

The *Xiphinema americanum*-group. II. Morphometric relationships

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Summary. Hierarchical cluster analysis based on morphometrics placed 117 populations, representing 39 putative species, of the *Xiphinema americanum* group into four clusters. Cluster 1 consisted of three populations identified as *X. brevisicum*; Cluster 2 consisted of five sub-clusters of populations; and Clusters 3 and 4 each consisted of seven sub-clusters. When several populations ascribed to a putative species were used, they usually clustered with a low range of variability, thus confirming their similarity. A population that had been identified as representing *X. diffusum* and another as being *X. incognitum* were placed in clusters different from that which characterized the rest of the populations of each species, respectively. Populations identified as *X. americanum sensu stricto*, *X. thornei*, *X. santos* and *X. pachydermum* were placed in 2 and 3 different sub-clusters within the same major cluster. Conversely, several populations of *X. madeirensis*, *X. duriense*, *X. simile* and *X. pachtaicum* had a low coefficient of dissimilarity (<2.8), which is considered as being indicative of intra-specific variability. Four populations, each identified as representing *X. pachydermum*, were placed in three different sub-clusters of Cluster 4, thus indicating wide morphometric variability for this putative species.

Key words: hierarchical cluster analysis, intra-specific variability, morphometrics, nematodes.

Studies on the diversity of species within the *Xiphinema americanum*-group by means of principal components and hierarchical cluster analysis of morphometrics divided 49 populations into five distinct clusters of populations (Lamberti & Ciancio, 1993). The 17 characters analyzed in this initial study were not available for all the populations tested, therefore the exercise was repeated but using only seven morphometric characters that were available for 39 described species within the *X. americanum*-group (Lamberti & Ciancio, 1994). The occurrence of five clusters was confirmed in this second study. Also, the results indicated that whilst the system is probably inappropriate for species identification, it did have some utility when investigating relationships between the putative species.

Lamberti *et al.* (2000) attributed 51 putative species to the *X. americanum*-group, including two considered *species inquirendae* because of their insufficient description. Many of these species are being re-identified and characterized by means of isozyme and DNA analysis within the framework

of a project funded by the Commission of the European Union. Therefore, it was considered useful to re-examine the morphometric relationships of the 39 species originally examined by Lamberti & Ciancio (1994). For this new study 117 populations representing the 39 putative species were included, and the 17 morphometric characters used by Lamberti & Ciancio (1993) were obtained for specimens from each population. For each population the identification of the species as reported by the various authors was accepted as valid.

MATERIALS AND METHODS

One hundred and seventeen populations representing 39 putative species of the *X. americanum*-group, and one population of *X. index* used as an out-group species, were selected for the study (Table 1). Each of the populations chosen had been described in the literature by the entire set of 17 morphometric characters as reported in Table 2. Cluster analysis was achieved by the Joining (Tree

Table 1. Populations selected for statistical analysis.

Pop.	Species	Authority	Geographic origin	Literature reference
1	<i>X. index</i>	Thorne <i>et al.</i> , 1950	Italy	Lamberti <i>et al.</i> , 1985
2	<i>X. americanum</i>	Cobb, 1913	Virginia, USA	Lamberti & Golden, 1984
3	<i>X. americanum</i>		Virginia, USA	Lamberti & Golden, 1984
4	<i>X. americanum</i>		Maryland, USA	Lamberti & Golden, 1984
5	<i>X. americanum</i>		Maryland, USA	Lamberti & Golden, 1984
6	<i>X. americanum</i>		Rhode Island, USA	Lamberti & Bleve-Zacheo, 1979
7	<i>X. americanum</i>		Canada	Lamberti & Bleve-Zacheo, 1979
8	<i>X. americanum</i>		Louisiana, USA	Lamberti & Bleve-Zacheo, 1979
9	<i>X. americanum</i>		Maryland, USA	Lamberti & Bleve-Zacheo, 1979
10	<i>X. americanum</i>		South Africa	Lamberti <i>et al.</i> , 1995
11	<i>X. americanum</i>		South Africa	Lamberti <i>et al.</i> , 1995
12	<i>X. americanum</i>		South Carolina, USA	Lamberti & Bleve-Zacheo, 1979
13	<i>X. brevicolle</i>	Lordello <i>et al.</i> , 1961	Brazil	Lamberti <i>et al.</i> , 1991
14	<i>X. brevicolle</i>		Brazil	Lamberti <i>et al.</i> , 1991
15	<i>X. brevisicum</i>	Lamberti, Bravo, Agostinelli <i>et al.</i> , 1994	Portugal	Lamberti <i>et al.</i> , 1994
16	<i>X. brevisicum</i>		Portugal	Lamberti <i>et al.</i> , 1994
17	<i>X. brevisicum</i>		Portugal	Lamberti <i>et al.</i> , 1994
18	<i>X. californicum</i>	Lamberti <i>et al.</i> , Bleve-Zacheo, 1979	California, USA	Lamberti & Bleve-Zacheo, 1979
19	<i>X. californicum</i>		California, USA	Lamberti & Bleve-Zacheo, 1979
20	<i>X. californicum</i>		Mexico	Lamberti & Bleve-Zacheo, 1979
21	<i>X. citricolum</i>	Lamberti <i>et al.</i> , Bleve-Zacheo, 1979	Florida	Lamberti & Bleve-Zacheo, 1979
22	<i>X. diffusum</i>	Lamberti <i>et al.</i> , Bleve-Zacheo, 1979	La Reunion, France	Lamberti & Bleve-Zacheo, 1979
23	<i>X. diffusum</i>		Easter Island, Chile	Lamberti & Bleve-Zacheo, 1979
24	<i>X. diffusum</i>		Israel	Lamberti <i>et al.</i> , 1991
25	<i>X. diffusum</i>		South Africa	Lamberti <i>et al.</i> , 1991
26	<i>X. diffusum</i>		Florida	Lamberti & Bleve-Zacheo, 1979
27	<i>X. diffusum</i>		Portugal	Lamberti <i>et al.</i> , 1994
28	<i>X. diffusum</i>		Madeira, Portugal	Lamberti <i>et al.</i> , 1994
29	<i>X. duriense</i>	Lamberti, Lemos, Agostinelli <i>et al.</i> , 1993	Portugal	Lamberti <i>et al.</i> , 1993
30	<i>X. duriense</i>		Portugal	Lamberti <i>et al.</i> , 1994
31	<i>X. duriense</i>		Portugal	Lamberti <i>et al.</i> , 1994
32	<i>X. duriense</i>		Portugal	Lamberti <i>et al.</i> , 1994
33	<i>X. duriense</i>		Portugal	Lamberti <i>et al.</i> , 1994
34	<i>X. floridae</i>	Lamberti <i>et al.</i> , Bleve-Zacheo, 1979	Florida	Lamberti & Bleve-Zacheo, 1979
35	<i>X. floridae</i>		Florida	Lamberti & Bleve-Zacheo, 1979
36	<i>X. fortuitum</i>	Roca, Lamberti <i>et al.</i> , Agostinelli, 1987	Italy	Roca <i>et al.</i> , 1987
37	<i>X. georgianum</i>	Lamberti <i>et al.</i> , Bleve-Zacheo, 1979	Georgia	Lamberti & Bleve-Zacheo, 1979
38	<i>X. himalayense</i>	Ahmad, Lamberti, Rawat, Agostinelli <i>et al.</i> , Srivastava, 1998	India	Ahmad <i>et al.</i> , 1998
39	<i>X. incertum</i>	Lamberti, Choleva <i>et al.</i> , Agostinelli, 1983	Bulgaria	Lamberti <i>et al.</i> , 1983
40	<i>X. incertum</i>		Croatia	Barsi, 1994
41	<i>X. incognitum</i>	Lamberti <i>et al.</i> , Bleve-Zacheo, 1979	Japan	Lamberti & Bleve-Zacheo, 1979
42	<i>X. incognitum</i>		Egypt	Lamberti <i>et al.</i> , 1996
43	<i>X. incognitum</i>		South Africa	Lamberti <i>et al.</i> , 1995
44	<i>X. intermedium</i>	Lamberti <i>et al.</i> , Bleve-Zacheo, 1979	Florida	Lamberti & Bleve-Zacheo, 1979
45	<i>X. intermedium</i>		Pakistan	Lamberti <i>et al.</i> , 1987
46	<i>X. laevistriatum</i>	Lamberti <i>et al.</i> , Bleve-Zacheo, 1979	Florida	Lamberti & Bleve-Zacheo, 1979
47	<i>X. longistylum</i>	Lamberti, Bravo, Agostinelli <i>et al.</i> , Lemos, 1994	Portugal	Lamberti <i>et al.</i> , 1994
48	<i>X. luci</i>	Lamberti <i>et al.</i> , Bleve-Zacheo, 1979	Senegal	Lamberti & Bleve-Zacheo, 1979
49	<i>X. madeirensense</i>	Brown, Faria, Lamberti, Halbrendt, Agostinelli <i>et al.</i> , Jones, 1993	Madeira, Portugal	Brown <i>et al.</i> , 1992
50	<i>X. madeirensense</i>		Portugal	Lamberti <i>et al.</i> , 1994
51	<i>X. madeirensense</i>		Portugal	Lamberti <i>et al.</i> , 1994
52	<i>X. madeirensense</i>		Azores, Portugal	Lamberti <i>et al.</i> , 1994
53	<i>X. madeirensense</i>		Portugal	Lamberti <i>et al.</i> , 1994
54	<i>X. madeirensense</i>		Portugal	Lamberti <i>et al.</i> , 1994
55	<i>X. madeirensense</i>		Portugal	Lamberti <i>et al.</i> , 1994
56	<i>X. mesostylum</i>	Lamberti, Bravo, Agostinelli <i>et al.</i> , Lemos, 1994	Portugal	Lamberti <i>et al.</i> , 1994
57	<i>X. microstylum</i>	Lamberti, Bravo, Agostinelli <i>et al.</i> , Lemos, 1994	Portugal	Lamberti <i>et al.</i> , 1994
58	<i>X. minor</i>	Ahmad, Lamberti, Rawat, Agostinelli <i>et al.</i> , Srivastava, 1998	India	Ahmad <i>et al.</i> , 1998

