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Istituto di Nematologia Agraria, C.N.R., 70126 Bari, Italy
and Department of Agricultural Development, Fruit
and Fruit Technology Research Institute, Stellenbosch, South Africa

SPECIES OF THE *XIPHINEMA AMERICANUM*-GROUP (NEMATODA, DORYLAIMIDA) OCCURRING IN THE WESTERN CAPE PROVINCE, SOUTH AFRICA

by
F. LAMBERTI, H. J. HUGO, T. D'ADDABBO, A. AGOSTINELLI and A. LARIZZA

Summary. The taxonomic study of 20 populations of the *Xiphinema americanum* - group, collected from the Western Cape Province in South Africa, revealed the occurrence of three species: *X. incognitum*, Lamberti *et* Bleve - Zacheo, the most common, *X. americanum sensu stricto* Cobb, also widespread and *X. pachtaicum* (Tulaganov) Kirjanova, more restricted in its distribution. Identifications were confirmed by principal component and hierarchical cluster analysis of 17 morphometric characters, that indicated a clear separation of the three species among themselves and from *X. diffusum* Lamberti *et* Bleve-Zacheo and *X. taylori* Lamberti *et al.* to which some populaitons of *X. incognitum* were biometrically close.

Four species of the *Xiphinema americanum*-group were reported from the Western Cape Province in South Africa. They are *X. americanum* Cobb (Heyns, 1974; Loots and Heyns, 1984; Van Mieghem and Pieterse, 1989), *X. brevicolle* Lordello *et* Da Costa (Heyns, 1974; Kruger and Heyns, 1986; Van Mieghem and Pieterse, 1989), *X. pachtaicum* (Tulaganov) Kirjanova (Heyns, 1977; Lamberti and Bleve-Zacheo, 1979; Van Mieghem and Pieterse, 1989) and *X. diffusum* Lamberti *et* Bleve-Zacheo (Lamberti *et al.*, 1991).

However, the occurrence of *X. brevicolle* was questioned by Lamberti and Bleve-Zacheo (1979) who hypothesized that the South African populations so identified were constituted either by *X. diffusum* or by a mixture of the two species.

To clarify this point a study was undertaken of populations belonging to the *X. americanum*-group collected from various localities of the Western Cape Province.

Materials and methods

Soil samples were taken during the years 1988, 1989, 1994 and 1995 from the rhizosphere of trees and vines in 65 localities. Nematodes were extracted by means of Cobb's wet sieving technique, killed and fixed with 5% hot formalin and processed to anhydrous glycerol. Twenty putative populations of the *X. americanum*-group, the majority of individuals being females specimens, were selected for this study (Table I). Measurements were taken with the aid of a camera lucida. Juvenile stages were separated on the basis of the functional and replacement

odontostyles, considering also the total body and the tail lengths (Vovlas and Larizza, 1994). To study the relationship among the populations and with the similar species (Table I) principal component (PCA) and hierarchical cluster (HCA) analysis were performed. The 17 morphometric characters considered on female populations are given in Table II. Measurements were taken from the literature for the Italian population (*Rubus* sp., Modugno, Bari) of *X. pachtaicum* and the paratypes of *X. diffusum* and *X. incognitum* (Lamberti and Bleve-Zacheo, 1979), for topotypes of *X. americanum* (Lamberti and Golden, 1984) and for paratypes of *X. taylori* (Lamberti *et al.*, 1991). Multivariate statistics were performed with the SAS programme release 6.03. The correlation matrix was used for PCA and the results of principal components were used for HCA based on the average distance method (SAS, 1985). Analysis was first done cumulatively for all the characters considered and then for each single character.

TABLE I - *Populations subjected to principal component and cluster analysis.*

Code	Species	Locality	Host
A	*X. diffusum*	paratypes	
B	*X. incognitum*	Ernita (Wellington)	Poplar (*Populus alba* L.)
C	*X. incognitum*	Pakwood	Peach [*Prunus persica* (L.) Batsch]
D	*X. incognitum*	Groot Constantia (Constantia)	Grapevine (*Vitis* sp.)
E	*X. incognitum*	Bergendal (Citrusdal)	Peach
F	*X. incognitum*	Patatskloof (Wellington)	Grapevine
G	*X. incognitum*	Laborie (Paarl)	Grapevine
H	*X. incognitum*	Keurfontein (Paarl)	Grapevine
I	*X. incognitum*	Fontein	Pear (*Pyrus communis* L.)
J	*X. incognitum*	paratypes	
K	*X. americanum*	topotypes	
L	*X. americanum*	Elsenburg (Stellenbosch)	Grapevine
M	*X. americanum*	Ernita (Wellington)	Poplar
N	*X. americanum*	Groen Fontain (Wellington)	Grapevine
O	*X. americanum*	Hexbierg (Wellington)	Grapevine
P	*X. americanum*	Hoop op Constantia (Constantia)	Grapevine
Q	*X. americanum*	Klein Constantia (Constantia)	Grapevine
R	*X. americanum*	Keurfontein (Paarl)	Grapevine
S	*X. taylori*	paratypes	
T	*X. incognitum*	Graymead (Vyeboom)	Apple (*Malus sylvestris* Mill.)
U	*X. incognitum*	Eikenhof (Grabouw)	Apple
V	*X. pachtaicum*	Italian population (Modugno, Bari)	*Rubus* sp.
W	*X. pachtaicum*	Groot Constantia (Constantia)	Grapevine
X	*X. pachtaicum*	Klein Constantia (Constantia)	Grapevine
Y	*X. pachtaicum*	Witzenberg (Tulbach)	Apricot (*Prunus armeniaca* L.)

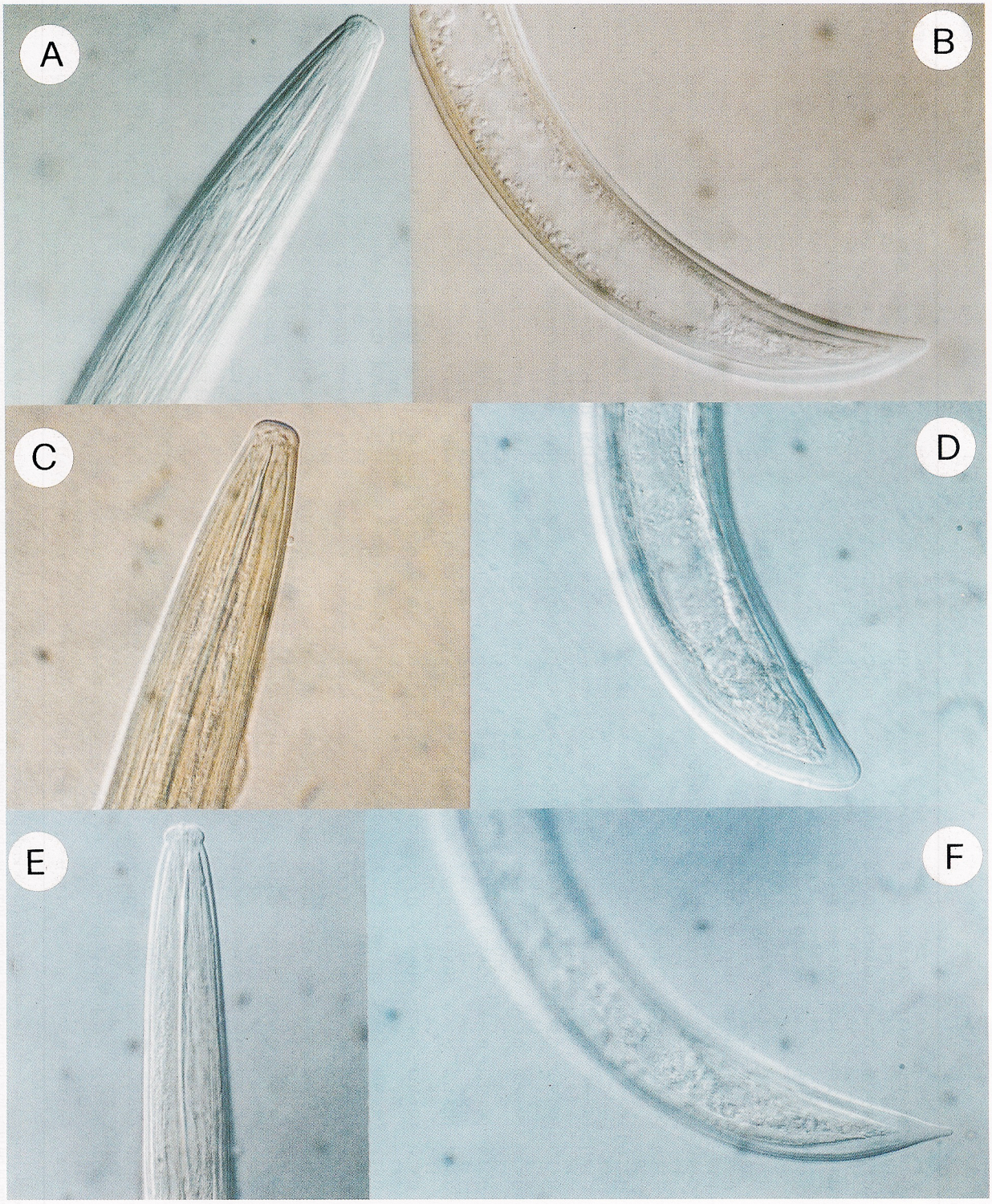


Fig. 1 - Photomicrographs of anterior and posterior regions of *Xiphinema americanum* (A, B), *X. incognitum* (C, D) and *X. pachtaicum* (E, F).

