Cluster Analysis of *Longidorus* Species (Nematoda: Longidoridae), a New Approach in Species Identification¹

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Abstract: Hierarchical cluster analysis based on female morphometric character means including body length, distance from vulva opening to anterior end, head width, odontostyle length, esophagus length, body width, tail length, and tail width were used to examine the morphometric relationships and create dendrograms for (i) 62 populations belonging to 9 *Longidorus* species from Arkansas, (ii) 137 published *Longidorus* species, and (iii) 137 published *Longidorus* species plus 86 populations of 16 *Longidorus* species from Arkansas and various other locations by using JMP 4.02 software (SAS Institute, Cary, NC). Cluster analysis dendograms visually illustrated the grouping and morphometric relationships of the species and populations. It provided a computerized statistical approach to assist by helping to identify and distinguish species, by indicating morphometric relationships among species, and by assisting with new species diagnosis. The preliminary species identification can be accomplished by running cluster analysis for unknown species together with the data matrix of known published *Longidorus* species.

Key words: hierarchical cluster analysis, identification, Longidorus, morphometrics.

The first Longidorus species, L. elongatus de Man, was described in 1876. The genus now includes 139 nominal species. These nematodes are ectoparasites of many crops and are widely distributed throughout the world. Some are important vectors of nepoviruses, and their association is species specific (Taylor and Brown, 1997). Therefore, correct identification of Longidorus species is economically important. Currently, species discrimination in *Longidorus* is based primarily on morphometrics. A high degree of variability within morphometrics leads to considerable overlap among species and increases the potential for mis-identification. Some nematologists have expressed doubts on the necessity and nominality of some proposed species, in the absence of other data other than that based on morphometrics (McHenry, 1987; Thorne, 1961).

Lamberti (1975) published a dichotomous key to the species of Longidorus that is considered outdated and difficult to update to include new species descriptions. Rey et al. (1988) proposed a computer method for identifying Longidorus species; however, no subsequent paper has used their approach. Identifying species by means of a polytomous key permits a range of characters to be used simultaneously, which makes it more effective for identifying closely related species with overlapping features. Romanenko (1978) published such a polytomous key for identifying Longidorus species, and it was revised by Chen et al. (1997) and Loof and Chen (1999). More recently, computer software was developed to aid the species identification in Longidorus (Tiefenbrunner et al., 2002). Unfortunately, in practice, the usefulness of keys in the identification of Longidorus species is limited due to high intraspecific

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variability and minor interspecific differences that result in great overlap of morphometrics. Moreover, none of the above methods lead directly to species identification.

Taxonomists who wish to use numerical methods in the study of similarities and differences among organisms and for the construction of classifications now have a variety of methods of measuring similarity and analyzing matrices of similarity values. A number of statistical techniques have been employed including factor analysis, principal component analysis, and multiple regression analysis. But more recently the problem has been addressed with some success by cluster analysis techniques (Roca, 1996; Rubtsova et al., 1999). Such techniques are generally used for the grouping of objects or individuals under investigation. Ideal data for such analysis would yield clusters so obvious that they could be picked out, at least in small-scale cases, without the need for complicated mathematical techniques. A dendrogram generated by cluster analysis may simply represent a convenient method for organizing a large data set so that it can be more easily understood and information can be retrieved more efficiently. If the data can nominally be summarized by a small number of groups of objects, then group labels may provide a concise description of patterns of similarities and differences in the data. They may be used to search for natural groupings in the data, to simplify the description of a large set of data, and to generate hypotheses to be tested on future samples. The need to summarize data sets in this way is becoming increasingly important because of the growing number of nematode species being described.

Lamberti and Ciancio (1993, 1994) used principal components and hierarchical cluster analysis to separate 49 populations of the *Xiphinema americanum*-group into five groups but were not successful in simplifying species identification. Lamberti et al. (2002) used hierarchical cluster analysis for 117 populations representing 39 putative species in *Xiphinema americanum*-group into four groups. Cho and Robbins (1991) studied mor-

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phological variation among 23 X. americanum-group populations by canonical discriminant analysis and three groups were detected, but clear distinction between total populations within and between the groups could not be made because of overlap. Griesbach and Maggenti (1990) proposed X. californicum as a junior synonym of X. americanum Cobb, 1913 based on descriptive statistics and a stepwise discriminant analysis. Brown et al. (1997) examined the morphometric variability between populations of L. vineacola and morphologically related species by canonical analysis using five morphometric characters. The clusters formed were proven to be a reliable means for distinguishing members of the L. vineacola complex of morphologically similar species. In the above study, L. apuloides was regarded as a junior synonym of L. vineacola. Cluster analysis was also used in new species description to compare the new species with other closely related species, for example L. apuloides (Roca, 1996) and L. artemisiae (Rubtsova et al., 1999). Bravo and Roca (1998) used multivariate analysis including principal component analysis and hierachical cluster analysis to separate the four juvenile stages of L. vinearum and L. belloi from Portugal. However, none of the previous studies have attempted to examine the relationships of all the species in either Longidorus or Xiphinema.

The objectives of this study were to investigate the morphometric relationships by generating dendrograms for (i) the *Longidorus* species occurring in Arkansas, (ii) the 137 published *Longidorus* species, (iii) the published *Longidorus* species plus 86 populations of 16 *Longidorus* species from Arkansas and various other locations, and (iv) to assess hierachical cluster analysis usefulness as a *Longidorus* species identification tool.

MATERIALS AND METHODS

Arkansas nematode samples and measurements: Arkansas nematode specimens were obtained from several different sources. Most of them were collected from sandy soil around hardwood trees growing on Arkansas stream banks from 1999 to 2001. The others were from either the junior author's slide collection or from various other Arkansas locations (Ye and Robbins, 2003a, 2003b, 2004). Specimens were examined using a Nikon Optiphot II compound microscope with Nomarski differential interference contrast. Measurements were made using a Nikon drawing tube or an ocular scale and micrometer. All measurements are in micrometers and processed using Excel (Ye, 1996).

Hierarchical cluster analysis: For each population, nine characters were used in cluster analysis, e.g., body length (L), distance of vulva from the anterior end (VL), lip width, odontostyle length, distance of guide ring from anterior end (DGR), esophagus length, body width, tail length, and anal body width (ABW). These nine characters covered most of the morphological fea-

tures of the species but did not cover aspects of head shape, amphid shape, tail shape, and the presence or absence of males. Since a single value for each population of a data matrix is required for cluster analysis, the mean of the values measured was adopted as the most satisfactory entry. Hierarchical cluster analysis was performed using Average method with the JMP 4.02 program (SAS Institute Inc., Cary, NC). Table 1 lists the species, study population number, associated plants, locations, and measurements. Table 2 lists the measurements and authority of all the published Longidorus species and, for ease of reading, species authority's are not cited in the following text. Authority references are omitted in the literature cited to save space as they are readily available in the polytomous keys of Chen et al. (1997) and Loof and Chen (1999). Morphometric values were obtained from paratype means or the holotype of the original species descriptions. The lectotype of L. crassus (Robbins and Brown, 1995) was used instead of the data from the brief description by Thorne (1974). Because of insufficient data, L. heynsi and L. tardicauda were not included in this study. The similarity level of the species is determined by the distance of the horizontal line in the dendrogram, but no numerical similarity level is provided by JMP software. The graph at the bottom of each dendrogram indicates that the distance of the horizontal line is proportional to the increasing rate of the curve from left to right.

RESULTS

Arkansas Longidorus species: Hierachical cluster analysis generated eight groups (Fig. 1) in the 68 populations (Table 1). The groups are as follows: Group 1, 9 populations of *L. biformis* and 1 population of *L. crassus;* Group 2, 1 population of *L. crassus*, 1 population of *L. glycines*, and 3 populations of *L. grandis;* Group 3, 5 populations of *L. paravineacola* and 2 populations of *L. crassus;* Group 5, 19 populations of *L. crassus;* Group 6, 4 populations of *L. fragilis;* Group 7, 14 populations of *L. paralongicaudatus;* and Group 8, 3 populations of *L. diadecturus.* Populations from the same species are grouped together by cluster analysis, except for populations of *L. crassus* found in 3 different clusters.

All 137 published Longidorus species: Hierarchical cluster analysis of 137 published Longidorus species in Table 2 grouped the species according to morphometric similarity (Fig. 2). For example: L. diadecturus, L. himalayensis, L. jonesi, L. fursti, L. macromucronatus, L. jagerae, L. martini, L. mobae, L. doonensis, L. fangi, L. naganensis, L. laricis, and L. litchi, all with posteriorly located guide ring and many other similar features, were grouped together. Two New Zealand species also with posterior guide ring position, L. orongorongensis and L. waikouaitii, are in a separate cluster due primarily to their dissimilar bodies (Table 2). Some species with a high degree

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Species	Population number	u	г	٨٢	Lip width	Odontostyle	DGR	Esophagus	Body width	Tail length	ABW	Associated plant	Locality
L biformis	Long-4	25	6,276	2,984	23.8	103.3	33.0	443.5	54.6	56.0	39.6	Elm, hackberry, maple,	Middle Fork of White River, near
L. biformis	Long-76	9	7,455	3,403	23.7	107.2	31.2	434.2	51.2	54.3	37.3	snrub Birch, sweet gum,	Elkins, wasnington County South Fork of Little Red River,
L. biformis	Long-105	x	6,515	3,026	22.9	103.6	31.5	346.9	48.4	63.9	35.0	sycamore Elm, hackberry	Cunton, van Buren County Crooked Creek, Yellville, Marion
L. biformis	Long-131	9	7,628	3,755	23.3	108.2	32.2	388.3	52.3	60.5	38.5	Grape, oak	County County Road 62 Bridge, Illinois
L. biformis	Long-133	60	7.127	3.453	22.3	108.3	30.7	398.3	46.0	56.3	37.7	Box elder. cottonwood.	River, Washington County War Eagle Mill. near Rogers.
	001 Q	5		2								locust, maple	Benton County
L. biformis	Long-136	œ	5,901	2,840	20.6	100.8	32.8	378.3	44.3	56.9	33.9	Box elder, hackberry,	Little Missouri River by Highway
L. biformis	Long-149	7	7,324	3,544	24.0	107.9	35.1	381.4	54.0	60.9	38.7	Elm, Osage orange, syca-	Dage Creek, Highway 412,
L. biformis	Long-158	10	7,333	3,467	23.9	113.5	34.2	452.0	55.8	55.3	41.3	more, willow Birch, black cherry, river	Carrol County Big Piney Creek Access Area,
\$)											cane	Highway 164, Pope County
L. biformis	Long-264	0	6,303	2,917	22.0	104.3	30.3	353.3	42.0	62.0	34.7	Birch, black walnut, hickory, maple, syca-	Frog Bayou, Highway 162, south of Alma, Crawford County
L. breviannulatus	Long-66	20	4,798	2,332	17.4	82.1	25.6	348.8	41.4	36.7	29.1	more, use or neaven Amorpha sp.	Beulah near Des Arc, Prairie
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T. DIEDIMINIUM	rong-oa	n	000,0	010,7	C.01	C.CO	70.7	C.062	1.11	1.1.1	0.16	Dettrigrass	Vista, Benton County
L. breviannulatus	Long-116	12	5,045	2,323	19.5	87.6	27.4	336.0	48.5	36.3	34.9	Black cherry, box elder, cottonwood, maple,	War Eagle Mill, near Rogers, Benton County
												sycamore, willow	
L. breviannulatus	Long-124	10	5,149	2,568	19.2	82.5	25.1	338.0	45.4	37.6	32.6	Elm, persimmon, willow	Arkansas River, Haroldton Access. Van Buren.
													Crawford County
L. breviannulatus	Long-140 Long-156	6 u	4,812 5 790	2,293 9 090	17.0 90 c	79.8	24.1 20 E	268.0 990 0	40.0	36.0 35 o	27.7 97 c	Cottonwood	Toad Suck Park, Perry County
L. Dreviannuaus	nci-guot	0.7	001,0	7,070	C: 07	94.0	C.DC	0.000	40.0	0.00	C.1C	рисп, ѕweet gum	Clinton, Van Buren County
L. crassus	Long-10	35	6,929	3,573	20.2	87.1	26.3	374.7	54.4	40.1	36.8	Soybean	Kibler, Arnolds farm, Crawford
L. crassus	Long-12	19	4,630	2,264	17.5	97.6	27.6	359.1	54.3	35.3	37.2	Japanese holly	County Little Rock, Pulaski County
L. crassus	Long-13	9	4,628	2, 226	18.8	104.1	26.7	334.3	49.9	40.2	35.9	Centipide grass	Lowe Lawn, Texarkana, Miller
L. crassus	Long-14	6	4,434	2,176	18.6	103.4	25.5	399.1	47.7	34.2	32.4	St. Augustine grass	Lowe Lawn, Texarkana, Miller
		-	0011	00000	1 0 7	0.001		0.000	0	000	1 00		County County
L. crassus L. crassus	Long-40 Long-42	1 4	4,180 4,405	2,002 2,243	19.5 17.5	103.2 99.5	21.4 24.8	229.5 290.5	51.4	37.5	33.1 38.0	water oak Grass	booneville, Logan County Rebsaman Golf Course, Little
snssbar 1	I onœ-63	Ξ	5 431	9 800	10 %	107.9	7 68	495.8	67 3	36.4	46.8	Wisteria	Rock, Faulkner County Beaver I ake Dam Fureka
			0,101	1,000	2.01	C. 101		0.041		1.00	0.01		Springs, Carrol County
L. crassus	Long-68	4	4,680	2,413	17.5	95.3	26.3	290.0	54.3	35.7	38.7	Centipide grass	Royce Martin Lawn, Mavern, Hot Springs County