Table 1 (continued). Populations selected for statistical analysis.

Pop. number	Species	Authority	Geographic origin	Literature reference
59	<i>X. opistohysterum</i>	Siddiqi, 1961	India	Lamberti & Bleve-Zacheo, 1979
60	<i>X. oxycaudatum</i>	Lamberti et al., Bleve-Zacheo, 1979	Nigeria	Lamberti & Bleve-Zacheo, 1979
61	<i>X. oxycaudatum</i>		Pakistan	Nasira & Maqbool, 1998
62	<i>X. pachtaicum</i>	(Tulaganov, 1938)	Italy	Lamberti & Bleve-Zacheo, 1979
63	<i>X. pachtaicum</i>	Kirjanova, 1951	Bulgaria	Lamberti et al., 1997
64	<i>X. pachtaicum</i>		Crete, Greece	Lamberti & Bleve-Zacheo, 1979
65	<i>X. pachtaicum</i>		France	Lamberti & Bleve-Zacheo, 1979
66	<i>X. pachtaicum</i>		Morocco	Lamberti & Bleve-Zacheo, 1979
67	<i>X. pachtaicum</i>		Portugal	Lamberti et al., 1994
68	<i>X. pachtaicum</i>		Madeira, Portugal	Lamberti et al., 1994
69	<i>X. pachtaicum</i>		Azores, Portugal	Lamberti et al., 1994
70	<i>X. pachtaicum</i>		Slovakia	Lamberti et al., 1999
71	<i>X. pachtaicum</i>		Spain	Lamberti & Bleve-Zacheo, 1979
72	<i>X. pachtaicum</i>		Turkey	Lamberti & Bleve-Zacheo, 1979
73	<i>X. pachydermum</i>	Sturhan, 1963	Portugal	Lamberti et al., 1994
74	<i>X. pachydermum</i>		Portugal	Lamberti et al., 1994
75	<i>X. pachydermum</i>		Portugal	Lamberti et al., 1994
76	<i>X. pachydermum</i>		Portugal	Lamberti et al., 1994
77	<i>X. pakistanense</i>	Nasira et al., Maqbool, 1998	Kashmir, Pakistan	Nasira & Maqbool, 1998
78	<i>X. paramonovi</i>	Romanenko, 1981	Russia	Romanenko, 1981
79	<i>X. parvum</i>	Lamberti, Ciancio, Agostinelli et al., Coiro, 1992	Jamaica	Lamberti et al., 1994
80	<i>X. peruvianum</i>	Lamberti et al., Bleve-Zacheo, 1979	Peru	Lamberti & Bleve-Zacheo, 1979
81	<i>X. pseudogurianii</i>	Lamberti, Ciancio, Agostinelli et al., Coiro, 1992	Madagascar	Lamberti et al., 1992
82	<i>X. rivesi</i>	Dalmasso, 1969	Portugal	Lamberti et al., 1994
83	<i>X. rivesi</i>		Portugal	Lamberti et al., 1994
84	<i>X. rivesi</i>		Kansas, USA	Lamberti & Bleve-Zacheo, 1979
85	<i>X. rivesi</i>		Nebraska, USA	Lamberti & Bleve-Zacheo, 1979
86	<i>X. santos</i>	Lamberti, Lemos, Agostinelli et al., D'Addabbo, 1993	Portugal	Lamberti et al., 1993
87	<i>X. santos</i>		Portugal	Lamberti et al., 1994
88	<i>X. santos</i>		Madeira, Portugal	Lamberti et al., 1994
89	<i>X. santos</i>		Azores, Portugal	Lamberti et al., 1994
90	<i>X. santos</i>		Egypt	Lamberti et al., 1996
91	<i>X. sheri</i>	Lamberti et al., Bleve-Zacheo, 1979	Thailand	Lamberti & Bleve-Zacheo, 1979
92	<i>X. sheri</i>		Thailand	Lamberti & Bleve-Zacheo, 1979
93	<i>X. simile</i>	Lamberti, Choleva et al., Agostinelli, 1983	Bulgaria	Lamberti et al., 1983
94	<i>X. simile</i>		Serbia	Barsi, 1994
95	<i>X. simile</i>		Serbia	Barsi, 1994
96	<i>X. simile</i>		Montenegro	Barsi, 1994
97	<i>X. simile</i>		Slovakia	Lamberti et al., 1999
98	<i>X. simile</i>		Slovakia	Lamberti et al., 1999
99	<i>X. simile</i>		Slovakia	Liskova & Brown, 1996
100	<i>X. simile</i>		Slovakia	Liskova & Brown, 1996
101	<i>X. tarjanense</i>	Lamberti et al., Bleve-Zacheo, 1979	Florida	Lamberti & Bleve-Zacheo, 1979
102	<i>X. taylori</i>	Lamberti, Ciancio, Agostinelli et al., Coiro, 1992	Italy	Lamberti et al., 1992
103	<i>X. taylori</i>	(as <i>X. brevicolle</i>)	Italy	Lamberti et al., 1985
104	<i>X. taylori</i>		Bulgaria	Lamberti et al., 1983
105	<i>X. taylori</i>		Bulgaria	Lamberti et al., 1991
106	<i>X. taylori</i>	(as <i>X. brevicolle</i>)	Slovakia	Lamberti & Bleve-Zacheo, 1979
107	<i>X. taylori</i>		Slovakia	Lamberti et al., 1999
108	<i>X. taylori</i>	(as <i>X. brevicolle</i>)	Hungary	Lamberti & Bleve-Zacheo, 1979
109	<i>X. taylori</i>	(as <i>X. brevicolle</i>)	Poland	Lamberti & Bleve-Zacheo, 1979
110	<i>X. taylori</i>		Croatia	Barsi, 1994
111	<i>X. taylori</i>		Serbia	Barsi, 1994
112	<i>X. tenuicutis</i>	Lamberti et al., Bleve-Zacheo, 1979	Tennessee, USA	Lamberti & Bleve-Zacheo, 1979
113	<i>X. thornei</i>	Lamberti et al., Golden, 1984	Colorado, USA	Lamberti & Golden, 1984
114	<i>X. thornei</i>		Colorado, USA	Lamberti & Golden, 1984
115	<i>X. thornei</i>		Colorado, USA	Lamberti & Golden, 1984
116	<i>X. thornei</i>		Idaho, USA	Lamberti & Golden, 1984
117	<i>X. thornei</i>		Pakistan	Nasira & Maqbool, 1998
118	<i>X. uthaense</i>	Lamberti et al., Bleve-Zacheo, 1979	Utah, USA	Lamberti & Bleve-Zacheo, 1979