TABLE II - *Morphometrics of populations used for principal component and cluster analysis.*

Code and n. of specimens (♀♀)	L	a	b	c	c'	V	sty	est	ag	tail	J	lip	dag	does	vul	dan	beg
A 10	1.7	47.0	6.9	72.0	0.9	50.0	87.0	50.0	62.0	24.0	12.0	11.0	26.0	33.0	36.0	25.0	17.0
	(1.6-1.8)	(46.0-51.0)	(5.3-8.9)	(63.0-84.0)	(0.8-1.1)	(47.0-52.0)	(84.0-89)	(48.0-51.0)	(60.0-64.0)	(21.0-28.0)	(10.0-14.0)	(10.0-12.0)	(26.0-27.0)	(31.0-35.0)	(33.0-38.0)	(23.0-28.0)	(15.0-20.0)
B 8	1.9	44.5	6.3	75.0	0.9	53.0	90.0	50.0	73.7	24.9	8.4	12.3	29.2	35.9	42.8	27.6	15.5
	(1.8-2.0)	(39.3-47.6)	(5.7-6.7)	(68.9-81.1)	(0.8-1.0)	(50.0-55.0)	(86.0-94.4)	(47.8-52.2)	(68.3-77.2)	(22.2-26.1)	(7.2-8.9)	(11.7-12.8)	(27.2-30.5)	(33.3-40.5)	(37.8-48.3)	(25.5-29.4)	(13.9-17.2)
C 10	1.9	46.0	6.6	77.0	0.9	53.0	88.0	52.5	74.0	25.0	9.0	13.0	29.5	36.0	42.0	28.0	16.0
	(1.8-2.1)	(43.0-50.0)	(6.3-6.9)	(66.0-88.0)	(0.8-1.0)	(50.0-55.0)	(85.0-93.0)	(48.0-54.0)	(70.5-77.0)	(23.0-29.0)	(8.0-10.0)	(12.0-13.0)	(29.0-30.5)	(33.0-38.0)	(39.0-46.0)	(26.0-31.0)	(14.0-20)
D 10	1.9	43.6	6.4	76.0	0.9	52.5	90.0	53.0	76.0	25.5	10.0	13.0	30.0	38.0	44.0	29.0	17.0
	(1.8-2.1)	(40.7-47.5)	(5.6-6.9)	(67.0-82.0)	(0.8-1.0)	(50.0-55.0)	(87.0-93.0)	(50.0-56.0)	(74.0-80.0)	(23.0-28.0)	(9.0-11.0)	(12.0-13.0)	(29.0-31.0)	(34.0-39.0)	(40.0-49.0)	(27.0-32.0)	(14.0-20.0)
E 20	1.9	44.6	6.2	75.9	0.9	52.0	88.3	53.8	75.3	25.4	8.6	12.7	30.0	37.7	43.1	26.1	15.4
	(1.7-2.1)	(38.9-51.1)	(5.5-6.9)	(67.0-92.1)	(0.8-1.0)	(50.0-55.0)	(84.4-94.1)	(50.0-57.8)	(72.2-80.6)	(22.8-28.9)	(7.2-10.0)	(12.2-13.5)	(27.1-31.7)	(34.4-40.5)	(36.7-48.0)	(24.4-31.1)	(13.3-17.8)
F 10	1.9	46.5	6.1	68.0	1.1	52.0	92.0	51.0	75.0	28.0	8.0	11.0	28.5	35.0	41.0	26.0	13.5
	(1.8-2.0)	(43.9-47.5)	(5.4-6.9)	(58.4-80.0)	(1.0-1.2)	(50.0-55.0)	(90.0-97.0)	(45.0-57.0)	(71.0-78.0)	(25.0-31.0)	(7.0-9.0)	(11.0-12.0)	(26.0-30.0)	(33.0-39.0)	(37.0-45.0)	(25.0-28.0)	(11.0-15.5)
G 10	1.9	47.7	6.5	69.7	1.0	50.0	91.3	54.0	74.0	28.0	10.0	12.0	28.0	36.0	41.0	27.0	15.0
	(1.8-2.1)	(44.4-52.5)	(5.7-7.3)	(64.7-81.5)	(1.0-1.1)	(47.0-52.0)	(87.0-94.0)	(48.0-57.0)	(71.0-77.0)	(26.0-30.0)	(9.0-11.0)	(11.0-13.0)	(26.0-30.0)	(31.0-37.0)	(34.0-43.0)	(24.0-29.0)	(13.0-17.0)
H 10	1.9	47.1	6.3	67.7	1.1	51.0	91.0	55.0	76.0	30.0	10.0	12.0	29.0	35.0	40.0	28.0	14.0
	(1.7-1.9)	(44.9-49.6)	(5.8-7.2)	(57.2-70.6)	(1.0-1.1)	(47.0-53)	(87.0-94.0)	(54.0-56.0)	(70.0-79.0)	(27.0-33.0)	(9.0-11.0)	(11.0-12.0)	(28.0-31.0)	(34.0-38.0)	(35.0-42.0)	(26.0-30.0)	(13.0-16.0)
I 10	1.9	42.8	7.8	66.8	1.0	50.5	94.0	54.0	76.0	29.0	8.0	11.0	30.0	38.0	44.0	28.5	15.0
	(1.7-2.1)	(40.0-48.9)	(6.8-9.2)	(57.2-77.8)	(1.0-1.1)	(48.0-53.0)	(90.0-97.0)	(51.0-56.0)	(71.0-80.0)	(26.0-30.0)	(7.0-10.0)	(11.0-12.0)	(29.0-31.0)	(36.0-39.0)	(40.0-50.0)	(27.0-30.0)	(14.0-17.0)
J 20	1.9	45.0	6.3	62.0	1.1	51.0	87.0	52.0	72.0	30.0	10.0	12.0	28.0	37.0	42.0	28.0	15.0
	(1.7-2.1)	(41.0-49.0)	(5.2-7.9)	(47.0-75.0)	(0.9-1.3)	(48.0-53.0)	(82.0-93.0)	(46.0-56.0)	(67.0-78.0)	(25.0-38.0)	(8.5-12.5)	(11.0-13.0)	(26.0-31.0)	(34.0-42.0)	(36.0-45.0)	(24.0-33.0)	(12.0-18.0)
K 20	1.6	50.0	6.8	45.0	1.9	50.0	80.0	45.0	65.0	35.0	7.0	10.0	23.0	28.0	32.0	19.0	7.0
	(1.4-1.7)	(46.0-57.0)	(5.3-8.2)	(39.0-52.0)	(1.7-2.2)	(49.0-53.0)	(74.0-83.0)	(42.0-47.0)	(60.0-71.0)	(33.0-38.0)	(6.0-8.0)	(9.0-10.0)	(19.0-26.0)	(26.0-32.0)	(29.0-36.0)	(17.0-21.0)	(6.0-8.0)
L 20	1.7	55.3	6.5	49.3	1.9	52.0	79.8	45.1	68.9	35.7	7.6	9.0	28.1	28.3	31.9	18.5	7.1
	(1.4-2.0)	(50.3-60.0)	(5.8-7.5)	(39.4-58.2)	(1.7-2.2)	(50.0-56.0)	(73.9-85.0)	(41.7-48.3)	(65.5-72.2)	(30.5-38.9)	(6.1-11.1)	(8.9-10;5)	(22.2-26.1)	(25.0-30.5)	(27.8-35.0)	(16.7-20.0)	(6.1-9.4)
M 3	1.8	53.7	7.9	54.6	1.7	48.0	77.6	42.6	68.7	32.9	6.7	9.9	23.9	28.5	33.5	18.9	7.0
	(1.7-1.9)	(50.1-57.0)	(7.2-8.8)	(52.8-57.0)	(1.7-1.8)	(47.0-50.0)	(70.5-81.7)	(42.2-45.5)	(67.8-69.4)	(32.2-33.3)	(6.7-6.7)	(8.9-11.0)	(23.9-23.9)	(27.8-28.9)	(33.5-33.9)	(18.3-19.4)	(6.1-7.8)
N 10	1.7	54.4	5.9	47.2	1.8	52.0	81.5	44.3	65.9	35.2	6.8	9.3	22.8	27.3	30.5	19.1	6.9
	(1.6-1.7)	(52.8-56.1)	(5.5-6.5)	(43.8-54.1)	(1.7-2.0)	(50.0-53.0)	(79.4-82.9)	(40.0-46.3)	(64.0-69.0)	(31.4-38.3)	(5.7-8.0)	(9.0-9.7)	(22.3-23.4)	(26.3-29.1)	(29.1-32.0)	(18.3-20.0)	(5.7-8.0)
O 10	1.7	56.0	6.4	49.0	1.9	48.5	82.0	44.0	67.0	35.0	7.0	10.0	23.0	27.0	31.0	19.0	7.0
	(1.5-1.9)	(52.0-61.0)	(5.6-7.3)	(43.0-57.0)	(1.7-2.0)	(47.0-50.0)	(79.0-84.0)	(41.0-49.0)	(65.0-71.0)	(31.0-37.0)	(6.0-8.0)	(9.0-10.0)	(22.0-24.0)	(25.0-29.0)	(29.0-33.0)	(15.0-21.0)	(7.0-8.0)
P 10	1.7	55.0	5.9	51.0	1.7	52.0	82.0	44.5	67.0	33.0	7.0	9.0	23.0	28.0	31.0	19.0	8.0
	(1.6-1.8)	(52.0-59.0)	(5.5-6.5)	(47.0-54.0)	(1.5-1.9)	(50.0-53.0)	(77.0-86.0)	(42.0-47.0)	(63.0-69.0)	(30.0-36;5)	(6.0-7.0)	(9.0-10.0)	(22.0-24.0)	(26.0-29.0)	(29.0-33.0)	(17.0-21.0)	(6.0-9.0)
Q 5	1.8	53.7	6.8	52.6	1.8	50.0	82.0	43.0	67.0	34.5	7.0	9.0	23.0	29.0	34.0	19.0	8.0
	(1.7-2.0)	(48.5-57.7)	(6.1-7.8)	(48.9-58.3)	(1.7-2.0)	(47.0-53.0)	(81.0-84.0)	(41.0-46.0)	(63.0-70.0)	(34.0-36.0)	(6.0-7.0)	(9.0-9.0)	(22.0-25.0)	(27.0-31.0)	(31.0-38.0)	(17.0-20.0)	(7.0-9.0)
R 3	1.7	49.0	6.3	55.5	1.5	52.0	80.0	48.0	66.0	31.0	9.0	10.0	24.0	31.0	35.0	20.0	9.0
	(1.7-1.8)	(47.0-50.4)	(5.9-7.0)	(54.1-57.3)	(1.4-1.6)	(50.0-53.0)	(78.0-81.0)	(46.0-49.0)	(63.0-68.0)	(31.0-31.0)	(8.0-9.0)	(10.0-10.0)	(23.0-25.0)	(29.0-33.0)	(34.0-38.0)	(19.0-22.0)	(9.0-10.0)
S 15	2.3	50.7	7.1	83.0	0.9	49.7	94.0	58.5	78.3	27.7	10.3	13.8	32.1	39.9	45.1	30.4	19.5
	(2.1-2.5)	(49.3-54.2)	(5.9-8.3)	(74.0-92.7)	(0.9-1.0)	(48.0-52.0)	(90.0-97.1)	(55.3-61.8)	(74.7-82.3)	(24.1-31.8)	(8.8-13.3)	(13.5-14.7)	(30.0-33.5)	(36.5-42.3)	(40.0-48.8)	(27.6-34.1)	(17.6-23.5)
T 20	2.0	45.3	6.6	69.7	1.0	51.7	93.7	53.5	79.0	28.3	7.8	11.7	28.5	36.2	43.5	27.7	14.8
	(1.8-2.2)	(40.9-48.2)	(5.6-8.1)	(60.0-80.4)	(0.9-1.1)	(50.0-54.0)	(87.2-97.2)	(45.5-56.7)	(75.0-83.3)	(25.5-31.7)	(6.1-9.4)	(11.1-12.2)	(27.2-30.5)	(33.9-38.9)	(39.4-51.1)	(25.0-31.1)	(11.7-16.7)
U 20	2.1	46.2	7.1	73.2	1.0	51.0	93.5	53.3	79.5	28.3	8.9	11.7	28.7	36.6	44.8	27.5	14.8
	(1.8-2.3)	(40.5-50.3)	(6.0-8.3)	(64.3-86.1)	(0.9-1.2)	(50.0-55.0)	(86.1-98.3)	(47.2-57.8)	(73.3-83.9)	(25.0-31.1)	(7.2-12.2)	(11.1-12.8)	(27.8-30.5)	(34.4-40.0)	(39.4-51.7)	(24.4-31.1)	(13.3-18.9)
V 10	1.8	61.0	6.5	66.0	1.6	56.0	79.0	46.0	71.0	28.0	8.0	8.0	20.0	26.0	30.0	17.0	8.0
	(1.7-2.1)	(56.0-66.0)	(5.5-7.4)	(59.0-73.0)	(1.5-1.9)	(51.0-59.0)	(71.0-87.0)	(40.0-48.0)	(65.0-74.0)	(23.0-31.0)	(6.5-10.0)	(7.5-8.5)	(19.0-21.0)	(23.0-29.0)	(27.0-35.0)	(16.0-18.0)	(6.0-8.5)
W 10	2.1	74.0	7.4	61.0	2.0	57.0	89.0	50.0	77.0	35.0	9.0	9.0	21.0	25.5	28.5	17.0	7.5
	(1.9-2.2)	(69.0-82.0)	(6.1-8.0)	(55.0-66.5)	(1.9-2.2)	(54.5-58.0)	(82.0-94.0)	(47.0-54.0)	(71.0-84.0)	(33.0-38.0)	(8.0-11.0)	(8.0-9.0)	(21.0-22.0)	(24.0-27.0)	(27.0-31.0)	(15.0-18.0)	(7.0-8.0)
X 3	2.1	68.4	8.1	57.3	2.1	55.5	93.0	48.0	82.0	37.0	11.0	8.5	22.0	27.0	31.0	18.0	7.0
	(2.0-2.2)	(64.7-71.2)	(7.6-8.4)	(52.5-63.0)	(2.0-2.2)	(54.5-57.0)	(90.0-95.0)	(47.0-50.0)	(80.0-84.0)	(35.0-40.0)	(10.0-13.0)	(8.0-9.0)	(21.0-22.0)	(26.0-28.0)	(30.0-31.0)	(17.0-18.0)	(7.0-8.0)
Y 10	2.0	68.0	7.2	56.0	2.1	54.0	87.0	47.0	76.0	35.5	10.0	9.0	21.0	25.0	29.0	17.0	7.0
	(1.9-2.2)	(64.0-77.0)	(6.5-7.9)	(51.0-60.5)	(1.9-2.3)	(53.0-55.0)	(83.0-89.0)	(45.0-50.0)	(73.0-80.0)	(31.0-39.0)	(9.0-11.0)	(8.0-9.0)	(20.0-22.0)	(23.0-27.0)	(26.0-34.0)	(15.0-19.0)	(7.0-9.0)