Species	Population number	u	г	TA	Lip width	Odontostyle	DGR	Esophagus	Body width	Tail length	ABW	Associated plant	Locality
L. crassus	Long-75	3	4,033	2,083	16.7	0.66	28.3	366.7	53.3	34.3	45.0	Grass	War Memorial Golf Course, Little
I. crassns	I.on <i>o</i> -79	x	4.450	2.158	20.5	104.3	29.8	382.0	53.0	40.6	37.8	Unidentified plant	Rock, Fulaski County Ozarks, Washington County
L. crassus	Long-80	4	5.543	2.925	21.3	115.8	36.0	478.8	51.5	57.8	44.8	Unknown	Ozarks, Washington County
L. crassus	Long-84	6	4,448	2,122	19.0	102.8	27.9	407.1	55.8	36.8	36.9	Oak, Osage orange	Combs Park, Fayetteville,
)											0	Washington County
L. crassus	Long-86	00	4,113	2,000	22.0	107.0	31.0	403.3	49.0	37.3	36.7	Grape	Crowley's Ridge State Park,
		,	1			1			1				Greene County
L. crassus	Long-88	0	5,586	2,736	18.8	116.9	33.8	465.0	65.5	39.7	46.8	Cypress, elm, maple, oak	Shirey Bay—Rainey Brake
													Wildlife Management Area, Lawrence County
L. crassus	Long-90	12	3,998	1,985	17.3	100.8	26.9	317.2	46.8	37.8	34.3	Elm, maple, white oak	Wilbur Botts Access Area, St.
)												Charles, Arkansas County
L. crassus	Long-94	10	5,323	2,722	21.1	103.7	31.1	380.9	53.8	41.6	40.0	Elm, oak	Wyman Bridge, White River, Equation Weshington
													rayettevinte, washington County
L. crassus	Long-112	60	4,910	2,367	17.3	7.66	30.7	410.0	49.3	39.3	35.7	Blackberry	Bayou Meto Wildlife
													Management Area, Arkansas Countv
L. crassus	Long-115	20	4,931	2,472	19.0	107.3	31.3	418.7	58.7	38.9	42.4	Box elder, elm, grape,	Illinois River, County Road 62
)											oak, Osage orange, red bud. svcamore	Bridge, Washington County
L. crassus	Long-147	Ŋ	4.500	2.276	18.6	109.0	29.0	384.0	52.4	36.0	37.6	Box elder	Kings River, Highway 412,
	0		(-										Marble, Madison County
L. crassus	Long-157	6	4,156	1,994	21.0	106.6	28.4	352.9	54.7	36.3	35.9	Hickory	Illinois Bayou, Highway 27, Pope
L. crassus	Long-206	9	4,601	2,163	20.0	104.3	29.2	367.5	50.3	36.2	35.0	Birch, grape, river cane	Caddo River below Lake De Gray
	D											D	Hot Spring County
L. crassus	Long-214	3	3,940	1,823	20.7	103.3	26.3	409.0	49.3	34.3	35.0	Birch, black cherry, river	Big Piney Creek Access Area,
straspar 1	I ong-993	Ą	4,633	006.6	10.3	105.3	0.06	405 O	58 J	34.0	41.0	calle, wille oak Bov elder ivw	Haroldton Access Arbanses
	S11 S101		0001	001	2.21	2001	2						River, Van Buren, Crawford
I diadactations	I 01 0 101	10	9 079	1 0 3 2	16.1	118.4	64.1	о И И	107	1 00	30 K	Binch block channer how	County Sminchill Book Arkonsee Diver
L. ataaettarus	roug-171	17	0,8,0	1,000	1.01	110.1	04.1	0.000	44.1	1.07	C.0C	bitch, black cherry, box elder	Sebastian County
L. diadecturus	Long-23	25	3,942	1,802	15.3	108.2	61.4	379.2	43.2	27.5	32.6	Cottonwood, elm, Osage	Middle Fork of White River, near
												orange, sweet gum, hackberry, maple	Elkins, Washington County
L. diadecturus	Long-64	17	4,371	2,002	16.5	122.8	65.7	367.6	49.4	26.9	33.5	Osage orange	Mud Creek, Old Missouri Road, Fayetteville, Washington
	1	ļ		, , ,			- 00		0.00	1 2 1	000	-	County
L. fragus	Long-9/	11	0,111,c	2,455	12.0	91.1	1.06	515.9	6.66	0.67	20.02	Cottonwood, sycamore	Wapanocca National Wildlife
I fvamilie	1 and 197	ц	д 476 2	9 600	196	04.8	8.06	366.4	19.0	75 4	0.76	Row alder cottonwood	Refuge, Crittenden County Tood Such Dark Derry County
L. Jugues	roug-14/	n	J, 1 / U	4,030	14.0	71.0	0.67	200.4	14.0	1.0.1	71.0	box eluer, couonwoou, maple	1040 SUCK FAIS, FEILY COULTY

TABLE 1. Continued.

TABLE 1. Continued.

Species	Population number	u	Г	٨٢	Lip width	Odontostyle	DGR	Esophagus	Body width	Tail length	ABW	Associated plant	Locality
L. fragilis	Long-224	10	5,347	2,416	12.8	93.7	29.9	387.0	43.9	78.8	29.2	Grape, willow	Haroldton Access, Arkansas River, Van Buren, Crawford Connty
L. fragilis	Long-225	Ŋ	5,322	2,496	13.0	88.6	30.8	370.6	47.8	67.4	27.2	Cottonwood, sycamore	Fort Smith Park, Fort Smith, Sebastian County
L. glycines	Long-9	23	7,550	3,917	22.4	89.9	24.3	361.0	46.3	37.2	32.6	Soybean	University of Arkansas main research station, Fayetteville, Washington, County
L. grandis	Long-148	14	7,244	3,473	22.7	94.4	29.6	406.8	52.3	36.8	36.9	Elm, Osage orange, wramore willow	Osage Creek, Highway 412, Carrol County
L. grandis	Long-151	3	6,870	3,353	26.0	93.3	28.7	393.7	49.0	37.3	41.3	Elm, hackberry, red bud	Crooked Creek, Yellville, Marion
L. grandis	Long-201	11	6,575	3,178	26.5	6.06	27.5	391.0	47.5	39.2	40.3	Black cherry, river cane	County Big Piney Creek Access Area, Highway 164. Pone County
L. paralongicaudatus L. paralongicaudatus	Long-17 Long-72	27 13	3,649 3,198	1,608 1,518	$14.0 \\ 14.5$	98.4 110.0	24.9 24.8	321.8 271.0	40.8 37.5	52.2 55.1	$25.6 \\ 25.1$	Japanese holly White oak	Little Rock, Pulaski County Beaver Lake, Hickory Creek Park,
L. paralongicaudatus L. paralongicaudatus	Long-78 Long-110	4	4,160 3,233	$1,908 \\ 1,545$	15.0 15.3	123.8 111.0	28.5 26.8	348.3 332.3	42.5 38.5	51.8 63.0	$26.3 \\ 27.5$	Unidentified plant Grape	benton County Ozarks, Washington County Crowley's Ridge State Park,
L. paralongicaudatus	Long-132	60	3,853	1,783	16.3	113.0	28.3	338.3	46.0	63.3	29.0	Grape	Caddo River below Lake De Gray,
L. paralongicaudatus	Long-135	15	2,886	1,389	14.5	104.8	24.7	328.1	39.7	51.3	24.1	Ash	Hot Spring County Ouachita River, Hwy 270 Bridge, Monteomory County
L. paralongicaudatus	Long-137	26	3,620	1,700	15.7	105.0	25.5	309.9	43.3	47.2	26.8	Elm, maple, oak	Montgomery county Illinois River, County Road 62 Bridge Washington County
L. paralongicaudatus	Long-143	16	3,259	1,526	14.9	106.1	26.7	368.8	40.4	49.1	25.6	Birch, black walnut, blackberry, elm, bickory manle	Frog Bayou, Highway 162, South of Alma, Crawford County
L. paralongicaudatus	Long-153	4	3,435	1,570	15.0	108.3	25.5	287.8	43.0	53.0	26.8	Elm, oak	Des Arc Bayou, near Floyd, White County
L. paralongicaudatus	Long-155	9	3,705	1,632	15.0	108.0	27.2	368.0	43.0	51.3	27.0	Birch, oak, sweet gum,	South Fork of Little Red River, Clinton Van Rusen County
L. paralongicaudatus	Long-207	60	3,670	1,667	15.7	107.0	25.7	443.3	40.3	48.7	26.0	Hackberry, Ivy	Haroldton Access, Arkansas River, near Van Buren, Crewender County
L. paralongicaudatus	Long-208	4	3,475	1,638	15.0	103.3	27.5	341.3	41.8	46.5	25.0	Birch	East Cadron Creek, Highway 107 Bridge Faulkner County
L. paralongicaudatus	Long-210	4	3,628	1,679	13.9	108.8	27.0	351.0	47.0	48.0	27.5	Unidentified plant	Beaver Lake, Fulton's cabin, Renton County
L. paralongicaudatus L. paravineacola	Long-220 Long-108	<i>e</i> C 20	3,390 7,645	1,587 3,739	15.0 25.3	101.3 101.0	24.3 32.3	327.7 455.8	41.7 65.6	47.7 32.9	27.7 45.8	Grape, pecan Elm, Osage orange, sycamore, willow	Totad Suck Park, Perry County Osage Creek, Highway 412, Carrol County

Locality	Illinois River, County Road 62 Bridge, Washington County	Old Missouri Road, Mud Creek, Fayetteville, Washington County	South Fork of Little Red River, Clinton, Van Buren County	Middle Fork of White River, near Elkins, Washington County
Associated plant	Box elder, elm, grape, maple, oak, Osage orange, red bud, sycamore	Osage orange	Birch, sweet gum	Red bud
ABW	46.8	43.0	45.0	45.5
Tail length	38.8	36.5	37.0	36.0
Body width	65.3	61.3	63.0	64.5
Esophagus	457.3	430.3	435.0	477.5
DGR	33.9	31.0	28.4	34.5
Odontostyle	106.5	104.5	104.0	107.0
Lip width	24.2	22.8	25.0	24.5
٨L	4,164	3,705	3,630	3,960
Г	8,824	7,635	7,310	8,085
u	12	4	1	10
Population number	Long-123	Long-216	Long-154	Long-266
Species	. paravineacola	. paravineacola	. paravineacola	. paravineacola

Continued.