Clustering) procedure of the software STATISTICA (Version 5, StatSoft®, 1997) using the UPGMA method (unweighted pair-group method using arithmetic averages) (Sneath & Sokal, 1973) and using the Euclidean distance as distance measures. The data matrix was standardized for each of the 17 morphometric characters used before starting the analysis. Populations from the same putative species usually did not have dissimilarity coefficients higher than 2.8. Sub-clusters of populations were determined on the basis of a dissimilarity coefficient higher than 3.0; discrimination of the species within sub-clusters was done according to the species identifications as described in the literature.

RESULTS AND DISCUSSION

The population of *X. index* was widely separated from all other populations (Fig. 1), and the 39 *X. americanum* group populations separated into four distinct clusters (Fig. 1).

Cluster 1 consisted of three populations of *X. brevisiculum* (Table 3), each from Portugal, and this cluster showed the highest distance from all the other clusters.

Cluster 2 separated into five sub-clusters (Table 4). Sub-cluster *a* comprises *X. paramonovi* (Russia) and *X. georgianum* (USA); sub-clusters *b* and *c* each consist only of the type population of *X. himalayense* (India), and *X. diffusum* (France, La Reunion), respectively; sub-cluster *d* comprises two populations of *X. sheri* (Thailand), *X. pseudoguirani* (Madagascar) and two highly similar populations of *X. brevicolle* (Brazil); and sub-cluster *e* comprises ten populations of *X. taylori* (Bulgaria, Croatia, Hungary, Italy, Poland, Serbia, Slovakia), two populations of *X. incognitum* (Japan, South Africa), and five populations of *X. diffusum* (Chile, Israel, Portugal, South Africa). With this latter sub-cluster seven populations of *X. taylori* (two each from Italy and Slovakia, and one each from Hungary, Poland, and Serbia) form a homogeneous group; two populations of *X. incognitum* (from Japan and South Africa) are very similar, and three populations of *X. diffusum* (Israel, Easter Island, Chile, and Madeira, Portugal) showed a high degree of similarity. Two populations originally identified as *X. brevicolle*, but subsequently assigned to *X. taylori* (Bulgaria and Slovakia) were slightly separated from the other populations of *X. taylori*, with the population from Bulgaria apparently more similar to the population of *X. diffusum* from South Africa.

Cluster 3 can be separated into seven sub-clusters (Table 5). Sub-cluster *a* is comprised of a

population of *X. americanum* from Virginia, USA; sub-cluster *b* comprises a single population of *X. tarjanense* (USA) and one of *X. citricolum* (USA); sub-cluster *c* comprises single populations of *X. pakistanense* (Pakistan) and *X. laevistriatum* (USA); nineteen populations form sub-cluster *d*, including ten populations of *X. americanum* (Canada, South Africa, USA), one population of *X. minor* (India), two populations of *X. oxycaudatum* (Nigeria, Pakistan) and two of *X. intermedium* (Pakistan, USA), and four populations of *X. santos* (Egypt, Portugal); sub-cluster *e* comprises *X. utahense* (USA), *X. tenuicutis* (USA), *X. peruvianum* (Peru) two populations of *X. thornei* (USA) and three populations of *X. californicum* (Mexico, USA); sub-cluster *f* comprises two populations of *X. floridiae* (USA), two of *X. thornei* (USA), four populations of *X. rivesi* (Portugal, USA) and one population each of *X. incognitum* (Egypt), *X. santos* (Portugal) and *X. luci* (Senegal); and sub-cluster *g* comprises single populations of *X. parvum* (Jamaica), *X. thornei* (Pakistan) and *X. diffusum* (USA).

Cluster 4 comprises seven sub-clusters (Table VI). Sub-cluster *a* includes all seven populations of *X. madeirensis* (Portugal); Sub-cluster *b* comprises *X. fortuitum* (Italy) and *X. longistilum* (Portugal); sub-cluster *c* comprises all five populations of *X. duriense* examined (Portugal); sub-cluster *d* is comprised only of a single population of *X. mesostilum* (Portugal); sub-cluster *e* comprises only two populations of *X. pachydermum* (Portugal); sub-cluster *f* comprises eight populations of *X. simile* (Bulgaria, Montenegro, Serbia, Slovakia) and single populations of *X. opistohysterum* (India), *X. pachydermum* (Portugal) and *X. microstilum* (Portugal); and sub-cluster *g* comprises all populations of *X. pachtaicum* examined (Crete, Croatia, Bulgaria, France, Italy, Morocco, Portugal, Slovakia, Spain, Turkey), two populations of *X. incertum* (Bulgaria, Croatia) and one of *X. pachydermum* (Portugal).