L = body length (mm); a, b, c, V = de Man's ratios; sty = odontostyle lenght (µm) est = odontophore length (µm); ag = distance of the guiding ring from the anterior extremity (µm); tail = tail length (µm); J = length of the hyalin portion of tail (µm); lip = body diameter at lip region (µm); dag = body diameter at guiding ring (µm); does = body diameter at base of oesophagus (µm); vul = body diameter at vulva (µm); dan = body diameter at anus (µm); beg = body diameter at beginning of J (µm). Population codes as in Table I.

Results

According to the morpho-biometric studies the 20 populations from the Cape Province, the measurements of which are given in Table II, represent three species within the *X. americanum*-group. They are *X. americanum*, *X. incognitum* and *X. pachtaicum*. Brief descriptions and comments on their distribution in the Western Cape are given here.

XIPHINEMA AMERICANUM Cobb, 1913

(Fig. 1: A and B)

Seven of the 20 populations examined were identified as *X. americanum sensu stricto*. Female habitus of a more or less open C when killed. Body cylindrical tapering very gradually towards the extremities. Lip region separated from the rest of the body by a slight constriction, hemielliptical. Odontostyle 70 to 86 µm long. Vulva periequatorial, between 47 and 53%, reproductive system amphidelphic, with equally developed branches and reflexed ovaries. Tail elongate, conoid, ventrally bent, with subacute end.

A male was found in the population from Stellenbosch (grapevine, code L). Its measurements are:

L = 1.7 mm; a = 55.7; b = 6.4; c = 40.8; c' = 1.9; odontostyle = 82 µm; odontophore = 47 µm; oral aperture-guiding ring distance = 69 µm; tail length = 42 µm; J = 7 µm; spicules = 47 µm; the adanal pair of supplements is preceded by a ventromedian row of 10.

Only three juvenile stages (J_1, J_2 and J_3) occurred in the populations of *X. americanum*

TABLE III - *Morphometrics of the juvenile stages of the population of* X. americanum *from Elsenburg.*

	Stages		
	J1	J2	J3
n	7	10	10
L mm	0.66 (0.64-0.69)	0.84 (0.74-1.00)	1.12 (1.03-1.25)
a	35.2 (33.1-37.1)	40.6 (36.3-44.8)	45.3 (42.4-47.3)
b	3.5 (3.2-3.9)	3.9 (3.4-4.6)	4.5 (4.2-5.1)
c	6.1 (5.6-6.7)	27.3 (24.5-29.7)	35.0 (30.4-40.2)
c'	0.3 (0.2-0.3)	2.7 (2.2-2.7)	2.2 (2.0-2.5)
Odontostyle µm	40.2 (39.6-40.9)	49.3 (46.2-52.1)	61.8 (58.1-65.3)
Odontophore µm	29.6 (28.4-30.7)	33.1 (30.4-37.0)	38.7 (36.3-41.6)
Replacement odontostyle µm	50.8 (48.8-53.5)	64.1 (59.4-66.7)	79.4 (78.2-82.5)
Oral aperture to guiding ring µm	33.2 (31.7-34.3)	42.0 (39.6-44.9)	52.0 (48.8-54.1)
Tail µm	29.5 (28.4-32.0)	30.8 (29.0-35.0)	32.3 (29.0-35.7)
J µm	4.9 (4.6-5.3)	5.0 (3.6-6.6)	5.2 (4.0-5.9)
Body diam. at lip region µm	6.8 (6.6-7.3)	7.7 (6.6-8.6)	8.2 (7.9-8.6)
Body diam. at guiding ring µm	14.1 (13.2-15.2)	16.2 (14.5-18.5)	19.0 (17.8-19.8)
Body diam. at base of oesophagus µm	17.0 (16.2-17.8)	19.6 (18.8-21.1)	21.8 (21.1-22.8)
Body diam. at midbody µm	18.8 (17.2-20.8)	20.7 (19.1-22.4)	24.3 (23.2-25.7)
Body diam. at anus µm	11.4 (10.6-12.5)	12.9 (11.9-13.9)	14.5 (13.2-15.8)
Body diam. at beginning of J µm	4.9 (4.6-5.3)	5.2 (4.3-7.3)	5.9 (5.0-6.9)

studied (Table III), confirming the findings of Halbrendt and Brown (1992).

Compared to the topotypes (Lamberti and Golden, 1984) the Western Cape populations of *X. americanum* seem to have a slightly longer body (1.7-1.8 versus 1.6 in average), a higher value of c (47-55 versus 45), sometimes a lower value of c' (1.5-1.8 versus 1.9) and an anterior vulva (V = 48 versus 50) for the populations M and O, and a posterior vulva (V = 52 versus 50) for the populations L, N, P, and R.

Xiphinema americanum is widespread in the Western Cape; at Ernita and Keurfontein it was found in mixed populations with *X. incognitum*; at Klein Constantia it was in mixture with *X. pachtaicum*.

XIPHINEMA INCOGNITUM Lamberti *et* Bleve-Zacheo, 1979

(Fig. 1: C and D)

Syn. *X. diffusum* (Paarl, grapevine) apud Lamberti *et al.*, 1991.

Ten populations, one half of those considered, were identified as *X. incognitum*.

Female habitus at a more or less open C when killed. Body cylindrical, tapering very gradually towards the extremities. Lip region separated from the rest of the body by a slight constriction, hemielliptical. Odontostyle 86 to 98 µm long. Vulva periequatorial, between 47 and 55%, reproductive system amphidelphic, with equally developed branches and reflexed ovaries. Tail conoid dorsally convex with rounded end.

A male was found in the population from Patatskloof (grapevine, code F). Its measurements are:

L = 1.8 mm; a = 46.3; b = 5.6; c = 55.2; c' = 1.2; odontostyle = 92 µm; odontophore = 52 µm; oral aperture-guiding ring distance = 78.5 µm; tail length = 33 µm; J = 6.5 µm; spicules = 51.5 µm; the adanal pair of supplements is preceded by a ventromedian row of 9.

Four populations, those indicated with codes F, G, H and I, although having a slightly longer odontostyle, fitted generally with the type description (Lamberti and Bleve-Zacheo, 1979) of *X. incognitum*. Four other populations (indicated with codes B, C, D and E) conversely had a shorter tail (25 versus 28-30 µm) and consequently a lower value of c' which, according to the key of Lamberti and Carone (1991), would lead to *X. diffusum*. Compared with the original description of *X. incognitum*, populations T and U had longer bodies and odontostyles. Thus pointing, according to the Lamberti and Carone's key, to *X. taylori* Lamberti *et al.*, 1991.

Some of these populations contained abundant juvenile stages. It was thought that their tail shapes (Fig. 2) and biometrics (Tables IV, V and VI) would eventually enable these groups of populations to be separated. However, tail shapes and measurements of the various juvenile stages were too variable and inconsistent to characterize the population to which they belonged.

Xiphinema incognitum seems to be very common in the Western Cape. As already mentioned, at Ernita and Keurfontein it was associated with *X. americanum*. Mixed populations of *X. incognitum* and *X. pachtaicum* occurred at Groot Constantia.

On the basis of our study and after re-examination of the specimens it is suggested that *X. diffusum*, grapevine, from Paarl in Lamberti *et al.*, 1991 is regarded as *X. incognitum* which constitutes the first record for this species in South Africa.