TABLE 1.

of similarity were: L. aetnaeus with L. juvenilis; L. conicaudoides with L. mirus; L. conicaudoides and L. mirus with L. bernardi; L. concavus with L. conicephalus; L. juveniloides with L. reneyii; L. silvae with L. uroshis; L. cretensis with L. nevesi; L. grandis with L. glycines; L. closelongatus with L. seinhorsti; L. apulus with L. dunensis; L. apulus and L. dunensis with L. euonymus; L. crassus with L. pseudoelongatus; L. iranicus with L. trapezoides; L. fasciatus with L. pauli; and L. diadecturus with L. himalayensis.

Test populations with all published Longidorus species: Hierachical cluster analysis demonstrated the grouping and morphometric relationships among 86 test populations and 137 published Longidorus species (unpubl. data). Same-species test populations grouped together with morphologically similar species, generally with the identified species. Some of the test populations of L. africanus, L. crassus, and L. breviannulatus did not group exactly with the identified species. This unpublished dendrogram also demonstrated which existing described species were closely related to our 86 test populations.

DISCUSSION

This study has evaluated cluster analysis as a method for grouping and distinguishing Longidorus species by morphometric parameters. Hierarchical cluster analysis based on average female morphometric characters, including L, VL, DGR, lip width, odontostyle length, esophagus length, body width, tail length, and tail width, generated eight clusters for 62 populations of Longidorus species from Arkansas. The populations of the same species generally grouped together and were separated from the other species. Some populations identified as L. crassus were in different clusters due to high morphometric variability of the populations. This is discussed later. Thus, species identification of Longidorus should never be based solely on cluster analysis using morphometric characters. Other features used for species identification in our study include qualitative characters like head shape, tail shape, amphid shape, presence or absence of males, male morphology, number of juvenile stages, juvenile morphology, and DNA sequencing of the ITS1 region and the 18S rDNA gene. A possible shortcoming of cluster analysis may be that qualitative characters such as head shape, tail shape, amphid shape, male presence or absence, etc. are not used in the analysis. However, these qualitative characters were useful in diagnosis and relationship elucidation of species within a cluster. It must be noted and emphasized that the cluster analysis approach is based on morphometric data; it does not reflect phylogenetic relationships as do the species defined by Adams (1998).

Choosing the correct variables is critical in discriminant analysis. In *Longidorus* species, the length of ovaries depends on the age (reproductive history) of fe-

TABLE 2. Average morphometrics of 137 published Longidorus species used for cluster analysis (all measurements in µm).

Species	L	VL	Lip width	Odontostyle	DGR	Esophagus	Body width	Tail length	ABW
<i>L. aetnaeus</i> Roca, Lamberti, Agostinelli & Vinciguerra, 1986	3.250	1.495	9	76	25	349	38	49	24
L. africanus Merny, 1966	3,490	1,571	11	88	27	401	39.2	32.9	22
L. alaskaensis Robbins & Brown, 1996	5,452	2,641	17.9	113.6	34.8	486.1	73.9	47.1	48.5
L. alvegus Roca, Pereira & Lamberti, 1989	6,300	2,993	13.1	83	26	444	34	63	28
L. ampullatus Jacobs & Heyns, 1987	2,880	1,420	13	76	25	282	29	41	19
L. apuloides Roca, 1996	8,400	4,158	15.5	119	33.5	400	55	45	44
L. apulus Lamberti & Bleve-Zacheo, 1977	6,700 8 900	3,484	15 15 5	103	31	444 201	48 20	40 25	40 29
L. artemisiae Publicova, Chizboy & Subbotin, 1000	6,290 5,000	9 801	15.5	103	24.0	391 419	39 46	35 40	32 29
L. arthensis Brown, Grunder, Hooper, Klingler & Kunz 1994	5,900	2,091	15.5	108	2 <i>5</i> 35	449	40 67	40	49
L. athesinus Lamberti, Coiro, & Agostinelli, 1991	4.900	2.499	17	90	34	430	67	42	45
L. attenatus Hooper, 1961	6,100	2,989	12	78	28	401	38.6	52	29.3
L. auratus Jacobs & Heyns, 1987	3,650	1,664	10	86	29	287	31.5	37	22
L. balticus Brzeski, Peneva & Brown, 2000	7,738	4,024	21	97	27	433	63	33	41.3
L. belloi Andres & Arias, 1988	6,700	3,551	12.6	93	31	424	71	40	54
L. belondiroides Heyns, 1966	3,800	2,071	9	95	36.5	447	63	25	50
L. bernardi Robbins & Brown, 1996	4,071	1,948	10.9	74.8	24.9	315.6	39.4	45.4	27.1
L. bijormis Ye & Robbins, 2004	0,270	2,984	23.8 18	105.5	<i>33</i> 98	443.3 981	54.0 50	56.0 88 7	39.0 81
L. brevis Swart, Cadet & N'Diave, 1996	4,755	2,220	85	65.2 49.4	23 94	201	50 44	50.7 50.5	99
L. caespiticola Hooper, 1961	6,700	3.551	18	110	37	532	93	65	65
L. camelliae Zheng, Peneva & Brown, 2000	2.740	1.315	7.8	85	33	282	46	36	30
L. carpathicus Liskova, Robbins & Brown, 1997	6,360	3,358	16.2	154	44	441	71	41	51
L. carpetanensis Arias, Andres & Navas, 1986	4,200	2,050	12.5	59	23.8	323	38	52	28.9
L. chikmagalurensis Dhanam & Jairajpuri, 1997	2,800	1,428	9	99	30	397	41	34	33
L. closelongatus Stoyanov, 1964	6,300	3,068	21	114	31.4	432	46.5	43	39
L. cohni Heyns, 1969	8,390	4,237	17	114	33	450	44	49	36
L. concavus Singh & Khan, 1996	3,600	1,764	11	95	30	434	49	29.5	29.5
L. congoensis Aboul-Eid, 1970	3,000	1,350	12.5	74	25 27 C	280	57	33	26
L. conicaudatus Khan, 1986	5,500	2,833	13.4	90	37.6	444 995	63 97	53 40	52 95
L. conicatuatiates Jacobs & Heylis, 1987	3,580 3,580	1,065	10	00 95	20 36	202 202	37 45	40 90 8	25 30
L. crassus Thorne 1974 (Lectotypes Robbins & Brown 1995)	5,500	2 640	15	110	39 5	500	40 60	25.0 35	48
L. crassus Thorne, 1974 (Lectotype, from Robbins & Brown,	6,789	3,516	17	110	29	499	64	39	44
1995)	<i>.</i>	,							
L. crataegi Roca & Bravo, 1996	7,300	3,687	16.5	104	33.5	417	90.5	47.5	58
L. cretensis Tzortzakakis, Peneva, Terzakis, Neilson & Brown,	7,650	3,901	21	140	43	588	85	48	53
2001									
L. curvatus Khan, 1986	3,250	1,560	12	90	34	322	40	53	18
L. cylindricaudatus Kozlowska & Seinhorst, 1979	5,200	2,496	12	137	34	547	47	44	34.6
L. dalmasson Peneva, Looi & Brown, 1999	7,390	3,473 1,707	21	158	30 59	490	05	45 97	41 21
L. distinctus Lemberti, Choleva & Agostinelli, 1983	3,710 4,600	2 116	10	80	30	338	44	58	30
L. doonensis Singh & Khan, 1996	3,600	1.656	12.5	120	76	461	67	28	17
L. dunensis Brinkman, Loof & Barbez, 1987	6.510	3.314	15.1	100	31.2	428	47	41.5	34.8
L. edmundsi Hunt & Siddiqi, 1977	5,460	2,681	30	104	24	417	34	27	34
L. elongatus (de Man, 1876) Thorne & Swagger, 1936	5,500	2,695	17	94	33	414	60	56	47
(Hooper, 1961)									
L. eridanicus Roca, Lamberti & Agostinelli, 1984	4,800	2,064	11	163	38	558	52	26	39
L. euonymus Mali & Hooper, 1974	6,910	3,524	14	86	30	424	45	45	35
L. fagi Peneva, Choleva & Nedelchev, 1997	5,620	2,883	12	105	37	446	59	65 97	34
L. fangi Xu & Cheng, 1991	5,090	2,647	17	130	79	530	57	37	41
L. <i>Jascialus</i> Koca & Lamberu, 1961 L. <i>fragilis</i> Thorpe, 1974 (Lectotypes Robbins & Brown, 1995)	7,700	3,342 9 548	14	96	20 30	410 389 8	44	50 64	43 98
L. Jugas Thome, 1974 (Lectotypes Robbins & Brown, 1999)	4570	2,340	14 7	104	67 5	408	38.9	97	20 97
L. globulicauda Dalmasso, 1969	5.300	2.581	12	77	31	390	53	61	34
L. glycines Ye & Robbins, 2004	7,550	3,917	22.4	89.9	24.3	361	46.3	37.2	32.6
L. goodeyi Hooper, 1961	6,700	3,484	8	101	35	453	42	50	50
L. grandis Ye & Robbins, 2004	7,244	3,473	22.7	94.4	29.6	406.8	52.3	36.8	36.9
L. hangzhouensis Zheng, Peng, Robbins & Brown, 2001	4,500	2,205	10.9	118	43	421	70	33	47
L. henanus Xu & Cheng, 1992	6,080	2,979	16	98	42	461	54	36.5	39
L. hetveticus Lamberti, Kunz, Grunder, Molinari, de Luca,	7,600	3,800	21.8	145.3	44	558.8	107	47	67.6
Agostinelli & Radicci, 2001	9 600	1.740	145	190		967	94	94	90
L. numuuyensis (Milaii, 1900) All & Hooper, 1990	5,000 5,600	1,740 9,800	14.0 11	120	97.9 39 5	307 418	34 40	24 84	52 36
2000	5,000	4,000	11	50	54.5	110	-13	54	50

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TABLE 2. Continued.