CONCLUSIONS

The 117 populations of 39 putative species within the *X. americanum*-group were separated by the present statistical analysis into four main clusters, which makes a reduction with respect to the five clusters previously reported (Lamberti & Ciancio, 1993; 1994). This result is not unexpected, as morphometric variability increases in relation to the number, and the geographical distance, of the populations examined.

Cluster 1 comprises only three populations, each identified as *X. brevisiculum* and collected in northern Portugal (Lamberti *et al.*, 1994). This cluster is morphometrically distant from the other

Table 2. Average morphometric values of the populations considered.

Pop. Number	n of females	Body length (mm)	a	b	c	c'	V	Lengths (μm)					Diameters (μm)					
								ods*	odp*	grto*	tail	tjp*	lip	bgr*	oes*	vulva	anus	tjp*
1		3.4	62.0	7.4	90.0	1.0	39.0	135.0	75.0	123.0	38.0	15.0	13.0	38.0	48.0	55.0	37.0	19.0
2	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
3	10	1.5	54.0	5.8	49.0	1.8	50.0	69.0	44.0	53.0	31.0	5.0	8.0	19.0	26.0	28.0	17.0	5.0
4	10	1.5	47.0	6.9	46.0	1.8	49.0	77.0	47.0	62.0	34.0	9.0	10.0	24.0	29.0	33.0	19.0	8.0
5	11	1.7	50.0	7.0	48.0	1.8	51.0	73.0	47.0	63.0	36.0	9.0	10.0	24.0	30.0	35.0	20.0	8.5
6	16	1.7	51.0	6.9	52.0	1.7	51.0	68.0	42.0	58.0	32.0	8.0	10.0	22.0	30.0	34.0	19.0	8.0
7	10	1.6	51.0	6.7	47.0	1.8	50.0	80.0	42.0	65.0	35.0	9.0	10.0	23.0	29.0	32.0	19.0	8.0
8	4	1.8	56.0	6.4	54.0	1.8	51.0	67.0	46.0	59.0	34.0	8.0	10.5	23.0	29.0	33.0	19.0	7.0
9	5	1.7	50.0	6.4	49.0	1.8	52.0	79.0	45.0	67.0	34.0	9.0	10.0	23.0	29.0	33.0	19.0	8.0
10	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
11	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
12	5	1.5	43.0	6.2	46.0	1.7	50.0	70.0	43.0	57.0	32.0	8.0	10.0	23.0	30.0	35.0	19.0	8.0
13	17	2.1	44.5	6.4	77.8	1.0	53.0	101.9	57.0	86.3	26.8	8.0	11.5	29.8	39.4	46.6	26.6	13.7
14	10	2.1	47.9	6.2	86.9	0.9	52.3	104.5	58.6	90.0	24.3	7.9	11.6	30.8	38.1	44.0	26.8	14.4
15	13	2.2	87.0	7.6	58.0	2.5	56.0	60.0	43.0	53.0	41.0	9.0	9.0	18.0	23.0	26.0	16.0	6.0
16	5	2.5	91.0	9.0	59.0	2.6	55.0	63.5	44.0	54.0	44.0	11.0	10.0	19.0	24.0	27.0	17.0	7.5
17	5	2.3	87.0	9.0	52.5	2.9	56.0	60.0	43.0	53.0	44.0	9.0	9.0	18.0	23.0	26.0	15.0	7.0
18	20	1.9	56.0	6.9	58.0	1.7	51.0	86.0	48.0	74.0	33.0	8.5	10.5	25.0	31.0	34.0	20.0	9.0
19	4	2.0	60.0	6.8	63.0	1.6	51.0	90.0	48.0	76.0	31.0	6.0	10.0	23.0	29.0	33.0	19.0	7.0
20	19	1.9	61.0	7.0	69.0	1.5	50.0	82.0	47.0	70.0	31.0	7.0	10.0	23.0	27.0	31.0	20.0	8.5
21	2	1.7	45.5	6.0	49.0	1.6	52.5	86.0	47.0	66.5	35.0	13.0	12.5	31.5	36.5	38.5	22.0	8.8
22	10	1.8	46.0	6.7	67.0	1.0	49.0	88.0	46.0	64.0	27.0	14.0	12.0	27.0	36.0	40.0	27.0	20.0
23	7	1.8	43.2	5.9	72.8	0.9	50.0	87.7	53.3	73.8	24.8	8.6	12.6	30.3	37.4	41.7	27.0	15.2
24	20	1.8	48.1	6.1	71.7	1.0	49.7	87.4	53.1	74.0	25.8	9.0	12.8	29.1	35.1	38.2	25.7	15.4
25	20	1.9	44.8	6.4	79.5	0.9	50.7	88.4	53.2	72.4	23.3	11.4	12.7	29.9	37.2	41.2	26.9	18.7
26	10	1.7	45.0	5.8	74.0	0.9	53.0	87.0	45.0	68.0	23.0	6.0	11.0	26.0	34.0	38.0	24.0	13.0
27	5	2.0	49.0	6.6	70.0	1.0	50.0	92.0	55.0	76.0	29.0	10.0	13.5	29.0	37.0	41.0	29.0	18.0
28	3	1.9	46.0	6.6	68.0	1.0	51.0	89.5	52.0	75.0	27.0	8.0	12.0	27.5	36.0	41.0	27.0	15.0
29	10	1.8	74.0	6.0	58.0	2.1	60.0	70.0	37.0	61.0	31.0	7.3	8.1	17.0	21.0	24.0	14.0	6.4
30	10	1.6	73.5	5.9	52.5	2.4	61.0	68.0	37.0	57.0	31.0	7.5	8.0	16.0	20.0	22.0	13.5	5.5

Table 2 (continued). Average morphometric values of the populations considered.