XIPHINEMA PACHTAICUM (Tulaganov, 1938) Kirjanova, 1951

(Fig. 1: E and F)

Three populations were identified as *X. pachtaicum*.

Female habitus a closed C when killed. Body cylindrical, tapering very gradually towards the

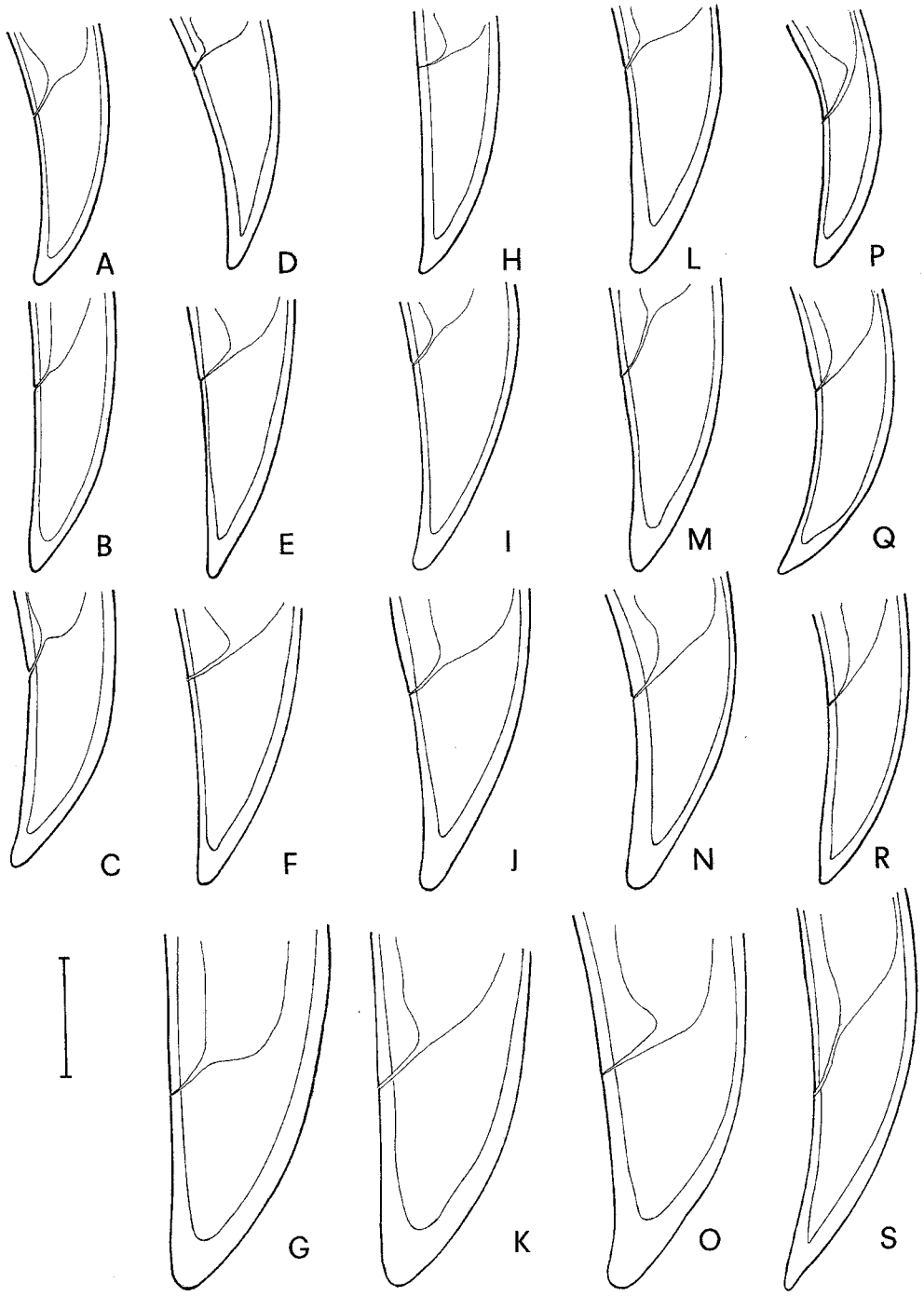


Fig. 2 - Tails of the juvenile stages of *X. americanum* (A-C = J_1-J_3) Elsenburg population; *X. incognitum* (D-G = J_1-J_4) Bergendal population; *X. incognitum* (H-K = J_1-J_4) Eikenhof population; *X. incognitum* (L-O = J_1-J_4) Laborie population; *X. pachtaicum*: (P-S = J_1-J_4) Witzenberg population (scale bar = 20 µm).

TABLE IV - *Morphometrics of the juvenile stages of the population of* X. incognitum *from Bergendal.*

	Stages			
	J1	J2	J3	J4
n	10	10	10	10
L mm	0.64 (0.56-0.66)	0.8 (0.71-1.07)	1.1 (0.96-1.14)	1.53 (1.4-1.6)
a	30.0 (26.7-32.7)	33.5 (29.2-37.1)	35.04 (31.6-37.7)	42.1 (38.2-44.4)
b	3.6 (2.1-5.3)	4.0 (2.8-5.3)	5.0 (4.4-6.1)	5.65 (5.4-5.9)
c	20.0 (17.4-21.3)	26.0 (22.6-34.7)	31.5 (27.1-37.4)	50.0 (43.7-69.9)
c'	2.5 (2.5-2.9)	2.2 (1.6-2.4)	1.8 (1.4-2.0)	1.26 (1.0-1.4)
Odontostyle µm	37.5 (34.3-40.9)	48.5 (44.9-58.1)	56.7 (53.5-62.0)	70.3 (66.8-74.0)
Odontophore µm	31.0 (27.7-34.3)	35.4 (33-38.9)	39.7 (37.0-40.9)	44.6 (40.0-48.0)
Replacement odontostyle µm	48.0 (44.9-54.8)	60.6 (58.4-65.3)	69.7 (62.7-73.9)	87.9 (85.7-90.3)
Oral aperture to guiding ring µm	30.9 (29.1-33.7)	39.7 (32.3-46.9)	48.7 (44.2-52.8)	60.4 (57.0-62.3)
Tail µm	31.5 (28.5-34.9)	32.2 (31.0-33.0)	34.0 (28.4-42.2)	31.0 (22.9-36.6)
J µm	5.3 (4.6-6.9)	6.6 (5.3-7.6)	7.1 (5.3-8.6)	9.2 (8.0-13.7)
Body diam. at lip region µm	7.5 (7.3-8.3)	8.8 (7.3-10.6)	9.4 (9.2-10.6)	11.1 (10.3-11.4)
Body diam. at guiding ring µm	16 (15.2-16.5)	17.9 (15.8-20.7)	20.7 (19.8-21.8)	25.8 (24.6-29.1)
Body diam. at base of oesophagus µm	18.6 (16.5-19.8)	22.2 (19.8-26.4)	25.7 (24.4-27.7)	32.6 (29.0-36.6)
Body diam. at midbody µm	20.4 (19.0-21.5)	25.0 (21.1-29.0)	30.3 (29.0-31.0)	36.1 (31.1-37.7)
Body diam. at anus µm	11.9 (10.2-13.2)	15.1 (13.2-19.1)	19.1 (17.2-22.1)	24.6 (22.3-28.0)
Body diam. at beginning of J µm	4.9 (3.9-5.9)	5.2 (4.6-7.3)	6.7 (5.3-7.9)	11.3 (10.3-14.3)

TABLE V - *Morphometrics of the juvenile stages of the population of* X. incognitum *from Eikenhof.*

	Stages			
	J1	J2	J3	J4
n	5	10	10	10
L mm	0.72 (0.66-0.72)	0.87 (0.8-0.9)	1.15 (1.1-1.2)	1.36 (1.1-1.5)
a	32.7 (29.3-35.4)	32.4 (28.7-35.5)	36.2 (32.8-38.8)	40.2 (37.1-45.1)
b	4.2 (3.3-5.0)	4.2 (3.5-5.0)	4.9 (4.4-5.5)	4.8 (4.6-5.2)
c	20.2 (18.6-21.6)	26.4 (24.3-27.9)	33.1 (30.0-36.8)	44.9 (34.9-65.2)
c'	2.8 (2.6-3.1)	2.1 (1.8-2.3)	1.9 (1.5-2.2)	1.5 (1.0-1.9)
Odontostyle µm	43.9 (37.6-46.2)	50.4 (46.2-54.1)	64.2 (57.4-68.9)	72.2 (66.7-77.9)
Odontophore µm	31.2 (29.0-33.7)	36.6 (35.0-38.0)	39.6 (37.7-42.6)	46.8 (37.6-50.2)
Replacement odontostyle µm	53.0 (50.8-53.9)	62.1 (54.1-67.3)	79.1 (71.3-80.2)	84.4 (80.5-98.0)
Oral aperture to guiding ring µm	37.1 (34.3-40.9)	44.0 (40.3-46.2)	51.5 (49.5-53.5)	59.5 (54.1-64.4)
Tail µm	35.1 (33.3-37.0)	33.3 (30.4-36.3)	34.8 (31.7-37.6)	31.2 (22.1-37.6)
J µm	6.4 (5.9-7.3)	5.9 (4.6-7.3)	8.9 (7.9-11.5)	10.2 (7.9-12.5)
Body diam. at lip region µm	7.5 (7.3-7.9)	8.6 (7.9-9.2)	9.3 (7.9-10.6)	10.2 (8.9-11.9)
Body diam. at guiding ring µm	16.7 (15.8-17.8)	19.3 (16.5-21.1)	22.4 (21.1-23.0)	21.4 (21.8-26.7)
Body diam. at base of oesophagus µm	20.2 (18.0-22.4)	24.5 (19.8-29.7)	27.0 (24.6-29.5)	30.3 (28.4-33.0)
Body diam. at midbody µm	21.7 (19.1-24.8)	27.1 (23.1-34.0)	31.9 (29.5-34.3)	33.8 (29.7-37.6)
Body diam. at anus µm	12.9 (11.9-14.5)	16.3 (15.2-17.5)	18.9 (16.4-21.3)	21.5 (17.8-27.7)
Body diam. at beginning of J µm	6.1 (5.3-7.3)	6.3 (5.3-7.9)	8.2 (6.6-9.8)	10.8 (7.9-15.2)

TABLE VI - *Morphometrics of the juvenile stages of the population of* X. incognitum *from Laborie.*

