 (88.3-99.2)	89.5	3.1 101.7±4.6 (90.8-107.7)	7.0 95.7±6.4 (84.7-102.9)
Distance from anterior end to hemizonid	5.0 101.4±6.4 (94.4-108.9)	100.4	4.6 111.9±4.6 (105.3-119.8)	6.6 105.5±7.0 (94.4-113.7)
V	6.4 79.9±0.5 (79.4-80.6)		4.1 79.9±1.0 (78.1-81.1)	6.6 0.7

TABLE VI - *Continued.*

	IT3 (w)	IT3 (w)	IT11 (w)	IT11 (w)
Anterior genital branch length	215.4±43.3 (167.0-257.7)	(233.5-308.6)	213.0±45.6 (175.5-308.6)	329.3±36.3 (261.4-367.8)
	20.1		21.4	11.0
G1	34.9±7.2 (26.6-43.3)		31.5±5.6 (26.2-42.7)	
	20.7		17.6	
Post-uterine branch length	17.9±1.2 (16.9-19.4)		18.5±2.4 (15.7-24.2)	
	6.7		12.8	
G2	2.9±0.2 (2.7-3.2)		2.8±0.4 (2.3-3.7)	
	8.3		14.8	
T		(37.9-52.8)	54.2±4.6 (44.0-58.5)	
			8.4	
Vulval - anus distance	n.d.		n.d.	
Post-uterine branch length % / Vulval - anus distance	n.d.		n.d.	
Body diameter at vulva	15.4±0.6 (14.5-15.7)		17.2±1.0 (15.7-19.4)	
	3.9		5.7	
Post-uterine branch length / Body diameter at vulva	1.2±0.1 (1.1-1.2)		1.1±0.2 (1.9-1.5)	
	4.3		16.5	
Tail length	n.d.	(23.0-25.4)	n.d.	25.3±1.4 (23.0-27.8)
				5.7
c	n.d.	(23.0-26.9)	n.d.	24.1±1.6 (21.8-26.6)
				6.7
Body width at anus	n.d.	(12.1-13.3)	n.d.	13.9±1.0 (12.1-15.7)
				7.3
c'	n.d.	(1.7-2.1)	n.d.	1.8±0.2 (1.5-2.3)
				12.0
Spicules (chord)		(15.7-16.9)		18.0±1.1 (16.9-19.4)
				5.8

n.d. = not determined.