Pop. Number	n of females	Body length (mm)	b	c	v	Lengths (μm)					Diameters (μm)							
						ods*	odp*	grto*	tail	tjp*	lip	bgr*	oes*	vulva	anus	tjp*		
31	10	1.8	72.0	7.0	65.0	1.8	64.0	67.5	38.5	57.5	28.0	7.5	8.0	18.0	22.5	25.0	16.0	7.5
32	5	1.9	80.0	7.2	57.0	2.4	62.0	66.0	39.0	53.0	33.0	9.0	8.0	16.5	21.0	24.0	14.0	6.0
33	5	1.8	79.0	6.8	53.0	2.4	63.0	66.0	37.0	53.0	34.0	9.0	8.0	16.0	21.0	23.0	14.0	6.0
34	20	1.8	44.0	6.3	59.0	1.3	51.0	90.0	54.0	74.0	31.0	9.0	13.0	29.0	36.0	42.0	25.0	9.0
35	10	1.7	43.0	6.0	63.0	1.1	51.0	87.0	52.0	74.0	27.0	7.0	13.0	30.0	36.0	40.0	24.0	9.0
36	5	2.6	83.4	7.1	75.7	1.9	54.0	102.0	50.6	83.2	35.3	8.9	8.7	21.8	27.5	32.1	18.6	8.3
37	10	1.9	47.0	6.1	64.0	1.3	53.0	112.0	53.0	98.0	31.0	12.0	12.0	32.0	38.0	41.0	23.0	10.0
38	7	2.6	54.8	6.8	85.5	1.0	52.0	112.5	64.4	94.7	30.6	9.6	12.7	34.9	42.4	47.9	30.5	18.7
39	4	1.9	57.0	6.4	69.0	1.5	57.0	92.0	51.0	71.0	28.0	7.0	9.0	22.0	29.0	34.0	19.0	10.0
40	2	1.9	62.9	6.3	72.9	1.5	58.7	90.5	49.5	82.9	26.7	7.8	8.8	23.1	27.8	30.8	17.6	9.8
41	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
42	15	1.9	48.0	5.9	68.0	1.0	52.0	89.0	52.0	79.0	28.0	7.0	13.0	29.5	35.0	39.5	27.0	13.0
43	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
44	10	1.6	43.0	6.0	47.0	1.5	52.0	76.0	45.0	63.0	33.0	10.0	10.5	27.0	34.0	37.0	22.0	9.0
45	11	1.8	45.0	6.4	51.0	1.6	50.0	78.0	50.0	66.0	35.0	10.0	11.0	27.0	34.0	39.0	22.0	10.0
46	6	1.6	49.0	7.0	49.0	1.5	51.0	79.0	41.0	57.0	34.0	12.0	10.0	25.0	32.0	34.0	22.0	11.0
47	13	2.8	76.0	6.9	80.0	1.5	56.0	112.0	53.0	104.0	35.0	11.0	9.0	26.0	31.0	36.0	23.0	10.0
48	7	1.8	51.0	7.0	65.0	1.2	51.0	95.0	50.0	76.0	28.0	8.5	10.5	26.0	34.0	35.0	24.0	14.0
49	20	2.2	69.2	6.3	58.7	1.9	55.2	105.2	52.5	90.2	37.6	10.8	9.0	23.2	28.6	31.8	19.2	8.3
50	5	2.2	72.0	6.2	55.0	2.2	56.0	103.0	53.0	87.0	41.0	13.0	8.0	22.5	29.0	31.0	19.0	7.0
51	5	2.1	74.0	6.0	59.0	2.0	57.0	103.0	50.0	89.0	35.0	9.0	9.0	23.0	25.0	28.0	18.0	7.0
52	5	2.1	66.0	6.4	53.0	2.1	54.0	102.0	50.0	83.0	40.0	10.0	8.5	22.0	28.0	31.0	19.0	7.0
53	5	2.1	72.0	6.3	54.0	2.2	55.0	101.5	52.0	89.5	40.0	10.0	8.0	22.0	27.0	30.0	18.0	7.0
54	5	2.0	69.0	6.2	55.0	2.0	55.0	102.0	48.5	84.5	36.0	10.0	8.0	22.0	26.5	29.0	18.0	7.0
55	5	2.2	68.0	6.6	62.0	1.9	54.0	108.0	52.0	92.0	36.0	9.0	9.0	24.0	28.0	32.0	19.0	7.0
56	15	2.5	91.0	8.0	94.0	1.5	57.0	93.0	50.0	80.0	26.0	9.0	9.0	21.0	24.5	28.0	17.0	9.0
57	15	2.6	86.0	8.0	74.0	1.8	57.0	74.0	45.5	63.0	35.0	10.0	9.0	21.0	26.0	30.0	19.0	8.0
58	7	1.5	48.6	5.9	49.9	1.6	50.9	68.5	44.4	57.3	30.1	9.4	9.9	23.6	27.9	30.7	18.2	8.8
59	2	1.8	59.5	7.4	56.0	1.9	57.0	66.0	36.0	50.0	33.0	6.0	9.0	17.0	24.0	30.0	16.0	7.0
60	3	1.6	47.0	5.5	51.0	1.6	52.5	82.0	45.0	71.0	33.0	9.0	10.0	24.0	31.0	34.0	20.0	9.0

Table 2 (continued). Average morphometric values of the populations considered.

Pop. Number	n of female	Body length (mm)	a	b	c	c'	V	Lengths (μm)					Diameters (μm)					
								ods*	odp*	grto*	tail	tjp*	lip	bgr*	oes*	vulva	anus	tjp*
61	20	1.6	45.1	5.4	43.7	1.6	51.9	74.8	44.2	62.0	36.9	11.2	9.4	25.1	30.4	32.6	22.6	9.6
62	10	2.0	67.0	6.8	74.0	1.6	59.0	77.0	45.0	70.0	27.0	9.0	8.0	20.0	26.0	30.0	17.0	7.0
63	12	2.1	70.9	7.2	67.0	1.7	56.0	84.8	46.7	73.3	31.5	8.0	8.7	21.4	26.3	29.9	18.0	7.5
64	10	1.8	59.0	6.5	63.0	1.6	56.0	84.0	47.0	73.0	29.0	9.0	9.0	23.0	29.0	32.0	18.0	8.0
65	9	1.7	58.0	7.6	57.0	1.6	57.0	86.0	44.0	72.0	30.0	10.0	9.0	22.0	27.0	30.0	18.0	9.0
66	10	2.0	57.0	7.0	61.0	1.7	55.0	88.0	46.0	74.0	33.0	9.0	8.0	23.0	30.0	35.0	20.0	7.5
67	5	2.1	71.0	6.4	63.0	2.0	53.0	84.0	48.0	70.0	33.0	10.0	9.0	21.0	26.0	29.0	17.0	8.0
68	5	1.9	66.0	6.0	60.0	1.7	56.0	88.0	49.0	79.0	32.0	9.0	9.0	21.0	26.0	29.0	18.0	8.0
69	5	1.9	64.0	6.6	63.0	1.8	56.0	86.0	48.0	73.0	30.0	12.0	8.0	21.0	26.0	30.0	17.0	9.0
70	10	1.9	72.0	7.2	65.6	1.9	55.0	80.2	42.5	71.8	29.9	7.2	8.4	19.7	23.0	27.0	15.5	6.2
71	6	1.6	54.0	6.8	55.0	1.6	54.0	81.0	47.0	64.0	29.0	9.0	8.0	21.0	27.0	30.0	18.0	8.0
72	10	1.7	62.0	6.7	62.0	1.7	57.0	82.0	47.0	71.0	27.0	10.0	8.0	21.0	25.0	28.0	16.0	8.0
73	5	2.4	72.0	7.4	79.5	1.4	60.0	80.0	48.0	68.0	30.0	11.0	9.0	22.0	29.0	33.0	21.0	11.0
74	5	2.1	76.0	6.8	79.0	1.6	61.0	79.0	43.0	64.0	26.0	8.0	8.0	19.0	23.0	27.0	17.0	8.0
75	4	2.4	63.0	7.1	70.0	1.5	59.5	91.0	49.0	76.5	35.0	11.0	10.0	25.0	32.0	39.0	24.0	11.0
76	5	2.4	75.0	8.3	83.0	1.5	55.0	77.0	48.0	66.0	29.0	9.0	9.0	21.0	27.0	32.0	19.0	9.0
77	10	1.5	37.7	6.4	51.8	1.2	51.1	66.5	45.6	56.5	28.9	11.3	10.9	27.1	32.0	39.9	23.2	11.1
78	27	2.1	49.6	6.1	60.5	1.1	52.0	103.5	56.7	79.6	36.1	9.0	14.6	31.7	40.1	43.4	32.4	7.0
79	11	1.6	49.1	5.8	66.2	1.2	53.0	93.0	49.0	76.0	24.5	5.0	10.0	25.0	28.0	33.0	25.5	10.0
80	10	1.7	49.0	6.7	56.0	1.4	52.0	88.0	49.0	72.0	30.0	8.0	10.0	26.0	29.0	33.0	21.0	9.0
81	3	1.9	44.3	5.8	92.6	0.8	54.5	111.0	56.5	88.0	20.5	8.5	11.0	30.5	37.0	43.0	27.0	17.5
82	5	2.0	53.0	7.0	61.0	1.5	52.0	91.0	50.0	73.0	33.0	9.0	9.0	26.5	34.0	37.0	22.5	12.0
83	3	2.1	55.0	6.8	61.0	1.4	52.0	96.0	52.0	77.0	35.0	9.0	10.0	28.0	35.0	39.0	25.0	13.0
84	8	1.7	41.0	6.4	51.0	1.4	52.0	84.0	51.0	74.0	34.0	7.0	10.0	28.0	37.0	42.0	25.0	11.0
85	3	1.9	45.0	6.6	59.0	1.3	52.0	85.0	48.0	74.0	33.0	6.5	10.0	27.0	37.0	43.0	24.0	12.0
86	20	1.8	54.0	6.0	54.0	1.7	51.0	83.0	50.0	67.0	34.0	10.0	10.0	25.0	32.0	35.0	20.0	9.8
87	5	1.7	45.0	6.0	56.0	1.5	51.0	81.0	48.0	63.0	31.0	11.0	10.0	25.0	34.5	38.5	20.0	11.0
88	5	1.8	47.0	5.9	58.0	1.4	50.0	80.0	50.0	64.0	31.0	10.0	11.0	26.0	34.0	38.0	21.0	11.0
89	5	1.9	44.0	6.4	54.0	1.5	49.0	86.5	50.0	66.0	35.0	8.0	11.0	29.0	37.0	43.0	23.0	10.0