	Stages			
	J1	J2	J3	J4
n	6	6	10	10
L mm	0.66 (0.63-0.69)	0.82 (0.78-0.88)	1.08 (0.94-1.3)	1.32 (1.26-1.41)
a	30.5 (29.2-31.4)	33.4 (32.1-35.2)	39.0 (36.7-42)	43.7 (42.6-45.4)
b	3.9 (3.8-4.0)	4.0 (3.8-4.3)	4.4 (3.7-5.1)	4.8 (4.2-6.4)
c	19.8 (19.5-20.2)	25.1 (23.4-26.4)	35.2 (30.0-40.3)	41.4 (36.0-50.7)
c'	2.4 (2.3-2.7)	2.2 (2.0-2.4)	1.7 (1.4-1.9)	1.5 (1.2-1.7)
Odontostyle µm	42.7 (40.6-44.2)	48.5 (47.5-50.8)	62.8 (60.7-64.7)	74.3 (71.3-78.5)
Odontophore µm	31.8 (31.0-33.0)	36.0 (35.0-37.0)	40.9 (38.9-42.9)	46.2 (40.9-50.2)
Replacement odontostyle µm	50.8 (48.2-54.1)	63.5 (60.7-64.7)	75.4 (71.3-77.2)	92.5 (83.8-110.2)
Oral aperture to guiding ring µm	33.2 (32.3-33.7)	40.1 (38.9-41.3)	49.1 (40.9-52.1)	60.2 (58.7-62.0)
Tail µm	33.4 (32.0-35.3)	32.7 (31.0-33.7)	30.8 (28.4-32.3)	32.2 (27.0-36.0)
J µm	7.0 (5.3-8.6)	6.8 (6.6-7.3)	8.5 (7.3-10.5)	10.6 (8.6-11.9)
Body diam. at lip region µm	7.3 (6.6-7.9)	7.8 (7.3-7.9)	8.8 (7.3-10.6)	9.9 (9.2-10.6)
Body diam. at guiding ring µm	16.6 (16.1-17.2)	17.4 (16.2-17.8)	21.6 (21.1-22.4)	23.8 (21.8-25.1)
Body diam. at base of oesophagus µm	20.1 (18.8-21.1)	22.1 (20.4-23.8)	26.4 (23.8-30.4)	28.8 (27.7-29.0)
Body diam. at midbody µm	21.8 (21.1-22.4)	24.7 (22.2-27.7)	28.4 (26.4-31.0)	30.2 (28.4-33.0)
Body diam. at anus µm	13.8 (11.9-15.2)	14.8 (13.9-16.5)	18.4 (16.5-20.5)	21.7 (20.5-22.8)
Body diam. at beginning of J µm	5.9 (5.3-6.6)	6.6 (5.9-7.3)	8.4 (7.3-9.9)	11.0 (9.2-12.5)

extremities. Lip region expanded, frontally flat and laterally rounded. Odontostyle 82 to 95 µm long. Vulva postequatorial, between 53 and 58%, reproductive system amphidelphic, with equally developed branches and reflexed ovaries. Tail elongate with subdigitate end, rounded on the dorsal and flat on the ventral side.

The populations of *X. pachtaicum* from the Cape Western, compared to previous reports (Lamberti and Martelli, 1971; Lamberti and Bleve-Zacheo, 1979), generally possess longer body (2-2.1 mm versus 1.6-2 mm), odontostyle (89-93 versus 79-90 µm) and tail (35-37 versus 27-32 µm) and a thinner body profile. The first three juvenile stages of a Western Cape population of *X. pachtaicum* (Table VII) conversely have shorter body compared to those of an Italian population (Lamberti and Martelli, 1971).

The variability of the tail shapes of the juveniles makes it impossible to distinguish among the three species for a correct identification in absence of females, except for *X. pachtaicum*, perhaps, when preadult juveniles occur. However, juveniles of *X. pachtaicum* are clearly distinguished from the other two species because of their expanded lip region.

For PCA and HCA the 20 populations from the Western Cape were plotted with topotypes of *X. americanum*, because seven populations were identified as such; with paratypes of *X. incognitum*, because four populations fitted within the species; with paratypes of *X. diffusum* and *X. taylori* because four and two populations, respectively, possessed a few biometric characters in common with them; finally they

TABLE VII - *Morphometrics of the juvenile stages of the population of* X. pachtaicum *from Tulbach.*

	Stages			
	J1	J2	J3	J4
n	6	10	10	10
L mm	0.61 (0.59-0.64)	0.87 (0.77-0.92)	1.09 (0.94-1.19)	1.4 (1.21-1.53)
a	37.6 (36.6-39.4)	43.2 (41.5-45.3)	51.0 (46.8-55.5)	53.9 (46.9-58.2)
b	4.2 (3.3-5.0)	4.5 (4.2-4.7)	5.0 (4.2-5.9)	5.8 (5.1-6.9)
c	22.9 (21.1-23.9)	26.6 (22.3-30.2)	34.1 (29.0-39.2)	39.6 (32.1-44.0)
c'	3.0 (2.7-3.1)	2.7 (2.5-3.1)	2.5 (2.3-3.0)	2.2 (1.9-2.5)
Odontostyle µm	40.2 (37.6-41.9)	47.3 (43.5-49.5)	61.3 (58.1-64.0)	70.2 (67.3-72.6)
Odontophore µm	29.9 (28.7-32.3)	32.1 (31.6-33.0)	37.2 (36.3-38.9)	41.3 (33.7-46.9)
Replacement odontostyle µm	50.1 (48.8-52.8)	59.6 (58.1-62.0)	69.5 (64.7-72.6)	83.5 (76.6-89.8)
Oral aperture to guiding ring µm	36.6 (35.6-37.6)	41.4 (39.6-44.2)	49.5 (37.3-52.5)	64.0 (52.1-63.7)
Tail µm	26.8 (24.8-30.4)	32.8 (29.7-34.3)	32.3 (29.7-38.9)	35.4 (32.3-38.3)
J µm	4.7 (4.0-5.3)	5.4 (4.6-5.9)	5.3 (4.0-6.6)	6.5 (4.6-8.3)
Body diam. at lip region µm	6.8 (6.6-7.3)	6.7 (5.9-7.3)	7.6 (7.3-7.9)	7.4 (6.6-7.9)
Body diam. at guiding ring µm	12.4 (11.9-12.9)	14.2 (13.9-14.5)	16.6 (15.2-17.8)	18.2 (15.8-19.5)
Body diam. at base of oesophagus µm	14.2 (13.2-15.2)	18.1 (17.2-19.1)	18.9 (18.5-19.8)	22.9 (21.1-23.8)
Body diam. at midbody µm	16.2 (15.2-17.5)	20.1 (17.8-22.1)	21.1 (19.2-23.8)	25.9 (24.4-27.7)
Body diam. at anus µm	9.0 (8.3-9.9)	12.1 (11.2-12.5)	13.1 (12.5-14.2)	16.3 (14.5-17.8)
Body diam. at beginning of J µm	4.0 (3.0-4.6)	4.6 (4.0-5.3)	5.0 (4.0-6.6)	5.6 (5.3-5.9)

were plotted with an Italian population of *X. pachtaicum* because three of them were identified as such.

The results of PCA and HCA confirmed previous identifications, as five different phenotypes were detected (Figs 3 and 4). The corre-lation coefficients among the variables used, the eigenvalues of the correlation matrix and the eigenvectors are given in Tables VIII, IX and X. Over 81% of the total variance was associated with the two first principal components, increasing to about 88% when the third principal component was also used (Table VIII). The highest positive correlations of the first principal component were observed with the body diameters and the odontophore length, whereas negative correlations resulted with c', tail length and a (Table VIII). The second principal component was positively correlated with body length and distance of guiding ring from oral aperture.

The range-value plottings of the 17 morphometric characters individually analyzed show that for the body diameter at lip region (lip), at guiding ring level (dag) (Fig. 5D), at base of oesophagus (does) and at anus level (dan) (Fig. 5C) the five species represent five different phenotypes. Four phenotypes occur for the ratio a (Fig. 5A), being *X. taylori* enclosed within the range of *X. americanum* and for the body diameter at beginning of J (beg) (Fig. 5C), being *X. pachtaicum* enclosed in *X. americanum.* Three separate groups appear for the distance guiding ring to oral aperture (ag) (Fig. 5B) in which *X. diffusum* and *X. americanum* stand isolated and there is overlapping between *X. pachtaicum* and *X. incognitum* and coinci-

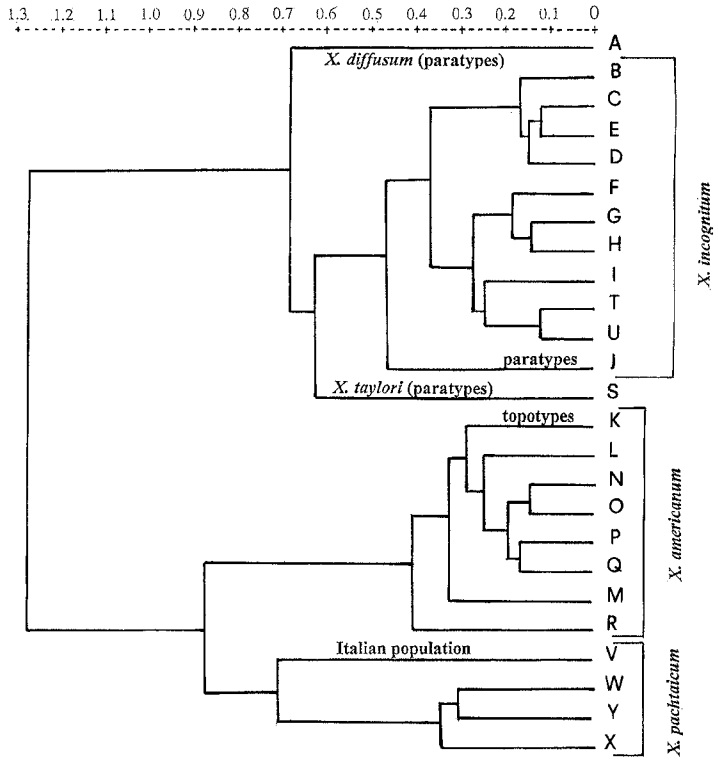


Fig. 3 - Dendrogram showing the clustering of 25 populations of *Xiphinema* (codes in Table I).