<i>i</i> . noncombas Nucleonsea & Schuces, 1979 4,200 1,960 11 91 83 459 456 46 46 <i>i</i> . immix Surchan & Barroui, 1983 5,969 3,031 12 112 35 472 48 43 <i>i</i> . immix Surchan & Barroui, 1983 4,000 2,162 85 90 32 454 40 61 31 <i>i</i> . immix Surchan & Barroui, 1983 4,000 3,000 3,000 316 11 67 341 33 22.5 21.5 <i>i</i> . impaction Surchan & Barroui, 1990 3,400 1,722 13.6 13.6 130 29.2 21 <th>Species</th> <th>L</th> <th>VL</th> <th>Lip width</th> <th>Odontostyle</th> <th>DGR</th> <th>Esophagus</th> <th>Body width</th> <th>Tail length</th> <th>ABW</th>	Species	L	VL	Lip width	Odontostyle	DGR	Esophagus	Body width	Tail length	ABW
L. indensitive Kordowska & Scienbors, 1979 4,250 1,35 112 13 29 472 48 43 44 L. industi Standa 5,090 2,031 12 35 472 58 40.66 31 L. indenti Forca, Crion, Shlevin, Bar-kyal & Brown, 1998 8,170 305 15 120 36 300 32 361 400 31 25 27 36	L. indicus Prabha, 1973	4,000	1,960	11	91	33	459	56	46	46
L. innizio Sturhan & Barconi, 1983 5,090 3,01 12 112 35 472 583 440 64 31 L. instances Penco, Orion, Shlevin, BarEyal & Broom, 1988 7,00 3,055 15 102 56 530 82 65 55 530 82 65 55 530 82 55 55 530 82 55 55 530 82 55 55 530 82 50 53 82 530 82 53 530 82 530 82 530 82 530 82 530 831 130 130 63 630 83 21 550 530 82 510 130	L. intermedius Kozlowska & Seinhorst, 1979	4,250	1,955	11.5	113	29	472	48	43	34
L shark linear, 1983 L shark linear, 1984 L shark linear, 1982 L shark linear, 1987 L shark linear, 1985 L shark linear, 1987 L shark linear, 1985 L shark linear, 1987 L shark linear, 1985 L shark l	L. iranicus Sturhan & Barooti, 1983	5,990	3,031	12	112	35	472	58	34	40.5
$ \begin{array}{c} L. model and Parcha, Drano, Shievin, Barkyak Eurosin, 1988 8, 170 4, 110 18.6 130 37 279 11 41 48 \\ L. ingelandis Rock, Lambert K. Agonsinelli, 1984 7, 103 8, 205 15 120 36 73 31 32 225 21.5 \\ L. jegens Herns & Swart, 1998 3, 480 1, 472 12 103 67 311 32 225 21.5 \\ L. jegens Herns & Kann, 1998 3, 480 1, 472 12 103 67 311 32 225 21.5 \\ L. jegenshis Damason, 1969 3, 200 1, 472 133 13 14 599 14 29 8 \\ L. jegenshis Damason, 1969 3, 200 1, 587 11 06 12 311 40.3 51 23 \\ L. jegenshis Damason, 1969 3, 200 1, 587 11 06 12 311 40.3 51 23 \\ L. jesenshis Damason, 1969 2, 200 1, 1587 11 66 12 316 44 428 3 21 \\ L. huckens Jeroshe, K. Herns, 1987 6, 540 3, 268 15 70 28 344 28 33 21 \\ L. huckens Jeroshe, K. Herns, 1987 7, 747 3, 357 28.6 107 27.6 455 11 28.3 366 44 73 22 \\ L. huckens Jeroshe, K. Herns, 1995 2, 200 1, 175 10 58 23 366 44 47 37.3 \\ L. huckens Jeroshe, K. Herns, 1995 2, 200 2, 258 17.2 171 94 573 66 30 42 \\ L. jegenshis Damason, Leoper, 1061 4, 420 2, 2468 19 144 35 156 481 485 14 \\ L. jegenshis Damason, K. Show, R. Show, R. Show, R. Show, N. Show 2, 268 19 144 35 156 90 386 88 28 40 \\ L. jegenshis Damason, K. Show, R. Show, R. Show, R. Show, Show 2, 266 19 144 35 155 90 386 88 28 40 \\ L. jegenshis Damason, K. Show, Show 1997 4, 560 2, 571 133 155 90 386 88 28 40 \\ L. jegenshis Damason, K. Show, Show 1997 4, 560 2, 571 133 40 5, 552 94 51 51 76 76 \\ L. jegenshis Damason, Show 2, 266 19 144 46 605 12 51 77 52 8 \\ L. jegenshis Damason, Show 2, 266 19 144 46 605 12 51 77 56 \\ J. magnetis Markenz, 1887 4, 500 4, 500 4, 500 24 113 42 5 56 105 41.4 40 \\ L. magnetis Markenz, 1887 4, 500 4, 500 4, 500 24 113 42 5 56 105 41.4 40 \\ J. magnetis Markenz, 1897 4, 500 4, 500 4, 500 24 113 42 5 56 105 41.4 40 \\ J. magnetis Markenz, 1897 4, 500 4, 500 4, 500 13 33 375 52 94 55 7 46 \\ J. magnetis Markenz, 1987 4, 500 4, 500 4, 500 10 78 82 500 405 31 42 24 \\ J. magnetis Markenz, 1987 4, 500 4, 500 4, 500 10 78 82 500 406 31 13 2 82 \\ J. maxiets Markenz, 1987 4, 500 4, 500 4, 500 10 78 82 500 406 31 13 2 82 \\ J. maxiets Mar$	L. ishrati Javed, 1983	4,600	2,162	8.5	90	32	354	40	46	31
	L. israelensis Peneva, Orion, Shlevin, Bar-Eyal & Brown, 1998	8,170	4,110	18.6	130	37	579	71	41	48
$ \begin{array}{c} 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 $	L. iugianais Koca, Lamberti & Agostinein, 1984	2 480	3,905 1.879	15	120	30 67	550 841	82 85	30 99 5	22 91 5
$T_{protection}$ 3.4301.7421.851.136.153.095.221.981.91 $T_{protection}$ Jaksona, Robins & Broom, 19976.9303.8111989322459644749 $L_{protection}$ Jaksona, Robins & Broom, 19972.8701.86011466223.1140.35123 $L_{protection}$ Jaksona, Robins & Broom, 19972.8701.86011466223.1142.83321 $L_{protection}$ Jaksona, 19652.5001.77710582343644732 $L_{protection}$ Jaksona, 19502.5011.77710582356643732 $L_{protection}$ Jaksona, 19602.9002.1511.755905.52943.669219.71.21.1711058233.668484444737.31.51.55905.668528401.661.66401.1812.952.533.65921.9.71.3011.61.66421.34421.52.551.64.1.44.73.51.64.373.552.94.651.91.44.661.93.651.91.44.661.93.651.91.44.661.93.651.91.44.661.93.651.11.52.52.51.61.7<	L. jagerae Heylis & Swalt, 1990	3 380	1,672	73	87	32	307	34	22.5	21.5
L , piegeniko Dankasso, 1969 1987 6.430 8.411 19. 89 32 4.53 11 66 22 51 11 4.64 18 2.78 34 29 21 L hubines between seven seve	L. jonesi Siddiai, 1962	3,430	1.742	13.5	113	61.5	399	52	21	28
L pierenikki Labansaso, 1960 3,220 1,587 11 66 22 311 40.3 51 25 12 Labatemis Dalmasso, 1960 3,220 1,587 14 66 18 278 42 29 21 Labatemis Dalma Jacobs & Heyns, 1987 6,540 3,263 15 70 28 414 28 33 21 Labatemis Jacobs & Heyns, 1987 7,70 3,297 28.6 107 27.6 455 51 28.8 36.9 Labatemis Dalma Jacobs & Heyns, 1999 2,200 1,175 10 58 23 606 44 37 32 Labatemis Labatemis J1995 5,20 2,551 17.2 17.1 94 573 56 30 40 Labatemis J1995 5,20 2,551 17.2 17.1 94 573 56 30 40 Labatemis J190 4,200 2,268 9.2 64 30 316 44 4.7 37.3 Labatemis J180 5, 155 90 536 58 28 40 Labatemis J200 5, 100 20 85 29 3,55 51 58 28 40 Labatemis J200 5, 100 20 85 29 3,55 57 33. 40 Labatemis Siddiqi, 1962 4,40 1,08 12 95 22.5 343 56 59.2 19.7 Labatemistics Macara, 1985 6,200 3,100 20 85 29 3,55 57 33. 40 Labatemists Siddiqi, 1962 4,41 200 2,465 20 133 37.5 552 94.5 27 46 Labatemists Siddiqi, 1962 4,41 200 5,460 24 134 42 66 417 52 41 21.8 29.5 Labatemists Siddiqi, 1962 4,41 7,000 5,460 24 134 42 66 312 51 77 46 Labatemists Siddiqi, 1962 4,390 2,000 5,460 24 134 42 66 312 51 77 46 Labatemists J200 577 10,000 5,460 24 134 42 66 312 51 77 46 Labatemists J200 577 10,000 5,460 24 134 42 66 312 51 77 46 Labatemists J200 577 10,000 5,460 24 134 42 66 312 51 77 46 Labatemists J200 577 3,370 10 78 25 300 39 42.5 28.5 12 macrosona Hooper, 1961 1,000 5,400 2,121 89 66 352 28 25 22.7 distamakamist J200 50 4,499 2,402 12 89 66 352 28 25 22.7 labatemists J200 50 4,490 2,120 12 89 66 352 28 25 22.7 labatemists J200 50 4,490 2,120 12 89 66 352 28 25 22.7 labatemists J200 50 4,490 2,120 12 89 66 352 28 25 22.7 labatemists J200 14 10 52 51 33 40 12 10 38 456 14 3 42 12 modified S100 1,598 1,400 1,589 1,100 1,584 11 425 51 31 60,5 33 42 24 Labatemists J106 1,192 4,300 2,520 2,341 11 62 26 133 60,5 31 32 24 Labatemists J200 4,495 1,500 4,400 2,520 2,341 12 19 34 456 61 43 42 24 modified S100 4,580 2,501 44 14 14 32.5 501 74 48,5 56 13 1, 200 120 120 120 120 120 120 120 120 120	L. juglandicola Liskova, Robbins & Brown, 1997	6,930	3,811	19	89	32	459	64	47	49
L jneeneiniden Jacobs & Heyns, 1987 2,870 1,360 11 46 18 278 34 29 21 L hakama Jacobs & Heyns, 1987 6,740 3,937 28.6 107 27.6 45.5 51 7.82 34.6 37.5 22.3 366 44.75 7.3 22 1.175 11 94 57.3 56 30.4 44 44.7 7.3 2.1 Linkick Williams, 1995 2.501 1.72 17.1 94 57.3 56 82 40 L longiculatus Koldiqi, 1962 2.600 1.108 12 95 22.5 7.33 40 L macroama Hooper, 1961 10.000 5.400 21 13.3 37.5 552 94.5 27 46 1.3 27 44 1.3 25 1.5 17.5 1.4 60 1.2 51 77 3.4 4. 4.6 605 1.12 51 77 3.4 4. 4.6 605 1.12 51 <td>L. juvenilis Dalmasso, 1969</td> <td>3,320</td> <td>1,587</td> <td>11</td> <td>66</td> <td>22</td> <td>311</td> <td>40.3</td> <td>51</td> <td>23</td>	L. juvenilis Dalmasso, 1969	3,320	1,587	11	66	22	311	40.3	51	23
L. kukapen Pinkman, Loof & Barbez, 1987 6,640 3,263 15 70 28 344 28 33 21 L. kukapen Pinkman, Loof & Barbez, 1987 7,70 3,937 28.6 107 27.6 455 12.8.3 36.9 L. kukapen Pinkman, Loof & Barbez, 1987 2,600 1,75 17.2 17.1 94 57.3 56 30 40 L. kukapen Pinkman, Loof & Barbez, 1980 2,400 2,268 9.2 64 30 316 44 47.7 33.8 54 L. kukankan, Loopen, Longan, Romanenko & Kruchina, 1991 44.00 2,268 9.2 53 58 28 40 L. ungarenkorus Siddiqi, 1962 4,460 2,001 14 12 63 472 44 21.3 22.5 343 665 12.2 74 1.3 42 660 112 51 77 28 14 measurename and	L. juveniloides Jacobs & Heyns, 1987	2,870	1,360	11	46	18	278	34	29	21
	L. kakamus Jacobs & Heyns, 1987	6,540	3,263	15	70	28	344	28	33	21
$ \begin{array}{c} Larace updatatis Williams, 1999 \\ Larace Hirrs, 1995 \\ L. epicons Dirace Matrix, 1995 \\ L. epicons Dirace Matrix, 1995 \\ L. glasses Univers, Subbotin, Romanenko & Kruchina, 1991 \\ L. glasses Univers, Subbotin, Romanenko & Kruchina, 1991 \\ L. glasses Univers, Subbotin, Romanenko & Kruchina, 1991 \\ L. ditchi Nu & Cheng, 1992 \\ L. totagicand Univers, Subbotin, Romanenko & Kruchina, 1991 \\ L. totagicand Univers, Subbotin, Romanenko & Kruchina, 1991 \\ L. totagicand Univers, Subbotin, Romanenko & Kruchina, 1992 \\ L. totagicand Univers, Subbotin, Romanenko & Kruchina, 1992 \\ L. totagicand Univers, Subbotin, Romanenko & Kruchina, 1992 \\ L. totagicand Univers, Subbotin, Romanenko & Kruchina, 1985 \\ L. macronoxomatus Siddiqi, 1962 \\ L. macronoxomatus Siddiqi, 1972 \\ S. Markins, 1987 \\ L. makotina Lacobs & Heyns, 1987 \\ L. makotina Lacobs & Heyns, 1987 \\ L. makotina Lacobs & Heyns, 1987 \\ L. makotina Siddiqi, 1972 \\ S. Modu Lacobs & Heyns, 1987 \\ L. monoxin Heyns, 1966 \\ L. monoxin Heyns, 1968 \\ L. monoxin Heyns, 1966 \\ L. monoxin Heyns, 1966 \\ L. monoxin Heyns, 1968 \\ L. monoxin Heyns \\ L. macronoxin Heyn$	L. kuiperi Brinkman, Loof & Barbez, 1987	7,470	3,937	28.6	107	27.6	455	51	28.3	36.9
$ \begin{array}{c} Lastance Mathematics Hooper, 1961 \\ Lastance Hooper, 1966 \\ Lastance Hooper, 1960 $	L. laevicapitatus williams, 1959	2,500	1,175	10	58 171	23	300 578	44 56	37 30	32 40