Table 2 (continued). Average morphometric values of the populations considered.

Pop. Number	n of female	Body length (mm)	a	b	c	c'	V	Lengths (μm)					Diameters (μm)					
								ods*	odp*	grto*	tail	tjp*	lip	bgr*	oes*	vulva	anus	tjp*
90	22	1.9	51.0	6.5	53.0	1.6	52.0	82.0	47.0	68.0	35.0	9.0	11.0	26.0	33.0	37.0	22.0	9.5
91	4	1.8	40.0	5.2	68.0	0.7	55.0	107.0	58.0	94.0	24.0	10.0	11.0	31.0	40.0	44.0	32.0	16.0
92	5	1.7	41.0	5.7	60.0	0.9	53.0	100.0	55.0	84.0	26.0	10.0	11.0	31.0	39.0	42.0	29.0	15.0
93	9	1.9	71.0	7.2	67.0	1.7	53.0	66.0	39.0	51.0	29.0	7.0	9.0	18.0	24.0	27.0	17.0	8.0
94	20	2.1	78.3	7.1	74.6	1.6	54.7	66.0	42.0	60.7	28.8	6.1	9.4	19.5	24.5	27.4	17.6	7.8
95	6	2.2	75.7	7.0	75.7	1.6	55.4	65.6	42.5	60.4	29.6	5.8	9.5	19.6	25.9	29.8	18.6	7.4
96	15	1.9	69.5	6.2	63.8	1.7	56.2	66.3	42.9	60.8	29.2	6.3	9.2	19.0	23.8	26.8	17.3	8.3
97	10	2.4	77.3	8.2	74.0	1.8	54.0	69.4	43.5	60.8	33.1	6.2	9.6	19.6	24.7	31.3	18.3	7.6
98	10	2.4	86.9	7.6	82.4	1.7	54.0	69.4	44.7	62.5	29.6	5.5	9.5	18.9	24.3	27.9	17.3	7.7
99	20	2.3	77.0	7.9	72.0	1.7	55.0	68.0	43.0	60.0	32.0	7.0	8.0	20.0	25.0	30.0	19.0	7.0
100	20	2.3	78.0	7.2	76.0	1.6	56.0	72.0	42.0	62.0	28.0	7.0	8.0	19.0	25.0	29.0	18.0	8.0
101	5	1.3	38.0	5.7	40.0	1.6	54.0	81.0	45.0	62.0	33.0	13.0	12.0	29.0	33.0	36.0	21.0	8.0
102	15	2.3	50.7	7.1	83.0	0.9	49.7	94.0	58.5	78.5	27.7	10.3	13.8	32.1	39.9	45.1	30.4	19.5
103	10	2.4	46.0	7.3	87.0	0.9	50.0	91.0	56.0	77.0	26.0	12.0	14.0	32.0	40.0	49.0	30.0	21.0
104	9	2.0	44.0	6.7	82.0	0.9	50.0	94.0	53.0	68.0	25.0	11.0	12.0	29.0	40.0	46.0	28.0	19.0
105	11	2.0	44.4	6.4	73.1	1.0	49.0	87.3	56.3	73.2	27.1	8.7	13.0	29.8	39.9	45.6	27.3	14.8
106	4	2.1	57.0	6.4	85.0	0.9	52.0	93.0	53.0	75.0	24.0	9.0	12.0	28.0	34.0	37.0	26.0	16.0
107	7	2.3	51.6	6.9	86.8	0.9	50.0	92.2	58.4	78.3	26.8	8.2	13.6	30.0	37.9	41.9	29.6	15.9
108	10	2.1	44.0	7.2	78.0	0.9	50.0	93.0	57.0	80.0	27.0	8.0	13.0	30.0	38.0	47.0	29.0	15.0
109	14	2.4	52.0	7.0	86.0	0.8	51.0	93.0	55.0	72.0	28.0	11.0	13.0	32.0	42.0	49.0	31.0	17.0
110	23	2.0	45.9	6.6	72.6	1.0	49.0	88.8	55.0	79.8	28.2	8.6	12.8	30.4	38.7	44.5	29.2	15.8
111	13	2.1	47.0	6.1	84.3	0.8	52.5	92.9	55.6	81.0	24.6	8.1	13.7	31.9	39.5	44.1	30.1	18.0
112	5	1.8	46.0	7.3	61.0	1.5	51.0	76.0	45.0	60.0	29.0	8.0	9.0	23.0	33.0	38.0	22.0	8.0
113	5	2.0	54.0	7.3	66.0	1.3	51.0	79.0	49.0	64.0	31.0	6.0	11.0	25.0	33.0	38.0	24.0	10.0
114	5	1.9	47.0	6.2	62.0	1.3	52.0	85.0	52.0	73.0	32.0	6.0	11.0	26.0	35.0	41.0	24.0	10.0
115	10	2.1	47.0	6.6	71.0	1.3	50.0	85.0	53.0	71.0	29.0	7.0	11.0	27.0	39.0	44.0	23.0	9.0
116	6	1.9	47.0	6.2	62.0	1.3	52.0	85.0	52.0	73.0	32.0	6.0	11.0	26.0	35.0	41.0	24.0	10.0
117	5	1.7	53.1	6.0	60.0	1.3	53.0	82.5	44.6	71.8	29.1	7.0	9.7	25.1	30.4	32.6	21.9	10.0
118	7	2.1	63.0	6.7	6.4	1.4	54.0	93.0	49.0	81.0	33.0	5.0	11.0	24.0	29.0	34.0	23.0	8.0

ods* odontostyle; odp* odontophore; grto* guiding ring to oral aperture; tjp* tail hyaline portion; bgr* basal guide ring; oes* oesophagus.