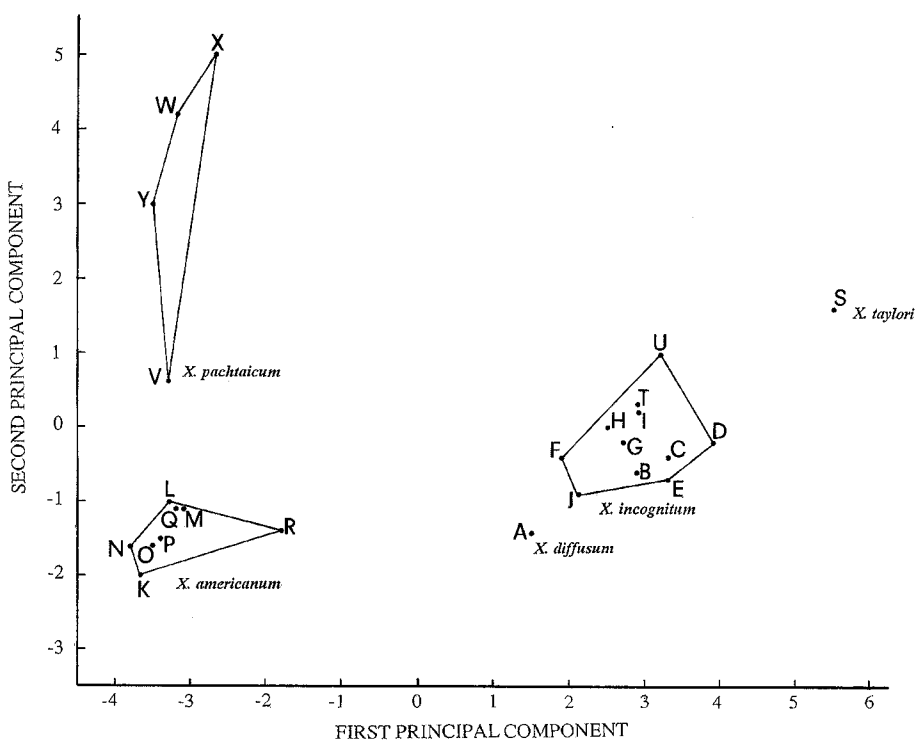


Fig. 4 - Scatterplot of 25 populations of *Xiphinema* (codes in Table I) on the first and second principal component axes.

TABLE VIII - *Correlation coefficients among the variables subjected to principal component analysis.*

	L	s	b	c	c'	V	sty	est	ag	tal	J	lip	dag	does	vul	dan
a	0.159															
b	0.438	0.393*														
c	0.616***	-0.472*	0.005													
c'	-0.275	0.831***	0.244	-0.865***												
V	0.294	0.577**	0.056	0.074	0.262											
sty	0.774***	-0.253	0.220	0.716***	-0.587**	0.125										
est	0.668***	-0.472*	0.011	0.859***	-0.799***	0.009	0.846***									
ag	0.884***	0.072	0.360	0.565**	-0.278	0.394*	0.810***	0.660***								
tail	-0.188	0.708***	0.259	-0.879***	0.936***	0.093	-0.443*	-0.671***	-0.181							
J	0.468*	0.013	0.212	0.536**	-0.348	0.189	0.544**	0.578**	0.354	-0.360						
lip	0.377	-0.735***	-0.192	0.797***	-0.877***	-0.320	0.582**	0.805***	0.353	-0.766***	0.359					
dag	0.343	-0.788***	-0.164	0.727***	-0.860***	-0.352	0.611***	0.787***	0.385	-0.690***	0.248	0.884***				
does	0.396*	-0.823***	-0.148	0.810***	-0.943***	0.323	0.673***	0.855***	0.409*	-0.792***	0.331	0.912***	0.942***			
vul	0.427*	-0.817***	-0.112	0.807***	-0.927***	-0.307	0.688***	0.829***	0.469*	-0.778***	0.267	0.895***	0.927***	0.987***		
dan	0.409*	-0.798***	-0.156	0.819***	-0.945***	-0.305	0.718***	0.868***	0.425*	-0.793***	0.378	0.925***	0.926***	0.980***	0.969***	
beg	0.440*	-0.720***	-0.130	0.906***	-0.960***	-0.217	0.704***	0.880***	0.382	-0.878***	0.511**	0.905***	0.873***	0.947***	0.918***	0.960***

(*) = P <0.05; (**) = P <0.01; (***) = P <0.001. Character codes as indicated in Table II.

TABLE IX - *Eigenvalues of the correlation matrix.*

*PRIN	Eigenvalue	Difference	Proportion	Cumulative
PRIN1	10.6208	7.41225	0.624751	0.62475
PRIN2	3.2085	2.10378	0.188737	0.81349
PRIN3	1.1047	0.29827	0.064985	0.87847
PRIN4	0.8065	0.32747	0.047440	0.92591
PRIN5	0.4790	0.22087	0.028176	0.95409
PRIN6	0.2581	0.08756	0.015184	0.96927
PRIN7	0.1706	0.07782	0.010033	0.97931
PRIN8	0.0927	0.00763	0.005456	0.98476
PRIN9	0.0851	0.00961	0.005007	0.98977
PRIN10	0.0755	0.01464	0.004442	0.99421
PRIN11	0.0609	0.04415	0.003581	0.99779
PRIN12	0.0167	0.00874	0.000984	0.99878
PRIN13	0.0080	0.00175	0.000469	0.99924
PRIN14	0.0062	0.00292	0.000367	0.99961
PRIN15	0.0033	0.00120	0.000195	0.99981
PRIN16	0.0021	0.00094	0.000124	0.99993
PRIN17	0.0012	–	0.000069	1.00000

*PRIN = principal component.

TABLE X - *Principal component analysis eigenvectors.*

	*PRIN1	PRIN2	PRIN3	PRIN4	PRIN5	PRIN6	PRIN7	PRIN8	PRIN9	PRIN10	PRIN11	PRIN12	PRIN13	PRIN14	PRIN15	PRIN16	PRIN17
L	0.1570	0.4365	0.1477	0.1297	0.0182	0.4940	-0.2029	0.0589	-0.2771	-0.0597	0.4183	0.0293	-0.3445	-0.0183	-0.1949	-0.0850	-0.1914
a	-0.2210	0.3616	-0.0946	-0.0543	0.0501	0.3642	-0.0554	0.2539	0.1147	0.1687	-0.1101	-0.1539	0.4460	-0.3967	0.1042	0.3918	0.0870
b	-0.0290	0.3429	0.5456	-0.3866	-0.5388	-0.2195	0.2372	0.0856	0.1576	-0.0622	0.0442	-0.0299	-0.0187	-0.0108	-0.0078	-0.0112	0.0048
c	0.2781	0.1158	-0.2063	-0.0769	-0.3330	0.2782	-0.1076	0.0225	-0.0799	0.1868	-0.2201	0.1308	-0.0367	0.3381	0.6331	-0.1377	0.1344
c'	-0.2913	0.1309	0.1144	0.0467	0.1810	0.0744	0.1687	-0.0463	0.0525	0.0882	0.0329	0.2518	0.2840	0.6460	-0.0103	0.1985	-0.4485
V	-0.0597	0.3642	-0.6003	0.2778	-0.1907	-0.3004	0.3929	0.1011	0.1211	-0.0399	0.3346	-0.0001	-0.0740	0.0098	0.0178	-0.0216	0.0194
sty	0.2346	0.2861	0.0973	0.0937	0.2304	-0.4150	-0.4857	0.0641	0.4003	0.3610	0.0242	0.2747	-0.0613	-0.0632	0.0442	-0.0004	-0.0565
est	0.2816	0.1510	-0.0379	0.0084	0.2034	-0.0070	0.0394	0.4674	0.1279	-0.6398	-0.4025	0.0929	-0.0939	0.1203	-0.0578	0.1060	-0.0262
ag	0.1570	0.4193	0.1152	0.3808	0.0170	-0.0830	0.0849	-0.4972	-0.1773	-0.0101	-0.4497	-0.2104	0.2077	0.0168	-0.1650	-0.1554	0.0827
tail	-0.2564	0.1214	0.3331	0.1432	0.4668	-0.0268	0.1797	0.1055	-0.0005	-0.0816	0.2117	-0.0821	-0.0494	0.0921	0.4083	-0.2374	0.4839
J	0.1411	0.2565	-0.2446	-0.7114	0.4187	-0.1166	0.1564	-0.2542	-0.2471	0.0412	0.0080	0.0270	-0.0648	-0.0409	0.0123	0.0261	-0.0122
lip	0.2831	-0.0895	0.0324	-0.0097	0.1018	0.4223	0.3749	-0.3278	0.6530	0.0065	0.0632	0.1494	-0.0518	-0.1074	-0.0494	-0.0542	0.0394
dag	0.2796	-0.1044	0.1539	0.1364	0.1179	-0.0150	0.4912	0.4029	-0.2449	0.5549	-0.1834	0.0187	-0.1584	-0.0689	-0.1075	0.0592	-0.0636
does	0.2985	-0.0856	0.0917	0.0581	0.0245	-0.0833	0.0950	0.0595	-0.1930	-0.1915	0.2365	0.2449	0.5563	-0.3185	0.2498	-0.3219	-0.3238
vul	0.2955	-0.0695	0.1327	0.1452	-0.0666	-0.1060	0.0032	-0.2142	-0.2176	-0.1257	0.2371	0.2647	0.0520	0.0347	0.0721	0.7041	0.3350
dan	0.3005	-0.0684	0.0651	0.0293	0.0960	-0.0965	-0.0228	-0.0295	0.1367	0.0238	0.1801	-0.7552	-0.0283	0.1206	0.2905	0.2205	-0.3309
beg	0.3003	-0.0345	-0.0736	-0.1449	-0.0172	0.0489	-0.1056	0.2149	0.0511	0.1034	0.2398	-0.1880	0.4374	0.3846	-0.4295	-0.1827	0.3986

* PRIN = Principal component. Character codes as indicated in Table II.

dence between *X. incognitum* and *X. taylori*. For the rest of the characters we have in L (Fig. 5A), *X. taylori* isolated, *X. pachtaicum* overlapping *X. incognitum*, some populations of *X. incognitum* coincident with *X. americanum*, in which *X. diffusum* is enclosed; in b (Fig. 5A), *X. diffusum* is separated, whereas the other four species overlap each other; in c (Fig. 5A), *X. taylori* and *X. americanum* remain separated, while the Italian population of *X. pachtaicum* coincides with *X. incognitum* which also includes *X. diffusum*; in c' (Fig. 5B), *X. diffusum* is isolated, *X. taylori* coincides with *X. incognitum* and the Italian population of *X. pachtaicum* overlaps with *X. americanum*; in sty (Fig. 5B), *X. americanum* and *X. diffusum* are isolated, *X. pachtaicum* and *X. incognitum* overlap, while *X. taylori* coincides with *X. incognitum*; in est (Fig. 5B), *X. diffusum* and *X. taylori* stand isolated, whereas there is a continuous overlapping of *X. pachtaicum* with *X. incognitum* and *X. americanum*; as concerning V (Fig. 5B), two clearly separated groups are formed, *X. pachtaicum* alone and the other four species all together; in tail (Fig. 5D), *X. diffusum* is isolated, *X. taylori* is enclosed in *X. incognitum* and *X. pachtaicum* overlaps *X. incognitum* and *X. americanum*; in J (Fig. 5D), *X. diffusum* and *X. taylori* are isolated and there is continous overlapping of *X. pachtaicum* with *X. incognitum* and *X. americanum*; finally in vul (Fig. 5C), there is a separate group for *X. incognitum* to which *X. taylori* is almost coincident, and two other groups slightly overlapping: one for *X. americanum*, in which *X. diffusum* coincides and the other for *X. pachtaicum*.