$ \begin{array}{c} \hline Tegramu Chinov, Subbonin, Romanenko & Kruchina, 1991 & 4800 & 2496 & 19 & 114 & 35 & 516 & 81 & 38 & 540 \\ \hline T. litchi Xu & Cheng, 1992 & 450 & 1185 & 155 & 90 & 556 & 58 & 84 & 0 \\ \hline Logicandramus Siddiqi, 1962 & 2.640 & 1,188 & 12 & 95 & 22.5 & 343 & 36 & 59.2 & 19.7 \\ \hline L hustinnicus Macara, 1985 & 6,20 & 3,100 & 20 & 85 & 29.35 & 57 & 33 & 40 & 20 & 20 & 20 & 20 & 20 & 20 & 20$	L. lehtocephalus Hooper 1961	4 200	2,551	9.9	64	30	316	30 44	30 44 7	373
L1. L_{n} field1.8.5<	L. lignosus Chizov, Subbotin, Romanenko & Kruchina, 1991	4.800	2,496	19	114	35	516	81	38	54
	L. litchii Xu & Cheng, 1992	4,560	2,371	13.5	155	90	536	58	28	40
L bilinding L bilindingImage 	L. longicaudatus Siddiqi, 1962	2,640	1,188	12	95	22.5	343	36	59.2	19.7
LLaccommute634724421.329.5LmacrosomeMooper, 190110,5005,460241344256510.541.469LmagueDambert, Blev-Zacheo & Arias, 19829,5004,65519114466051125177LmajorRoca & D'Errico, 198710,5005,46025133436691175281Lmatainua Jacobs & Heyns, 19873,8301,84611622533.6282422Lmataink Areny, 19664,2002,402128066352282522.7Lmata Khan, Chawla & Seshadri, 19723,4001,5501078253093942.583.5Lmotait Heyns, 196614.932,17910.55421.5233383026.8Lmotit Heyns, 19664,1902,241161538251360.53343.2Lneorei Macra, 19858,0004,9802014243552914356Lnirdialis Jofficij, 19654,1001,88810.510.033325533225.4Lnordie Hysicij, 19654,1001,8891,2010.668548799559507448.556Lnordingiandatis Ntherr, 19747,3503,602 <td>L. lusitanicus Macara, 1985</td> <td>6,200</td> <td>3,100</td> <td>20</td> <td>85</td> <td>29</td> <td>395</td> <td>57</td> <td>33</td> <td>40</td>	L. lusitanicus Macara, 1985	6,200	3,100	20	85	29	395	57	33	40
LLnacrosoma Hooper, 196110,5005,460241344256510541.469Lmagrus Lamberti, Bleve-Zacheo & Arias, 19829,5004,65519114466051125177Lmajor Roca & D'Errico, 198710,5005,46025133436691175281Lmakatinus Jacobs & Heyns, 19873,8001,84611622629533.62824Lmariti Marn, Chawla & Seshadri, 19723,4001,5301078253099042.528.3Lmoke Jacobs & Heyns, 19875,5202,8481311649386313222Lmosici Lamberti, Choleva & Agostinelli, 19837,2003,8161211934456614342Lmonibide, 19664,1902,17910.55421.5233383026.8Lmonibide, 19664,8002,22416.61538251360.533.442Lmonibide, 19664,8002,42510.61538525914355Lmonibide, 19654,1001,8981210333.338045.67831.1Lnordigram, 19858,1001,89210033325533225.4Lnordigram, 19854,1001,89812103	L. macromucronatus Siddiqi, 1962	4,340	2,009	14	121	63	472	44	21.3	29.5
LLaccordoomacroandus Altherr, 19/47,5603,8862013337,555294,557446Lmagnix Lanckhov & Arias, 19829,5004,65519114466051125177Lmakarian Jacobs & Heyns, 198710,5005,46025133436691175281Lmakarian Jacobs & Heyns, 19875,2602,44811622629533.62824Lmatrix Khan, Chawla & Seshadri, 19723,4001,5301078252993942.528.2Lmotei Leyns, 19664,1902,17910.55421.5233383026.8Lmontil Heyns, 19664,1902,22416.61538251360.53434.2Lmotei Heyns, 19654,1601,8981210333.38045.67831.1Lnewsi Macara, 19858,0004,0802014243552914356Lnieuki Skap, 19838,1101,8981210333.38045.67831.1LodgAnika & Metlinskaya, 19838,1011,8981210333.38045.67831.1Lnewsi Macara, 19854,9002,46510.51003335.553325555Lnewsi Macara, 19854,900 <td< td=""><td>L. macrosoma Hooper, 1961</td><td>10,500</td><td>5,460</td><td>24</td><td>134</td><td>42</td><td>565</td><td>105</td><td>41.4</td><td>69</td></td<>	L. macrosoma Hooper, 1961	10,500	5,460	24	134	42	565	105	41.4	69
Lmagin RocaDevelope Antas, 19923,0004,033191140000311251177Lmagin Roca& D'Errico, 19873,5301,84611622629533.62824Lmataitinus Jacobs & Heyns, 19873,5301,846116128282522.7Lmirus Khan, Chavla & Seshadri, 19723,4001,5301078253093942.528.2Lmoesicus Lamberti, Choleva & Agostinelli, 19837,2003,8161211934456614342Lmoesicus Lamberti, Choleva & Agostinelli, 19837,2003,8161211934456614342Lmessicus Lamberti, Choleva & Agostinelli, 19837,2003,8161211934456614342Lmessicus Lamberti, Bofé4,3602,22416.61538251360.53343.2Lnegatoris Kitara, 19858,0004,0802014243556183.455Lnoitentais States, Van Etteger & Hooper, 19927,2403,74322.610033325533225.4Lparaelogatizs VAn Etteger & Hooper, 19927,2403,7401,74114035450767614452Lparaelogatizs Alther, 19747,5003,62017.414035<	L. macroteromucronatus Altherr, 1974	7,560	3,856	20	133	37.5	552	94.5	27	46
Lmign Nota & Di lino, 139710,0005,0002.01,340102.2611102.2611102.2611102.2611102.2611101010111010111011101110111010111011101011101011101110111011101110111011101110111011101110111011101110111011101110111011 <td>L. magnus Lamberti, Bleve-Zacheo & Arias, 1982</td> <td>9,500</td> <td>4,655</td> <td>19</td> <td>114</td> <td>40</td> <td>605 660</td> <td>112</td> <td>51 59</td> <td>77 91</td>	L. magnus Lamberti, Bleve-Zacheo & Arias, 1982	9,500	4,655	19	114	40	605 660	112	51 59	77 91
$ \begin{array}{c} \begin{tabular}{ c c c c c c c c c c c c c c c c c c c$	L. maljor Roca & D Effico, 1987	3 830	1 846	25	69	45 96	009 995	33.6	92 98	94
L mirus Khan, Chawla & Seshadri, 1972 3,400 1,530 10 78 25 309 30 42.5 28.3 L mokaj Jacobs & Heyns, 1987 5,520 2,848 13 116 49 3866 31 32 22 L mosiis Lamberti, Choleva & Agostinelli, 1983 7,200 3,816 12 119 4 456 61 43 42 L moniidise, 1966 1966 4,800 2,719 10.5 54 21.5 23.3 38 30 26.8 L naganensis Hirata, 1995 4,360 2,224 16.6 153 82 513 60.5 33 43.2 1.8 1.1 1.0 1.0 1.0 1.8 1.1 3.25 50.7 74 48.5 56 1.0 1.1 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 3.3 380 45.6 78 31.1 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.	L. martini Merny, 1966	4,290	2,402	19	89	66	352	28 28	20 25	21 99.7
Lmobae Jacobs & Heyns, 19875,5202,8481311649386313222Lmonik Heyns, 19664,1002,17910.55421.5233383026.8Lmonik Heyns, 19664,1001,882155928.532548.63227.8Lnewesi Macara, 19954,8602,22416.61538251360.53343.2Lnewesi Macara, 19858,0004,0802014243552914356Lnitudi Siddiqi, 19954,1001,8981210333.38045.67831.1Lolgy Kankina & McUitskay, 19838,4104,4241411432.55017448.556Lorinetalis Loof, 19824,9302,46510.510033325533225.4Lparaelongatus Altherr, 19747,5503,60217.4140354596736.142.5Lparaleskaensis Robbins, 20033,62010.015.710525.5316313143.4Lparaminus Darckar & Khan, 19824,6001.62810.55325.5316313143.4Lparaminus Darckar & Kobbins, 20032,53014.57023.533.845.334.530.5Lparaleskeensi Luc & Coomans, 19885.0302,2091	L. mirus Khan, Chawla & Seshadri, 1972	3,400	1,530	10	78	25	309	39	42.5	28.3
Lmonic numberLamberti, Choleva & Agostinelli, 19837,2003,8161211934456614342Lmoniloids, 196619664,1902,17910.55421.5233383026.8LmagmensisHirtat, 19954,3602,22416.61538251360.53343.5Lneresi Macra, 19858,0004,0802014243552914356Lnirulai Siddiqi, 19654,1001,8981210333.358045.67831.1Lolgg Kankina & Metitiskay, 19834,4104,4241411432.55017448.556Lorongorongensis Yeates, Van Etteger & Hooper, 19927,2403,74322.616068548793959Lparaelongatus Altherr, 19747,5503,60217.7015.710525.530.943.347.226.8Lparalongicaudauts Ye & Robbins, 20033,6201,70015.710525.5309.943.347.226.8Lparanineologa Ve & Robbins, 20038,6201,62810.553.925.336.338.846.8Lparanineologa Ve & Robbins, 20038,8244,16424.2106.533.945.335.334.339Lparalensis Alberti, Molinari, De Luca, Agostinelli and Di Vito19997.600 <td< td=""><td>L. mobae Jacobs & Heyns, 1987</td><td>5,520</td><td>2,848</td><td>13</td><td>116</td><td>49</td><td>386</td><td>31</td><td>32</td><td>22</td></td<>	L. mobae Jacobs & Heyns, 1987	5,520	2,848	13	116	49	386	31	32	22
Lmonile Heyns, 19664,1902,17910.55421.5233383026.8Lmoniloids, 1966 Heyns3.8401.882155928.532548.63227.8Lnagamensis Hirata, 19954,3602.22416.61538251360.53343.2Lnewesi Macara, 19858,0004,0802014243552914356Lnirulai Siddiqi, 19654,1001,8981210333.338045.67831.1Lolegi Kankina & Meditskaya, 19838,4104,4241411432.55017448.556Lorientalis Loof, 19824,9302,46510.510033325533225.4Loraelongatus Altherr, 19747,3503,60217.4140354596736.142.4Lparalongicaudatus Ye & Robbins, 20033,6201,70015.710525.5309.943.347.226.8Lparaminus Darekar & Khan, 19824,6652,00910.58045352404437Lparalongicaudatus Ye & Robbins, 20038,8244,16424.2106.533.9457.365.338.846.8Lparaminus Darekar & Khan, 19825,0302,53014.57023.53184330Lparaminus Darekar & Kombins, 20	L. moesicus Lamberti, Choleva & Agostinelli, 1983	7,200	3,816	12	119	34	456	61	43	42
Lnominidade, 1966Heyns3,8401,882155928.532548.63227.8Lnagaenesis Hirata, 19954,3602,22416.61538251360.53343.2Lnewsi Macara, 19854,1001,8981210333.338045.67831.1Lorientalis Loof, 19824,9302,46510.510033325533225.4Lorientalis Loof, 19824,9302,46510.510033325533225.4Lorientalis Loof, 19824,9302,46510.510033325533225.4Lparaelongaents Miherr, 19747,503,60217.4140354596786.142.5Lparalenkaensis Robbins, 20033,6201,70015.710525.5309.943.347.226.8Lparaelongicaudatus Ve & Robbins, 20038,8244,16424.2106.533.9457.365.388.846.8Lparaelongicaudatus Neevn, 19825,00015.71055325.53163143.44.8Lparaelongicaudatus Ve & Robbins, 20038,8244,16424.2106.533.9457.365.388.846.8Lparaelongicaudatus Ve & Robbins, 20038,8244,16424.2106.533.945.335.5Lpici	L. monile Heyns, 1966	4,190	2,179	10.5	54	21.5	233	38	30	26.8
$ \begin{array}{c} L nagareness Hirata, 1995 \\ L neves Macara, 1985 \\ L neves Macara, 1985 \\ L nirulai Siddiqi, 1965 \\ L norentalis Loof, 1982 \\ L orentalis Loof, 1982 \\ L orentalis Loof, 1982 \\ L paralongatus Altherr, 1974 \\ L paralongatus Altherr, 1974 \\ L paralongicaudatus Ye & Robbins, 2003 \\ L paralongatus Altherr, 1974 \\ L paralongicaudatus Ye & Robbins, 2003 \\ L paralongicaudatus Ye & Robbins & Brown, 1997 \\ State Ye & Robbins & Robbins & Robbi$	L. moniloides, 1966 Heyns	3,840	1,882	15	59	28.5	325	48.6	32	27.8