Table 3. Populations (code, species, country from which they were collected) included in Cluster 1. Paratypes are in bold.

- 17. *X. brevisicum*, Portugal**
- 16. *X. brevisicum*, Portugal
- 15. *X. brevisicum*, Portugal

Table 4. Populations (code, species, country from which they were collected) included in Cluster 2. Paratypes are in bold.

5 Subgroups				
a	b	c	d	e
78 <i>X. paramonovi</i> , Russia	38 <i>X. himalayense</i>, India	22 <i>X. diffusum</i> , France, La Reunion	91 <i>X. sheri</i> , Thailand 92 <i>X. sheri</i> , Thailand	102 <i>X. taylori</i> , Italy 103 <i>X. taylori</i> , Italy 109 <i>X. taylori</i> , Poland 111 <i>X. taylori</i> , Serbia 106 <i>X. taylori</i> , Slovakia 108 <i>X. taylori</i> , Hungary 107 <i>X. taylori</i> , Slovakia 110 <i>X. taylori</i> , Croatia 104 <i>X. taylori</i> , Bulgaria 105 <i>X. taylori</i> , Bulgaria
37 <i>X. georgianum</i> , Georgia			81 <i>X. pseudoguirani</i> , Madagascar 13 <i>X. brevicolle</i> , Brazil 14 <i>X. brevicolle</i> , Brazil ^a	41 <i>X. incognitum</i> , Japan 43 <i>X. incognitum</i> , South Africa 24 <i>X. diffusum</i> , Israel 23 <i>X. diffusum</i> , Easter Isl. Chile 28 <i>X. diffusum</i> , Madeira, Portugal 27 <i>X. diffusum</i> , Portugal 25 <i>X. diffusum</i> , South Africa

^a topotypes

Table 5. Populations (code, species, country from which they were collected) included in Cluster 3. Paratypes are in bold.

7 Subgroups						
a	b	c	d	e	f	g
3 <i>X. americanum</i> Virginia	101 <i>X. tarjanense</i> , Florida	77 <i>X. pakistanense</i> Pakistan	6 <i>X. americanum</i> , Rhode Island 8 <i>X. americanum</i> , Louisiana 10 <i>X. americanum</i> , South Africa 2 <i>X. americanum</i> ^a , Virginia 7 <i>X. americanum</i> , Canada 4 <i>X. americanum</i> , Maryland 5 <i>X. americanum</i> , Maryland 9 <i>X. americanum</i> , Maryland 12 <i>X. americanum</i> , South Carolina 11 <i>X. americanum</i> , South Africa 58 <i>X. minor</i> , India 60 <i>X. oxycaudatum</i> , Nigeria 61 <i>X. oxycaudatum</i> , Pakistan 44 <i>X. intermedium</i> , Florida 45 <i>X. intermedium</i> , Pakistan 86 <i>X. santos</i> , Portugal 89 <i>X. santos</i> , Azores, Portugal 87 <i>X. santos</i> , Portugal 90 <i>X. santos</i> , Egypt	118 <i>X. utahense</i> , Utah 113 <i>X. thornei</i> , Colorado 116 <i>X. thornei</i> , Idaho 112 <i>X. tenuicutis</i> , Tennessee 18 <i>X. californicum</i> , California 19 <i>X. californicum</i> , California 20 <i>X. californicum</i> , Mexico 80 <i>X. peruvianum</i> , Peru	34 <i>X. floridiae</i> , Florida 35 <i>X. floridiae</i> , Florida 42 <i>X. incognitum</i> , Egypt 114 <i>X. thornei</i> , Colorado 115 <i>X. thornei</i> , Colorado 88 <i>X. santos</i> , Madeira, Portugal 85 <i>X. rivesi</i> , Nebraska 84 <i>X. rivesi</i> , Kansas 83 <i>X. rivesi</i> , Portugal 82 <i>X. rivesi</i> , Portugal 48 <i>X. luci</i> , Senegal	79 <i>X. parvum</i> , Jamaica 117 <i>X. thornei</i> , Pakistan 26 <i>X. diffusum</i> , Florida

^a topotypes.

Table 6. Populations (code, species, country from which they were collected) included in Cluster 4. Paratypes are in bold.

7 Subgroups						
a	b	c	d	e	f	g
49 <i>X. madeirensis</i> Madeira, Portugal	36 <i>X. fortuitum</i> , Italy	29 <i>X. duriense</i> , Portugal	56 <i>X. mesostilum</i> , Portugal	75 <i>X. pachydermum</i> , Portugal	93 <i>X. simile</i> , Bulgaria	74 <i>X. pachydermum</i> , Portugal
50 <i>X.madeirensis</i> , Portugal		30 <i>X. duriense</i> , Portugal		73 <i>X. pachydermum</i> , Portugal	96 <i>X. simile</i> , Montenegro	62 <i>X. pachtaicum</i> , Italy
51 <i>X. .madeirensis</i> , Portugal	47 <i>X. longistilum</i> , Portugal	31 <i>X. duriense</i> , Portugal			97 <i>X. simile</i> , Slovakia	70 <i>X.pachtaicum</i> , Slovakia
53 <i>X. .madeirensis</i> , Portugal		32 <i>X. duriense</i> , Portugal			98 <i>X. simile</i> , Slovakia	63 <i>X. pachtaicum</i> , Bulgaria
52 <i>X. .madeirensis</i> , Azores, Portugal		33 <i>X. duriense</i> , Portugal			99 <i>X. simile</i> , Slovakia	65 <i>X. pachtaicum</i> , France
54 <i>X. .madeirensis</i> , Portugal					100 <i>X. simile</i> , Slovakia	64 <i>X. pachtaicum</i> , Crete, Greece
55 <i>X. .madeirensis</i> , Portugal					94 <i>X. simile</i> , Serbia	72 <i>X. pachtaicum</i> , Turkey
					95 <i>X. simile</i> , Serbia	71 <i>X. pachtaicum</i> , Spain
					59 <i>X. opisthoysterum</i> , India	66 <i>X. pachtaicum</i> , Morocco
						69 <i>X. pachtaicum</i> , Azores, Portugal
						68 <i>X. pachtaicum</i> , Madeira, Portugal
						67 <i>X. pachtaicum</i> , Portugal
						39 <i>X. incertum</i> , Bulgaria
						40 <i>X. incertum</i> , Croatia