In conclusion *X. americanum* differs from *X. diffusum* for the characters a, b, c, c', sty, est ag, tail, J, lip, dag, does, dan and beg (14 out of 17 considered); from *X. incognitum* for the

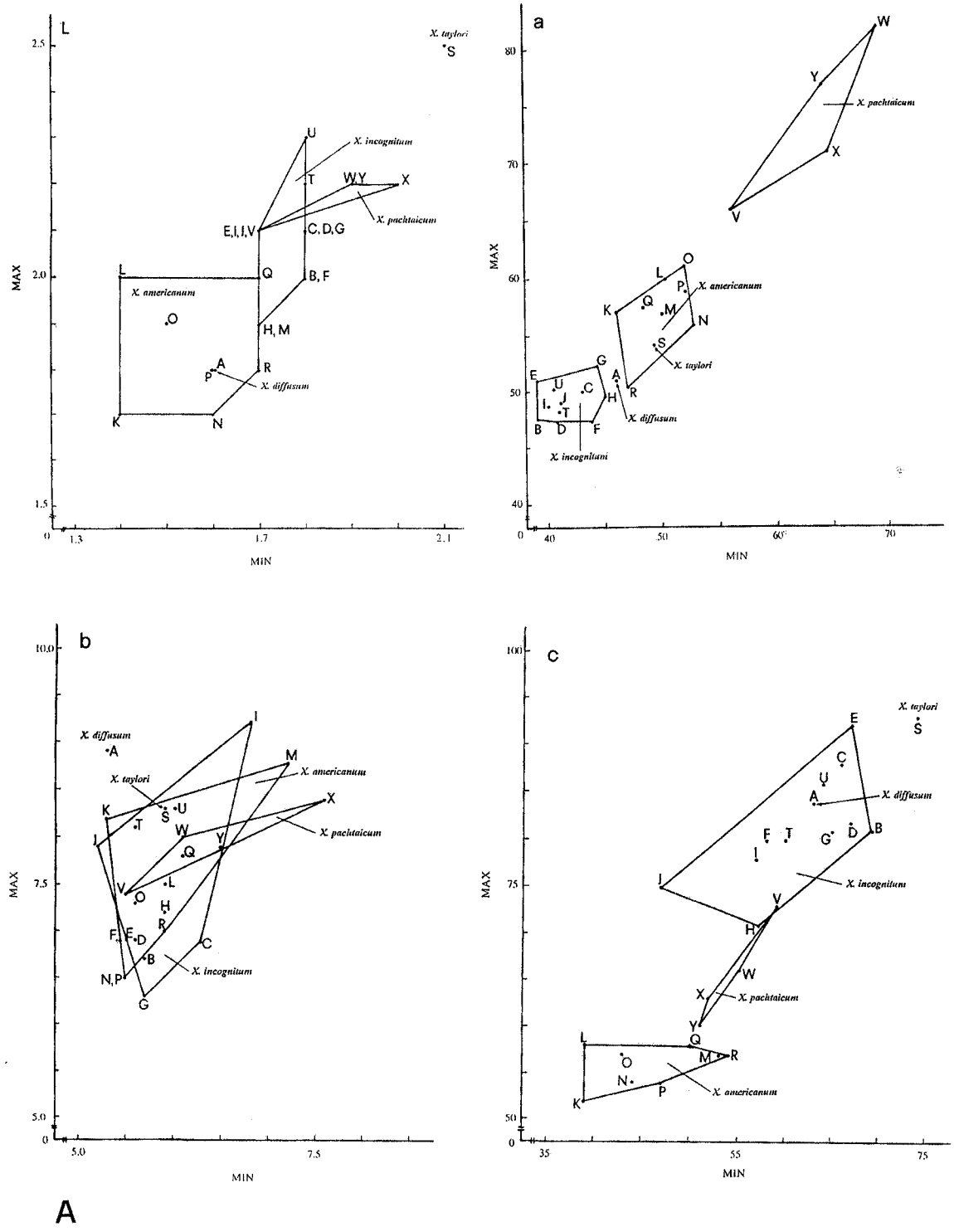
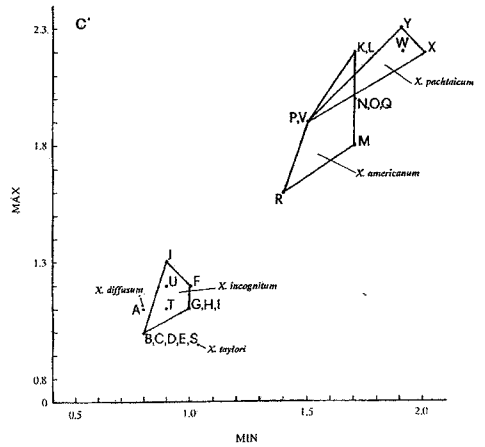
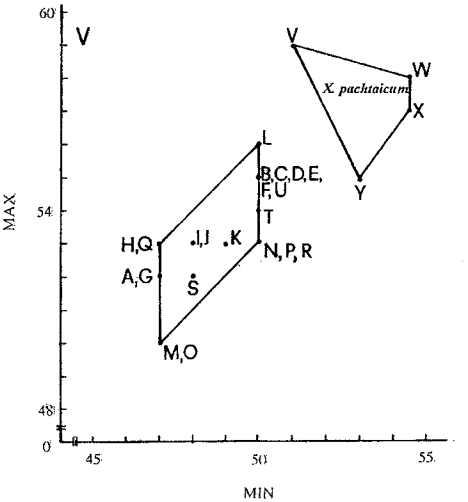
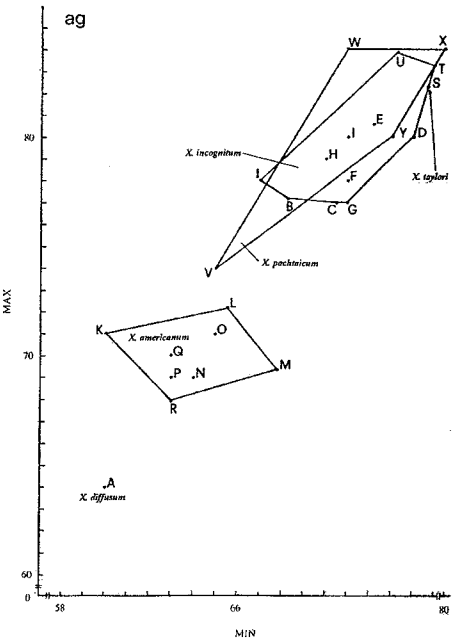
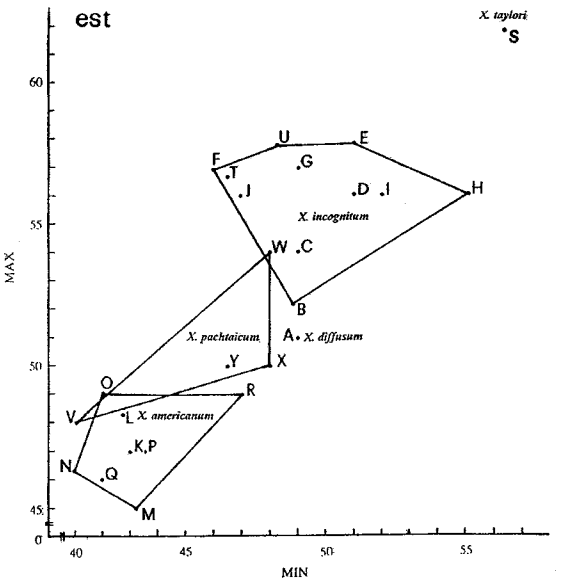


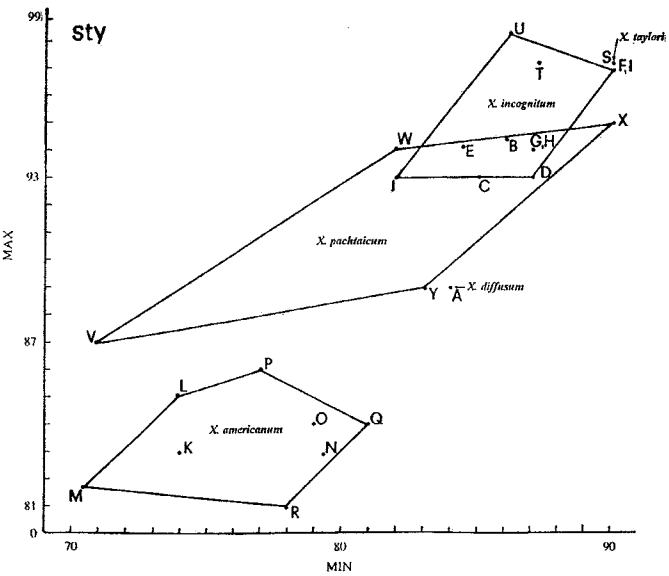
Fig. 5 (A-D). Graphic display of the morphometric values (codes in Table II) of the 25 populations (codes in Table I) of *Xiphinema*.