LnetwiskNacara, 19858,0004,0802014243502914350Lnirulai Siddiqi, 19654,1001,8981210333.38045.67831.1Lolegi Kankina & Meditskaya, 19838,4104,4241411432.55017448.556Lorientalis Loof, 19824,9302,46510.510033325533225.4Lorongorongensis Yeates, Van Etteger & Hooper, 19927,2403,74322.616068548793959Lparaelongizau datus Ye & Robbins, 20033,62017.4140354596736.142.5Lparaminus Darekar & Khan, 19823,7001.62810.58045352404437Lparaminezola Ye & Robbins, 20038,8244.16424.2106.533.9457.365.388.845.Lparaminezola Ye & Robbins, 20038,8244.16424.2106.533.9457.365.388.841.4Lparamenis Luc & Coomans, 19885,0302,53014.57023.533.84534.530.5Lpicicola Liskova, Robbins & Brown, 19975,1402,364161664255953433939Lpicinus Roca, Lamberti & Agostinelli, 19846,8003,604201373958681 <td>L. naganensis Hirata, 1995</td> <td>4,360</td> <td>2,224</td> <td>16.6</td> <td>153</td> <td>82</td> <td>513</td> <td>60.5</td> <td>33</td> <td>43.2</td>	L. naganensis Hirata, 1995	4,360	2,224	16.6	153	82	513	60.5	33	43.2
$ \begin{array}{c} \mbox{train} kinkin k Methitskaya, 1983 & 4,10 & 1,00 & 1,030 & 12 & 103 & 30.5 & 500 & 40.0 & 40.5 & 51 \\ \mbox{L} origination skinkin k Methitskaya, 1983 & 4,10 & 4,24 & 14 & 114 & 32.5 & 501 & 74 & 48.5 & 56 \\ \mbox{L} origination skinkin k Methitskaya, 1983 & 4,900 & 2,465 & 10.5 & 100 & 33 & 325 & 53 & 32 & 25.4 \\ \mbox{L} origination skinkin k Methitskaya, 1983 & 4,900 & 2,465 & 10.5 & 100 & 33 & 325 & 53 & 32 & 25.4 \\ \mbox{L} origination skinkin k Methitskaya, 1984 & 7,240 & 3,602 & 17.4 & 140 & 35 & 459 & 67 & 36.1 & 42.5 \\ \mbox{L} paraelongicaudatus Ye & Robbins & Brown, 1996 & 6,386 & 3,320 & 19 & 128 & 37 & 546 & 76 & 42 & 44 \\ \mbox{L} paraelongicaudatus Ye & Robbins, 2003 & 3,620 & 1,700 & 15.7 & 105 & 25.5 & 309.9 & 43.3 & 47.2 & 26.8 \\ \mbox{L} paravineacola Ye & Robbins, 2003 & 3,620 & 1,700 & 15.7 & 105 & 25.5 & 316 & 31 & 31 & 43.4 \\ \mbox{L} paravineacola Ye & Robbins, 2003 & 8,84 & 4,164 & 24.2 & 106.5 & 33.9 & 457.3 & 65.3 & 38.8 & 46.8 \\ \mbox{L} paul Lamberti, Molinari, De Luca, Agostinelli and Di Vito, 1999 & 7,600 & 3,884 & 15.2 & 109 & 30.6 & 447 & 57.5 & 37.8 & 41.4 \\ \mbox{L} pauveensis Luc & Coomans, 1988 & 5,030 & 2,530 & 14.5 & 70 & 23.5 & 338 & 45 & 34.5 & 30.5 \\ \mbox{L} picciola Liskova, Robbins & Brown, 1997 & 5,140 & 2,364 & 16 & 166 & 42 & 559 & 53 & 43 & 39 \\ \mbox{L} picciola Liskova, Robbins & Brown, 1997 & 5,140 & 2,364 & 16 & 166 & 42 & 559 & 53 & 43 & 39 \\ \mbox{L} picciola Liskova, Robbins & Brown, 1997 & 5,140 & 2,364 & 16 & 166 & 42 & 559 & 53 & 43 & 39 \\ \mbox{L} picciola Liskova, Robbins & Brown, 1997 & 5,140 & 2,364 & 16 & 166 & 42 & 559 & 53 & 43 & 39 \\ \mbox{L} picciola Liskova, Robbins & Brown, 1997 & 5,140 & 2,364 & 16 & 166 & 42 & 559 & 53 & 43 & 39 \\ \mbox{L} picciola Liskova, Robbins & Brown, 1997 & 6,300 & 3,604 & 20 & 137 & 39 & 586 & 81 & 38 & 59 \\ \mbox{L} picciola Liskova, Robbins & Brown & 3,700 & 3,710 & 14.4 & 97 & 37 & 504 & 67 & 45.5 & 41 \\ \mbox{L} picciola Liskova, 1993 & 7,300 & 3,489 & 18 & 107 & 34 & 476 & 59 & 38 & 45 \\ \mboxim Ho$	L. nevesi Macara, 1985	8,000	4,080	20	142	43 22 2	222 280	91 45.6	43 78	20 21 1
Lorge Hummens Lorge Hummens 	L. aleri Kankina & Metlitskava 1983	8 410	4 494	14	114	39.5 39.5	501	45.0 74	48.5	56
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	L. orientalis Loof. 1982	4.930	2.465	10.5	100	33	325	53	32	25.4
L. paraelongatus Altherr, 19747,3503,60217.4140354596736.142.5L. paralaskaensis Robbins & Brown, 19966,3863,3201912837546764244L. paralongicaudatus Ye & Robbins, 20033,6201,70015.710525.5309.943.347.226.8L. paraminus Darekar & Khan, 19823,7001,62810.58045352404437L. paraminus Darekar & Khan, 19824,6502,20910.55325.5316313143.4L. parawineacola Ve & Robbins, 20038,8244,16424.2106.533.9457.365.338.846.8L. pauli Lamberti, Molinari, De Luca, Agostinelli and Di Vito,19997,6003,88415.210930.644757.537.841.4L. picenis Luc & Coomans, 19885,0302,53014.57023.53384534.530.5L. picenis Roca, Lamberti & Agostinelli, 19846,8003,6042013739586813859L. picini Andres & Arias, 19874,7002,3979.56826328396326L. pisi Edward, Misra & Singh, 19643,1401,5927.55832.9266243413L pisu Barsi & Lamberti, 20015,3202,26622.5134.637.55018135.522L possnecke	L. orongorongensis Yeates, Van Etteger & Hooper, 1992	7,240	3,743	22.6	160	68	548	79	39	59
L. paralaskaensis Robbins & Brown, 19966,3863,3201912837546764244L. paralongicaudatus Ye & Robbins, 20033,6201,70015.710525.5309.943.347.226.8L. paramonite Jacobs & Heyns, 19824,6502,20910.55325.5316313143.4L. parawineacola Ye & Robbins, 20038,8244,16424.2106.533.9457.365.338.846.8L. paul Lamberti, Molinari, De Luca, Agostinelli and Di Vito,7,6003,88415.210930.644757.537.841.4L. pawneensis Luc & Coomans, 19885,0302,53014.57023.53384534.530.5L. piciecola Liskova, Robbins & Brown, 19975,1402,3641616642559534339L. pixi Edward, Misra & Singh, 19643,1401,5927.55832.9266243413L. pixis Baris & Lamberti, 20015,3202,66022.5134.637.553089.444.767.5L. poramus Burhan & Argo, 19837,3003,49114.497375046745.541L. pixis Baris & Lamberti, 20015,3202,66022.5134.637.553089.444.767.5L. protamus Burhan & Argo, 19837,3003,49114.497375046745.541L. prot	L. paraelongatus Altherr, 1974	7,350	3,602	17.4	140	35	459	67	36.1	42.5
L. paralongicaudatus Ye & Robbins, 2003 $3,620$ $1,700$ 15.7 105 25.5 309.9 43.3 47.2 26.8 L. paraminus Darekar & Khan, 1982 $3,700$ $1,628$ 10.5 80 45 352 40 44 37 L. paraminus Darekar & Khan, 1982 $4,650$ $2,209$ 10.5 53 25.5 31.6 31 31 43.4 L. paravineacola Ye & Robbins, 2003 $8,824$ $4,164$ 24.2 106.5 33.9 457.3 65.3 38.8 46.8 L. paravineacola Ye & Robbins, 2003 $7,600$ $3,884$ 15.2 109 30.6 447 57.5 37.8 41.4 L. paravineacola Ye & Robbins, 2003 $6,300$ $2,530$ 14.5 70 23.5 338 45 34.5 30.5 L. piceicola Liskova, Robbins & Brown, 1997 $5,140$ $2,364$ 16 166 42 259 53 43 39 L. pixeicola Liskova, Robbins & Brown, 1997 $5,140$ $2,397$ 9.5 68 26 228 39 63 26 L. pixei Roca, Lamberti & Agostinelli, 1984 $6,800$ $3,604$ 20 137 39 586 81 38 59 L. pixei Edward, Misra & Singh, 1964 $3,140$ $1,592$ 7.5 58 32.9 266 24 34 13 L. pixei Baris & Lamberti, 2001 $5,320$ $2,660$ 22.5 134.6 37.5 530 89.4 44.7 67.5 <td>L. paralaskaensis Robbins & Brown, 1996</td> <td>6,386</td> <td>3,320</td> <td>19</td> <td>128</td> <td>37</td> <td>546</td> <td>76</td> <td>42</td> <td>44</td>	L. paralaskaensis Robbins & Brown, 1996	6,386	3,320	19	128	37	546	76	42	44
L. paraminus Darekar & Khan, 1982 $3,700$ $1,628$ 10.5 80 45 352 40 44 37 L. paraxinine Jacobs & Heyns, 1982 $4,650$ $2,209$ 10.5 53 25.5 316 31 31 43.4 L. paraxinine acola Ye & Robbins, 2003 $8,824$ $4,164$ 24.2 106.5 33.9 457.3 65.3 38.8 46.8 L. paratinine acola Ye & Robbins, 2003 $8,824$ $4,164$ 24.2 100.5 53 25.5 316 31 43.4 L. paratinine acola Ye & Coomans, 1988 5030 $2,530$ 14.5 70 23.5 338 45 34.5 30.5 L. piceiola Liskova, Robbins & Brown, 1997 $5,140$ $2,364$ 16 166 42 559 53 43 39 L. picenus Roca, Lamberti & Agostinelli, 1984 $6,800$ $3,604$ 20 137 39 586 81 38 59 L. pixe Baris & Lamberti, 2001 $5,320$ $2,660$ 22.5 134.6 37.5 530 89.4 4.7 67.5 L. possneckensis Altherr, 1974 $8,700$ $3,710$ 14.4 97 37 504 67 45.5 41 L. proximus Sturhan & Argo, 1983 $7,300$ $3,489$ 18 107 34 476 59 38 45 L. protae Lamberti & Bleve-Zacheo, 1977 $6,700$ $3,216$ 12 79 27 424 43 35 32 L. proximu	L. paralongicaudatus Ye & Robbins, 2003	3,620	1,700	15.7	105	25.5	309.9	43.3	47.2	26.8
L. paramonile jacobs & Heyns, 1982 4,050 2,209 10.5 53 25.5 316 31 31 43.4 L. parawineacola Ye & Robbins, 2003 8,824 4,164 24.2 106.5 33.9 457.3 65.3 38.8 46.8 L. pauli Lamberti, Molinari, De Luca, Agostinelli and Di Vito, 7,600 3,884 15.2 109 30.6 447 57.5 37.8 41.4 L. pauli Lamberti, Molinari, De Luca, Agostinelli and Di Vito, 7,600 3,884 15.2 109 30.6 447 57.5 37.8 41.4 L. pauneensis Luc & Coomans, 1988 5,030 2,530 14.5 70 23.5 338 45 34.5 30.5 L. pini Andres & Arias, 1987 5,100 2,364 16 166 42 559 53 43 39 L. pisi Edward, Misra & Singh, 1964 3,140 1,592 7.5 58 32.9 266 24 34 13 L. protum Hoper, 1966 7,000 3,710 14.4 97 37 504 67 45.5 41 L. protundorum	L. paramirus Darekar & Khan, 1982	3,700	1,628	10.5	80 5 9	45	352	40	44	37
L. piardatineatoid if & R Kobolnis, 2003 5,324 4,104 24.2 100.3 35.9 457.3 05.5 36.0 40.6 L. pauli Lamberti, Molinari, De Luca, Agostinelli and Di Vito, 7,600 3,884 15.2 109 30.6 447 57.5 37.8 41.4 L. pauneensis Luc & Coomans, 1988 5,030 2,530 14.5 70 23.5 338 45 34.5 30.5 L. piceicola Liskova, Robbins & Brown, 1997 5,140 2,364 16 166 42 559 53 43 39 L. piceicola Liskova, Robbins & Brown, 1997 5,140 2,364 16 166 42 559 53 43 39 L. piceicola Liskova, Robbins & Brown, 1997 5,140 2,364 16 166 42 559 53 43.5 30.5 26 L. pist Barsi & Lamberti, Xong, 1987 4,700 2,397 9.5 68 26 328 39 63 26 L. pist Barsi & Lamberti, 2001 5,320 2,660 22.5 134.6 37.5 530 89.4 44.7 67.5	L. paramonile Jacobs & Heyns, 1982	4,650	2,209	10.5	53 106 E	25.5	310	31 65 9	31	43.4
In product and protocy7,6003,88415.210930.644757.537.841.4L. pawneensis Luc & Coomans, 19885,0302,53014.57023.53384534.530.5L. piceicola Liskova, Robbins & Brown, 19975,1402,3641616642559534339L. picenus Roca, Lamberti & Agostinelli, 19846,8003,6042013739586813859L. pini Andres & Arias, 19874,7002,3979.56826328396326L. pius Barsi & Lamberti, 20015,3202,66022.5134.637.553089.444.767.5L. possneckensis Altherr, 19748,7004,82921127.536.55618138.558L. protae Lamberti & Bleve-Zacheo, 19776,7003,216127927424433532L. proximus Sturhan & Argo, 19837,3303,4891810734476593845L. piseidologatus Altherr, 19765,3002,9151212030530583643L. pisiti Kana & Khan, 19723,2101,518129734353503535L. reisi Roca & Bravo, 19939,2004,5721710730.54494343L. reisi Roca & Bravo, 19939,2004,5721710730.544943	L. paravineacoia ie & Robbins, 2005	0,024	4,104	24.2	100.5	55.9	497.5	05.5	30.0	40.0
L. paaneensis Luc & Coomans, 19885,0302,53014.57023.53384534.530.5L. piceicola Liskova, Robbins & Brown, 19975,1402,3641616642559534339L. picenus Roca, Lamberti & Agostinelli, 19846,8003,6042013739586813859L. pini Andres & Arias, 19874,7002,3979.56826328396326L. pius Barsi & Lamberti, 20015,3202,66022.5134.637.553089.444.767.5L. possneckensis Altherr, 19748,7004,82921127.536.55618138.558L. profundorum Hooper, 19667,0003,71014.497375046745.541L. prote Lamberti & Bleve-Zacheo, 19776,7003,216127927424433532L. psidii Khan & Argo, 19837,3303,4891810734476593845L. psidii Khan & Khan, 19723,2101,518129734353503535L. resi Roca & Bravo, 19939,2004,5721710730.5449438430L. resi Roca & Bravo, 19939,2004,5721710730.5449438430L. rubi Romanenko, 19984,3602,28911763441546.42	1999	7.600	3.884	15.2	109	30.6	447	57.5	37.8	41.4