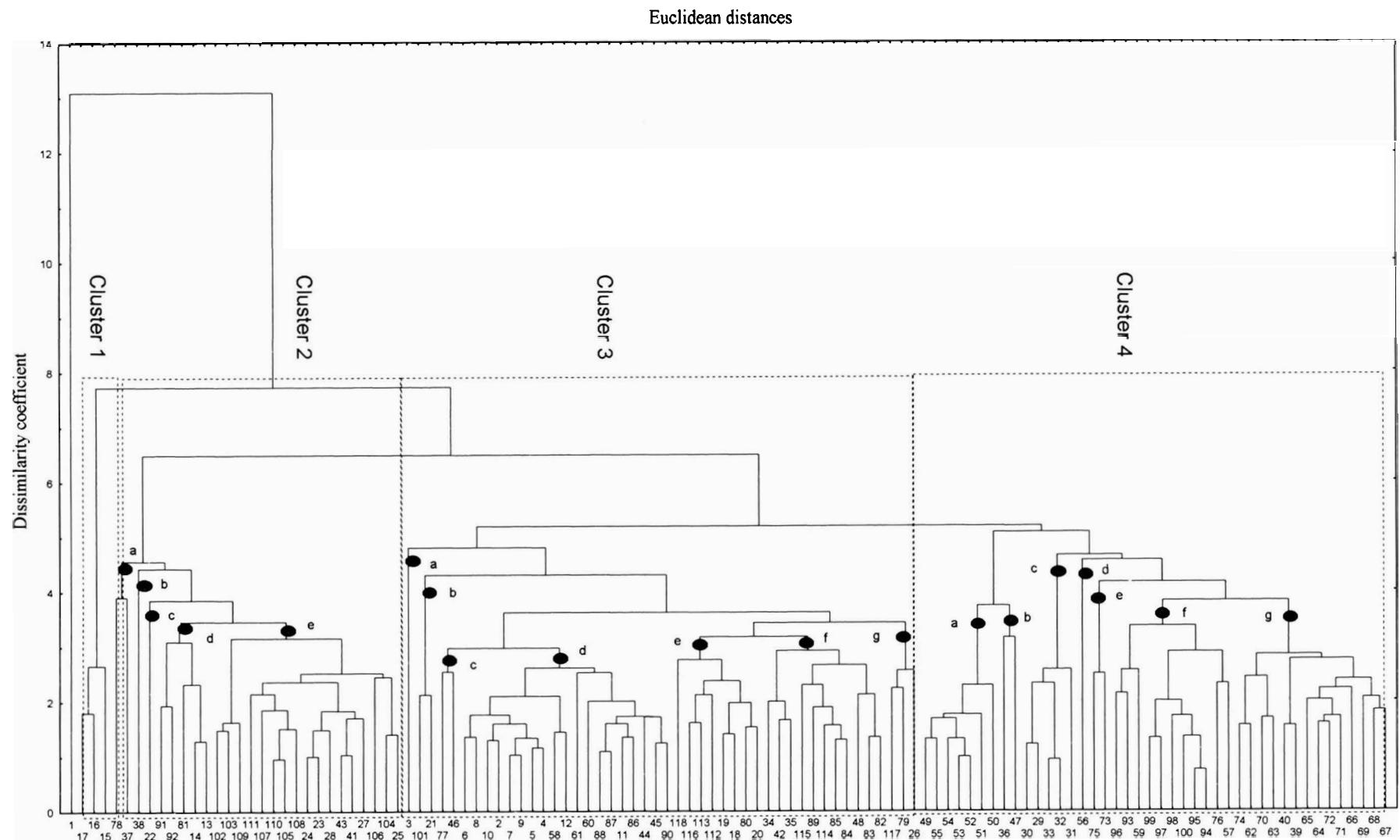


Fig. 1. Vertical Hierarchical Tree Plot with 117 populations belonging to *Xiphinema americanum*-group clustered and compared with an Italian population of *X. index*. Euclidean distances are plotted against linkage distance expressed as dissimilarity coefficients. The major population clusters, and their constituent sub-clusters, are indicated by numbers and letters, respectively.

three clusters and may be considered to be outside the *X. americanum* complex (Luc *et al.*, 1998).

Cluster 2 comprises 26 populations attributed to nine putative species, and these populations form five sub-clusters. The type populations of *X. diffusum* and *X. incognitum* are in this cluster. Although *X. diffusum* is the most geographically diverse species of the *X. americanum* complex (Lamberti *et al.*, 2000), five populations coming from very different parts of the world fell into the same sub-cluster of cluster 2, and are only slightly separated from the type population from France. Single populations of *X. diffusum* and *X. incognitum* (USA and Egypt, respectively) are rather distant from the type populations and are placed in cluster 3. Identification of such populations that appear to be outgroups from the majority of the populations representing the species requires confirmation.

Forty-six populations comprise cluster 3, representing 17 putative species, and form seven sub-clusters. The occurrence of one population each of *X. diffusum* and *X. incognitum* has been discussed above. In cluster 3, there is an obvious marked separation of *X. americanum* s.s. (topotypes from Virginia) from ten other populations of *X. americanum*. Four populations of *X. santos* from the Azores, Portugal and Egypt are included in sub-cluster 3d, whereas a population from Madeira is placed in sub-cluster 3e. Four North American populations of *X. thornei* are placed in sub-clusters 3e-f, whereas a population from Pakistan is placed in sub-cluster 3g, and these specimens, especially those from Pakistan, require their identification to be confirmed.

Forty-two populations, attributed to eleven putative species, comprise cluster 4, which is divided into seven sub-clusters. Each sub-cluster shows substantial homogeneity, most being comprised of a single, or very similar, species. The only exception is the wide distribution of the four populations of *X. pachydermum* examined in this study, which are distributed in three different, but neighbouring, sub-clusters (4e, 4f, 4g).

The results from the hierarchical cluster analysis indicates that most of the species attributed to the *X. americanum*-group are morphometrically well defined, and show a variability that can be considered as representing intra-specific variation. Nevertheless, some populations show major deviation from the type population, and this may represent environmental effects of the geographical origin on the phenotype or, more probably, incorrect measurements and erroneous identification.

Recently, Luc *et al.* (1998) proposed the junior

synonymy of *X. diffusum*, *X. incognitum*, *X. parvum*, *X. pseudoguirani*, *X. sheri* and *X. taylori* with *X. brevicolle*. Except for *X. parvum*, which is represented by a single population, all of the above-mentioned species are placed in cluster 2. A single population of *X. diffusum*, and of *X. incognitum*, are present in the same cluster as *X. parvum*, consequently, some of the hypotheses proposed by Luc *et al.* (1998) may have validity, but require rigorous testing. The most appropriate approach to validate such hypotheses is through application of biomolecular methods that provide an objective means, as distinct from the more subjective morphological approaches, to clarify such taxonomic problems.

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Lamberti F., Molinari S., Moens M., Brown D.J.F. Группа видов *Xiphinema americanum*. Взаимоотношения между видами на основе морфометрии.

Резюме. Иерархический кластерный анализ, основанный на морфометрических данных по 117 популяциям, включающим, в том числе, представителей 39 предполагаемых видов, подразделяет группу видов *Xiphinema americanum* на четыре кластера. Первый кластер состоит из трех популяций, определенных как *X. brevisicum*; второй кластер состоит из пяти подгрупп популяций, а кластеры 3 и 4 включают по семь подгрупп. При совместном анализе нескольких популяций, отнесенных к неописанным новым видам, они обычно попадали в одну группу. Четыре популяции, идентифицированные как *X. pachydermum*, попали в три различных подгруппы четвертого кластера, что указывает на высокую морфометрическую вариабельность этого вида.