c'
MAX
MIN
X. pachtaicum
X. americanum
X. diffusum
X. incognitum
X. taylori

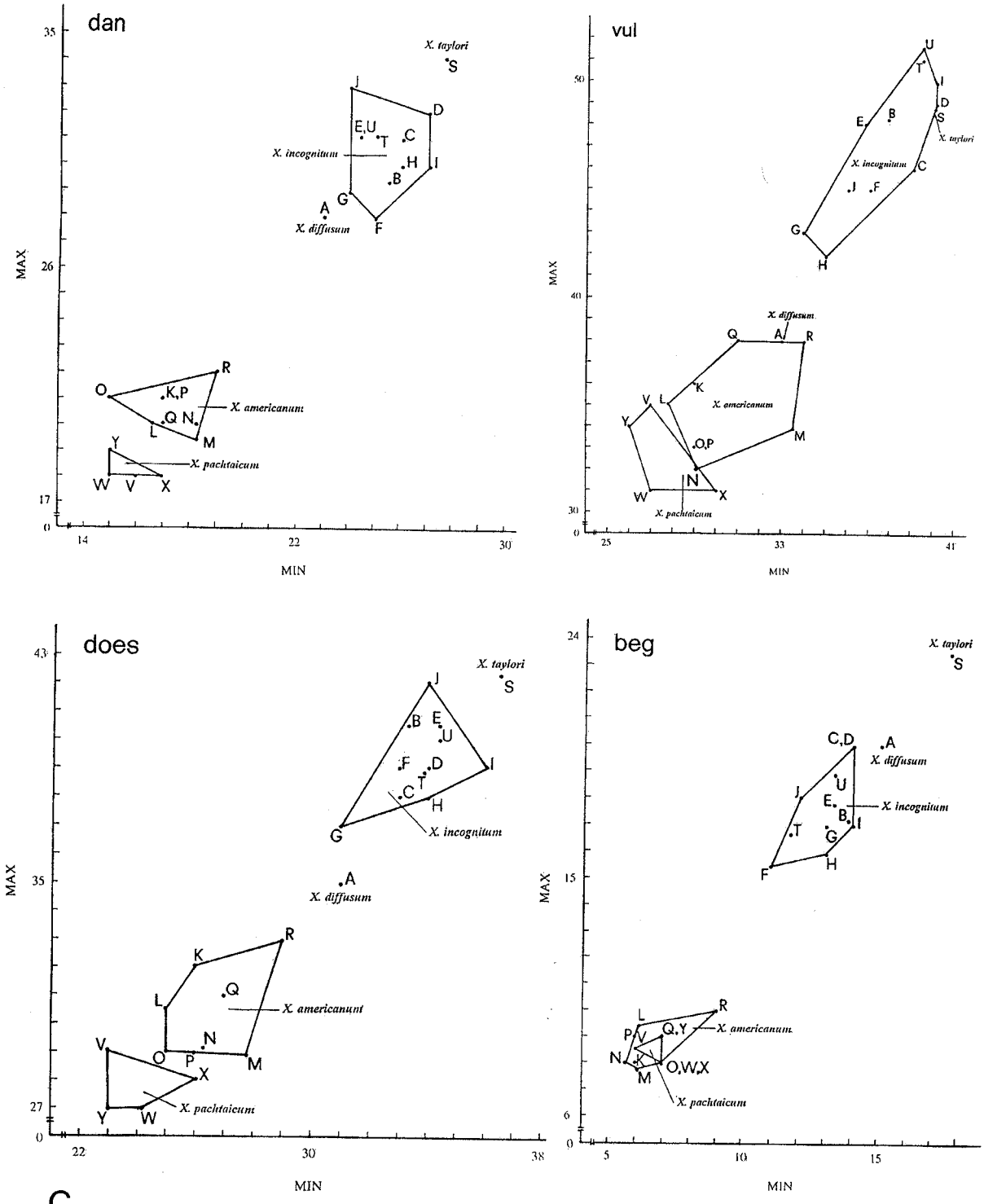

V
MAX
MIN
X. pachtaicum

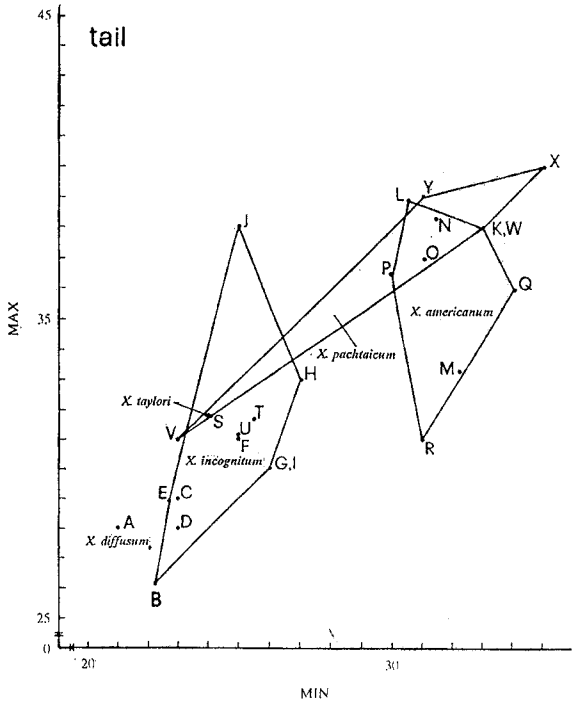

ag
MAX
MIN
X. incognitum
X. pachtaicum
X. americanum
X. diffusum
X. taylori

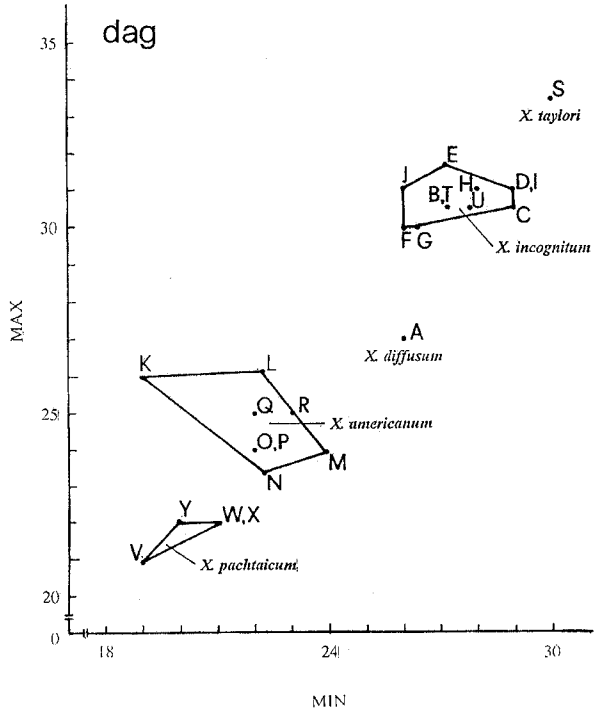

est
MAX
MIN
X. taylori
X. incognitum
X. pachtaicum
X. diffusum
X. americanum

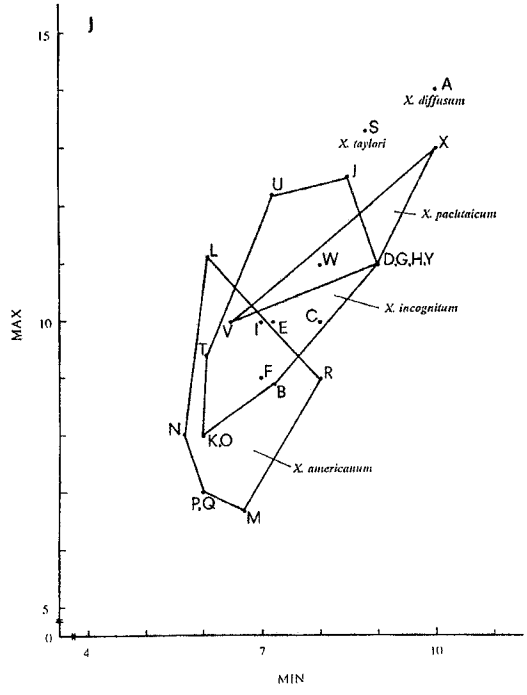

sty
MAX
MIN
X. taylori
X. incognitum
X. pachtaicum
X. diffusum
X. americanum

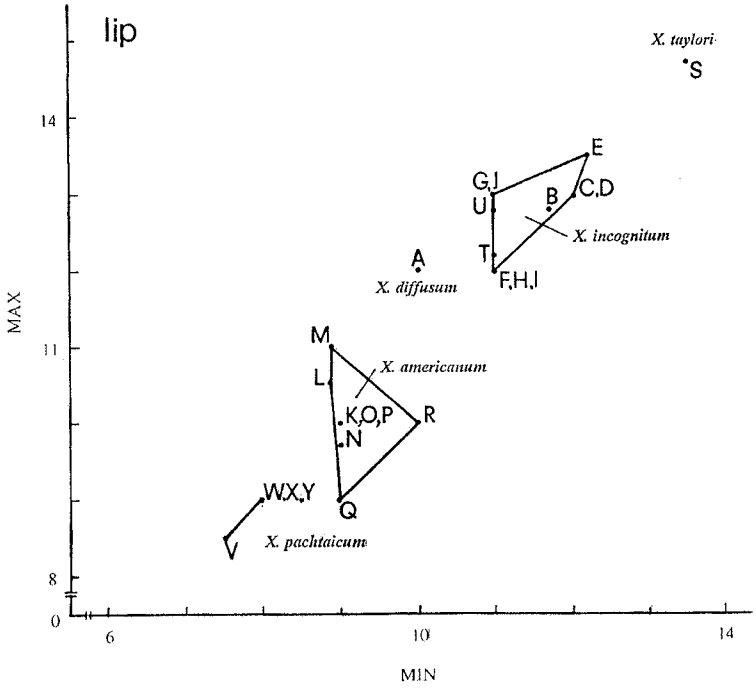
B


dan
MAX
MIN
35
26
17
0
14
22
30
X. taylori
S
X. incognitum
X. diffusum
X. americanum
X. pachtaicum
vul
50
40
30
25
33
41
does
43
beg
24
15
6
5
10
C


tail
MAX
MIN
X. taylori
X. incognitum
X. diffusum
X. pachtaicum
X. americanum


dag
MAX
MIN
X. taylori
X. incognitum
X. diffusum
X. americanum
X. pachtaicum


MAX
MIN
X. diffusum
X. taylori
X. pachtaicum
X. incognitum
X. americanum


lip
MAX
MIN
X. taylori
X. diffusum
X. incognitum
X. americanum
X. pachtaicum

D

characters a, c, c', sty, est, ag, tail, lip, dag, does, vul, dan and beg (13 out of 17); from *X. pachtaicum* for the characters L, a, c, sty, ag, V, lip, dag, does, and dan (10 out of 17); and from *X. taylori* for characters L, c, c', sty, est, ag, tail, J, lip, dag, does, vul, dan and beg (14 out of 17).

X. diffusum differs from *X. incognitum* for the characters a, b, c', sty, est, ag, tail, J, lip, dag, does, vul, dan and beg (14 out of 17); from *X. pachtaicum* for the characters L, a, b, c', sty, est, ag, tail, J, lip, dag, does, dan and beg (14 out of 17); and from *X. taylori* for the characters L, a, b, c, c', sty, est, ag, tail, J, lip, ag, does, vul, dan and beg (16 out of 17).

X. incognitum differs from *X. pachtaicum* for the characters a, c', V, lip, dag, does, vul, dan and beg (9 out of 17) and from *X. taylori* for the characters L, a, c, est, J, lip, dag, does, dan and beg (10 out of 17).

Finally *X. pachtaicum* differs from *X. taylori* for the characters, L, a, b, c, c', est, V, J, lip, dag, does, vul, dan and beg (14 out of 17).

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