L. piceicola Liskova, Robbins & Brown, 1997 $5,140$ $2,364$ 16 166 42 559 53 43 39 L. picenus Roca, Lamberti & Agostinelli, 1984 $6,800$ $3,604$ 20 137 39 586 81 38 59 L. pini Andres & Arias, 1987 $4,700$ $2,397$ 9.5 68 26 328 39 63 26 L. pisi Edward, Misra & Singh, 1964 $3,140$ $1,592$ 7.5 58 32.9 266 24 34 13 L. pius Barsi & Lamberti, 2001 $5,320$ $2,660$ 22.5 134.6 37.5 530 89.4 44.7 67.5 L. poessneckensis Altherr, 1974 $8,700$ $4,829$ 21 127.5 36.5 561 81 38.5 58 L. protae Lamberti & Bleve-Zacheo, 1977 $6,700$ $3,216$ 12 79 27 424 43 35 L. protae Lamberti & Ago, 1983 $7,330$ $3,489$ 18 107 34 476 59 38 45 L. pseudoelongatus Altherr, 1976 $5,300$ $2,915$ 12 120 30 530 50 35 35 L. ruskii Lamberti & Agostinelli, 1993 $7,400$ $3,774$ 17.1 98 36 525 90 43 84 30 L. resi Roca & Bravo, 1993 $9,200$ $4,572$ 17 107 30.5 449 43 84 30 L. rubi Romanenko, 1998 $4,360$ $2,289$ </td <td>L. pawneensis Luc & Coomans, 1988</td> <td>5,030</td> <td>2,530</td> <td>14.5</td> <td>70</td> <td>23.5</td> <td>338</td> <td>45</td> <td>34.5</td> <td>30.5</td>	L. pawneensis Luc & Coomans, 1988	5,030	2,530	14.5	70	23.5	338	45	34.5	30.5
L. picenus Roca, Lamberti & Agostinelli, 1984 $6,800$ $3,604$ 20 137 39 586 81 38 59 L. pini Andres & Arias, 1987 $4,700$ $2,397$ 9.5 68 26 328 39 63 26 L. pisi Edward, Misra & Singh, 1964 $3,140$ $1,592$ 7.5 58 32.9 266 24 34 13 L. pius Barsi & Lamberti, 2001 $5,320$ $2,660$ 22.5 134.6 37.5 530 89.4 44.7 67.5 L. possneckensis Altherr, 1974 $8,700$ $4,829$ 21 127.5 36.5 561 81 38.5 58 L. profundorum Hooper, 1966 $7,000$ $3,710$ 14.4 97 37 504 67 45.5 41 L. protae Lamberti & Bleve-Zacheo, 1977 $6,700$ $3,216$ 12 79 27 424 43 35 32 L. proximus Sturhan & Argo, 1983 $7,330$ $3,489$ 18 107 34 476 59 38 45 L. pseudoelongatus Altherr, 1976 $5,300$ $2,915$ 12 120 30 530 55 35 L. raskii Lamberti & Agostinelli, 1993 $7,400$ $3,774$ 17.1 98 36 525 90 43 84 L. reisi Roca & Bravo, 1993 $9,200$ $4,572$ 17 107 30.5 449 43 84 30 L. reisi Roca & Bravo, 1993 920 $4,572$ 17 1	L. piceicola Liskova, Robbins & Brown, 1997	5,140	2,364	16	166	42	559	53	43	39
L. pini Andres & Arias, 1987 $4,700$ $2,397$ 9.5 68 26 328 39 63 26 L. pisi Edward, Misra & Singh, 1964 $3,140$ $1,592$ 7.5 58 32.9 266 24 34 13 L. pius Barsi & Lamberti, 2001 $5,320$ $2,660$ 22.5 134.6 37.5 530 89.4 44.7 67.5 L. poessneckensis Altherr, 1974 $8,700$ $4,829$ 21 127.5 36.5 561 81 38.5 58 L. profundorum Hooper, 1966 $7,000$ $3,710$ 14.4 97 37 504 67 45.5 41 L. protae Lamberti & Bleve-Zacheo, 1977 $6,700$ $3,216$ 12 79 27 424 43 35 32 L. proximus Sturhan & Argo, 1983 $7,330$ $3,489$ 18 107 34 476 59 38 45 L. pseudoelongatus Altherr, 1976 $5,300$ $2,915$ 12 120 30 530 58 36 43 L. raskii Lamberti & Agostinelli, 1993 $7,400$ $3,774$ 17.1 98 36 525 90 43 59 L. reisi Roca & Bravo, 1993 $9,200$ $4,572$ 17 107 30.5 449 43 30 L. reisi Roca & Bravo, 1993 $9,200$ $4,572$ 17 107 30.5 449 43 30 L. reisi Roca & Bravo, 1998 $4,500$ $2,289$ 11 76 34 4	L. picenus Roca, Lamberti & Agostinelli, 1984	6,800	3,604	20	137	39	586	81	38	59
L. pisi Edward, Misra & Singh, 1964 $3,140$ $1,592$ 7.5 58 32.9 266 24 34 13 L. pius Barsi & Lamberti, 2001 $5,320$ $2,660$ 22.5 134.6 37.5 530 89.4 44.7 67.5 L. poessneckensis Altherr, 1974 $8,700$ $4,829$ 21 127.5 36.5 561 81 38.5 58 L. profundorum Hooper, 1966 $7,000$ $3,710$ 14.4 97 37 504 67 45.5 41 L. protae Lamberti & Bleve-Zacheo, 1977 $6,700$ $3,216$ 12 79 27 424 43 35 32 L. protae Lamberti & Argo, 1983 $7,330$ $3,489$ 18 107 34 476 59 38 45 L. pseudoelongatus Altherr, 1976 $5,300$ $2,915$ 12 120 30 530 58 36 43 L. raskii Lamberti & Agostinelli, 1993 $7,400$ $3,774$ 17.1 98 36 525 90 43 59 L. reisi Roca & Bravo, 1993 $9,200$ $4,572$ 17 107 30.5 449 43 84 30 L. reneyii Raina, 1966 $2,300$ $1,150$ 10 54 23 256 31 31 18 L. rubi Romanenko, 1998 $4,530$ $2,174$ 12 78 30 423 415 46.4 27 30 L. rubi Romanenko, 1998 $4,530$ $2,174$ 12 78 <	L. pini Andres & Arias, 1987	4,700	2,397	9.5	68	26	328	39	63	26
L. prus Barsi & Lamberti, 2001 5,320 2,660 22.5 134.6 37.5 530 89.4 44.7 67.5 L. poessneckensis Altherr, 1974 8,700 4,829 21 127.5 36.5 561 81 38.5 58 L. profundorum Hooper, 1966 7,000 3,710 14.4 97 37 504 67 45.5 41 L. protae Lamberti & Bleve-Zacheo, 1977 6,700 3,216 12 79 27 424 43 35 32 L. proximus Sturhan & Argo, 1983 7,330 3,489 18 107 34 476 59 38 45 L. psidii Khan & Khan, 1972 3,210 1,518 12 97 34 353 50 35 35 L. resi Roca & Bravo, 1993 7,400 3,774 17.1 98 36 525 90 43 84 30 L. resi Roca & Bravo, 1993 9,200 4,572 17 107 30.5 449 43 18 L. resi Roca & Bravo, 1993 9,200 4,572 17 107	L. pisi Edward, Misra & Singh, 1964	3,140	1,592	7.5	58	32.9	266	24	34	13
L. poessnetckensts Antren, 1974 3,700 4,829 21 127.5 36.5 501 31 38.5 56 L. profundorum Hooper, 1966 7,000 3,710 14.4 97 37 504 67 45.5 41 L. protae Lamberti & Bleve-Zacheo, 1977 6,700 3,216 12 79 27 424 43 35 32 L. proximus Sturhan & Argo, 1983 7,330 3,489 18 107 34 476 59 38 45 L. psidii Khan & Khan, 1972 3,210 1,518 12 97 34 353 50 35 35 L. resi Roca & Bravo, 1993 7,400 3,774 17.1 98 36 525 90 43 59 L. resi Roca & Bravo, 1993 9,200 4,572 17 107 30.5 449 43 30 L. resi Roca & Bravo, 1993 9,200 4,572 17 107 30.5 449 43 84 30 L. resi Roca & Bravo, 1993 2,300 1,150 10 54 23 256	L. prus Barsi & Lamberti, 2001	5,320	2,660	22.5 91	134.6	37.5 26.5	530 561	89.4	44.7 28 5	67.5 59
L. protation in Holpert, 1500 7,000 5,710 14.4 57 57 504 67 45.5 41 L. protate Lamberti & Bleve-Zacheo, 1977 6,700 3,216 12 79 27 424 43 35 32 L. proximus Sturhan & Argo, 1983 7,330 3,489 18 107 34 476 59 38 45 L. pseudoelongatus Altherr, 1976 5,300 2,915 12 120 30 530 58 36 43 L. psidii Khan & Khan, 1972 3,210 1,518 12 97 34 353 50 35 35 L. resi Roca & Bravo, 1993 7,400 3,774 17.1 98 36 525 90 43 59 L. resi Roca & Bravo, 1993 9,200 4,572 17 107 30.5 449 43 84 30 L. rotundicaudatus Jacobs & Heyns, 1987 4,360 2,289 11 76 34 415 46.4 27 30 L. rubi Romanenko, 1998 4,530 2,174 12 78 30	L. poessneckensis Almerr, 1974	8,700 7,000	4,629	21 14 4	127.5	30.5 87	501 504	67	30.9 45.5	20 41
L. proximus Sturhan & Argo, 1983 7,300 3,489 18 107 34 476 59 38 45 L. pseudoelongatus Altherr, 1976 5,300 2,915 12 120 30 530 58 36 43 L. pseudoelongatus Altherr, 1976 5,300 2,915 12 120 30 530 58 36 43 L. psidii Khan & Khan, 1972 3,210 1,518 12 97 34 353 50 35 35 L. reisi Roca & Bravo, 1993 7,400 3,774 17.1 98 36 525 90 43 59 L. reneyii Raina, 1966 2,300 1,150 10 54 23 256 31 31 18 L. rotundicaudatus Jacobs & Heyns, 1987 4,360 2,289 11 76 34 415 46.4 27 30 L. rubi Romanenko, 1998 4,530 2,174 12 78 30 423 41 57 29 L. saginus Khan, Seshadri, Weischer & Mathen, 1971 5,900 2,596 25 154 <	L. protae Lamberti & Bleve-Zacheo, 1977	6,700	3,216	19	79	97	494	43	35	32
L.pseudoelongatus Altherr, 19765,3002,9151212030530583643L.psidii Khan & Khan, 19723,2101,518129734353503535L.raskii Lamberti & Agostinelli, 19937,4003,77417.19836525904359L.reisi Roca & Bravo, 19939,2004,5721710730.5449438430L.reneyii Raina, 19662,3001,150105423256313118L.rotundicaudatus Jacobs & Heyns, 19874,3602,28911763441546.42730L.rubi Romanenko, 19984,5302,174127830423415729L.saginus Khan, Seshadri, Weischer & Mathen, 19715,9002,5962515434655653094	L. proximus Sturhan & Argo, 1983	7,330	3,489	18	107	34	476	59	38	45
L. psidii Khan & Khan, 19723,2101,518129734353503535L. raskii Lamberti & Agostinelli, 19937,4003,77417.19836525904359L. reisi Roca & Bravo, 19939,2004,5721710730.5449438430L. reneyii Raina, 19662,3001,150105423256313118L. rotundicaudatus Jacobs & Heyns, 19874,3602,28911763441546.42730L. rubi Romanenko, 19984,5302,174127830423415729L. saginus Khan, Seshadri, Weischer & Mathen, 19715,9002,5962515434655653094	L. pseudoelongatus Altherr, 1976	5,300	2,915	12	120	30	530	58	36	43
L. raskii Lamberti & Agostinelli, 19937,4003,77417.19836525904359L. reisi Roca & Bravo, 19939,2004,5721710730.5449438430L. reneyii Raina, 19662,3001,150105423256313118L. rotundicaudatus Jacobs & Heyns, 19874,3602,28911763441546.42730L. rubi Romanenko, 19984,5302,174127830423415729L. saginus Khan, Seshadri, Weischer & Mathen, 19715.9002.5962515434655653094	L. psidii Khan & Khan, 1972	3,210	1,518	12	97	34	353	50	35	35
L. reisi Roca & Bravo, 19939,2004,5721710730.5449438430L. reneyii Raina, 19662,3001,150105423256313118L. rotundicaudatus Jacobs & Heyns, 19874,3602,28911763441546.42730L. rubi Romanenko, 19984,5302,174127830423415729L. saginus Khan, Seshadri, Weischer & Mathen, 19715.9002.5962515434655653094	L. raskii Lamberti & Agostinelli, 1993	7,400	3,774	17.1	98	36	525	90	43	59
L. reneyu Rama, 1966 2,300 1,150 10 54 23 256 31 31 18 L. rotundicaudatus Jacobs & Heyns, 1987 4,360 2,289 11 76 34 415 46.4 27 30 L. rubi Romanenko, 1998 4,530 2,174 12 78 30 423 41 57 29 L. saginus Khan, Seshadri, Weischer & Mathen, 1971 5.900 2.596 25 154 34 655 65 30 24	L. reisi Roca & Bravo, 1993	9,200	4,572	17	107	30.5	449	43	84	30
L. rotunalcaudatus Jacobs & Heyns, 1987 $4,360$ $2,289$ 11 76 34 415 46.4 27 30 L. rubi Romanenko, 1998 $4,530$ $2,174$ 12 78 30 423 41 57 29 L. saginus Khan, Seshadri, Weischer & Mathen, 1971 5.900 2.596 25 154 34 655 65 30 24	L. reneyu Raina, 1966	2,300	1,150	10	54	23	256	31	31	18
<i>L. ruor</i> Komanenko, 1990 4,500 $2,174$ 12 78 50 425 41 57 29 <i>L. saginus</i> Khan, Seshadri, Weischer & Mathen, 1971 5.900 2.596 25 154 34 655 65 30 94	L. rotundicaudatus Jacobs & Heyns, 1987	4,360	2,289	11 19	76	34 20	415 192	46.4	27	30 90
	L. saginus Khan, Seshadri, Weischer & Mathen, 1971	$\frac{1,550}{5,900}$	2,174 2,596	25	154	34	655	65	30	23 24