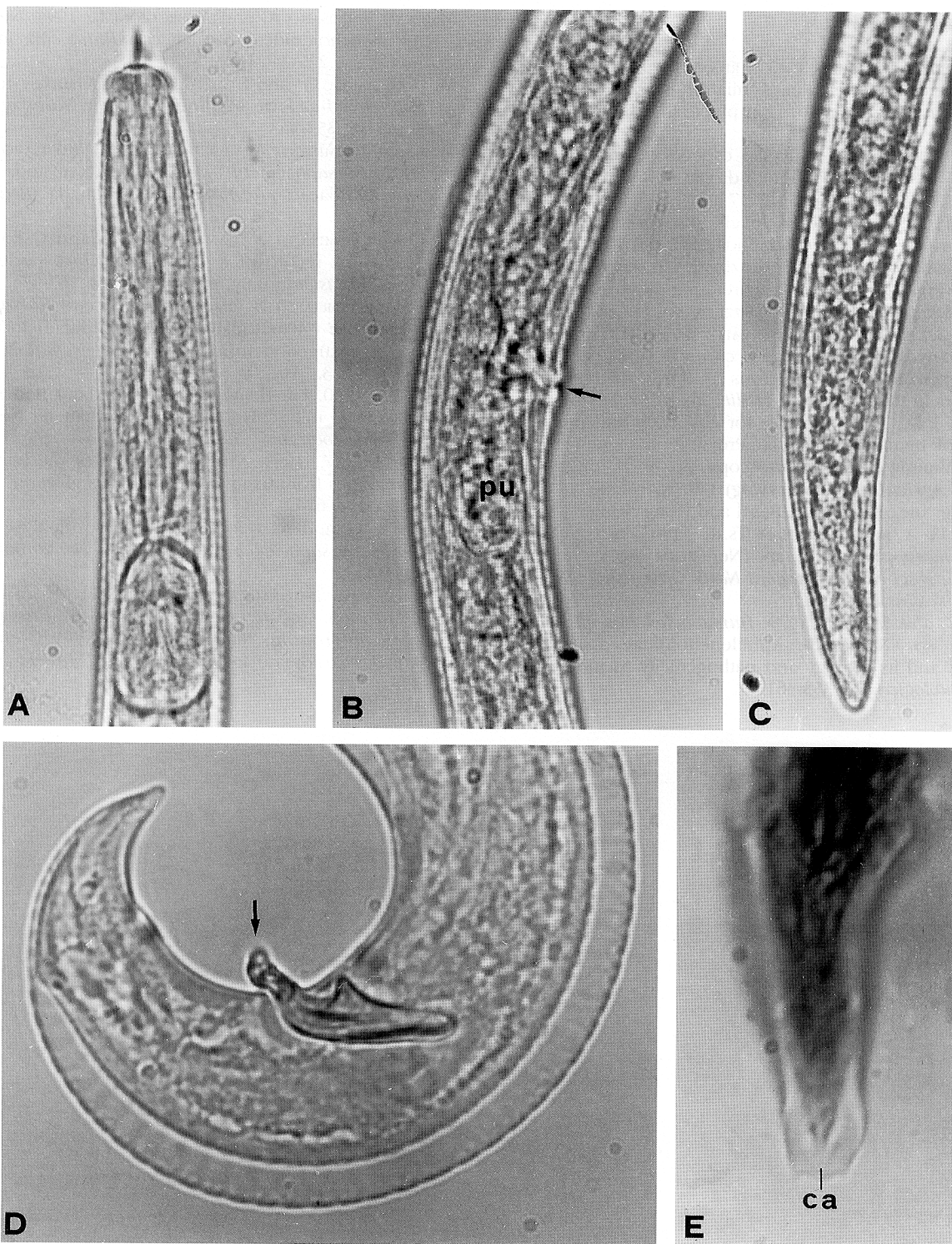


Fig. 5 - Photomicrographs of *B. teratospicularis*: A, female anterior region, ventral; B, female vulval region (arrow = protuberant vulval lips; pu = posterior uterine branch), lateral; C, female posterior region, lateral; D, male posterior region (arrow = protracted spicules), lateral; E, male tail terminus (ca = caudal ala), ventral.

Literature cited

- AMBROGIONI L., CERCHIARINI G., IRDANI T. and TOSSANI N., 1994. Indagine preliminare sulla diffusione di *Bursaphelenchus* spp. (Nematoda) in pinete italiane. *Redia*, 77: 273-278.
- BAUJARD P., 1980. Trois nouvelles espèces de *Bursaphelenchus* (Nematoda: Thylenchida) et remarques sur le genre. *Rev. Nematol.*, 3: 167-177.
- BRAASCH H., 1991. Erster Nachweis von *Bursaphelenchus mucronatus* Mamiya und Enda, 1979 in Deutschland und sein Vorkommen in Holzimporten aus der UdSSR nebst Ergänzungen zur Beschreibung dieser Art. *Archiv für Phytopathologie und Pflanzenschutz*, 27: 209-218.
- CAROPPO S., AMBROGIONI L., CAVALLI M. and CONIGLIO D., 1998. Investigations on the occurrence of *Bursaphelenchus* nematodes in coniferous trees and their possible vectors in Italy. *Nematol. mediterr.*, 26: 87-92.
- EISENBACK J. D., 1991. Methods for collection and preparation of nematodes. Part 2. Preparation of nematodes for scanning electron microscopy, pp. 87-96. In: *Manual of Agricultural Nematology* (W. R. Nickle ed). M. Dekker Inc., New York, Basel and Hong Kong.
- KAKULIYA G. A. and DEVDARIANI Ts. G., 1965. *Bursaphelenchus teratospicularis* n. sp. (Nematoda, Aphelenchoidae). *Soobscheniya Akademii Nauk Gruzinskoi SSR*, 38: 191-197 (Georgian).
- MAMIYA Y. and ENDA N., 1979. *Bursaphelenchus mucronatus* n. sp. (Nematoda: Aphelenchoididae) from pine wood and its biology and pathogenicity to pine trees. *Nematologica*, 25: 353-361.
- MARINARI PALMISANO A. and AMBROGIONI L., 1994. Nematodi Aphelenchoididae associati con *Pinus* spp. in Italia. *Redia*, 77: 225-240.
- MC NAMARA D. G. and STØEN M., 1988. A survey for *Bursaphelenchus* spp. in pine forests in Norway. *EPPO Bull.*, 18: 353-363.
- MARINARI PALMISANO A., AMBROGIONI L. and CAROPPO S., 1992. *Bursaphelenchus mucronatus* (Nematoda: Aphelenchoididae) su *Pinus pinaster* in Italia. *Redia*, 75: 517-527.
- MARINARI PALMISANO A., AMBROGIONI L. and CAROPPO S., 1994. First record of a *Bursaphelenchus* species from *Pinus pinaster* in Italy. *EPPO Bull.*, 24: 467-474.
- PHILIS J. and BRAASCH H., 1996. Occurrence of *Bursaphelenchus leoni* (Nematoda, Aphelenchoididae) in Cyprus and its extraction from pine wood. *Nematol. mediterr.*, 24: 119-123.
- RÜHM W., 1960. Ein Beitrag zur Nomenklatur und Systematik einige mit Scolytiden vergesellschafteter Nematodenarten. *Zool. Anz.*, 164: 201-213.
- SEINHORST J. W., 1959. A rapid method for the transfer of nematodes from fixative to anhydrous glycerin. *Nematologica*, 4: 67-69.
- TARJAN A. C. and ARAGÓN C. B., 1982. An analysis of the genus *Bursaphelenchus* Fuchs, 1937. *Nematologica*, 12: 121-144.
- TOMMINEN J., NUORTEVA M., PULKKINEN M. and VÄKEVÄ J., 1989. Occurrence of the nematode *Bursaphelenchus mucronatus* Mamiya & Enda 1979 (Nematoda: Aphelenchoididae) in Finland. *Silva Fennica*, 23: 271-277.