Table 2.	Continued.
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Species	L	VL	Lip width	Odontostyle	DGR	Esophagus	Body width	Tail length	ABW
L. seinhorsti Peneva, Loof & Brown, 1998	5,500	2,695	21	121	32	420	45	42	33
L. silvae Roca, 1993	6,900	3,353	15	123	40	543	69	42	53
L. socialis Singh & Khan, 1997	3,910	2,017	14	104	32	301	50	67	30.5
L. sturhani Rubtsova, Subbotin, Brown & Moens, 2001	5,500	2,860	15	89	30	305	49	36	36
L. sylphus Thorne, 1939 (lectotypes Robbins & Brown, 1995)	3,841	1,782	11	75	25	366	50	44	30
L. taniwha Clark, 1963	4,640	2,390	18	116	52	498	31	31	58.5
L. tarjani Siddiqi, 1962	6,800	3,536	34	180	35	523	68	50	45
L. trapezoides Nasira & Maqbool, 1995	6,500	3,029	12.2	109	32	428	51	38	42
L. unedoi Arias, Andres & Navas, 1986	5,400	2,916	12.5	59	25	360	40	40	25
L. uroshis Krnjaic, Lamberti, Krnjaic, Agostinelli & Radicci,									
2000	6,500	3,296	17	134	42.5	551	64	46	49
L. vineacola Sturhan & Weischer, 1964	8,160	4,260	20.3	97	32	464	60	39	50
L. vinearum Bravo & Roca, 1995	9,300	4,297	21	119	40	517	102	48	69
L. waikouaitii Yeates, Boag & Brown, 1997	6,790	3,510	16.5	115	58.5	530	82	39	62

male. Thus, anterior ovary length, posterior ovary length, G1%, and G2% have high variability within the same population and should not be used. The odontophore length is often difficult to measure because the odontophore base is usually not flanged and is barely distinguishable from adjacent tissue within the corpus of the esophagus. The length and width of the basal bulb of the esophagus can be easily affected by fixation and mounting procedures. Moreover, the length measurement of the basal bulb is often uncertain due to its flask shape and lack of a delimiting anterior feature. Therefore, these parameters were not used in species discrimination. The esophagus length was used because the basal bulb is clearly separated from the intestine. In our study, only linear morphometrics were used in our cluster analysis. Brown et al. (1997) and Georgi (1988) also used only the linear morphometrics in their analysis. However, in some studies (Griesbach and Maggenti, 1990; Lamberti and Ciancio, 1993, 1994; Roca, 1996; Rubtsova et al., 1999) de Man's ratios (a, b, c, V) were frequently used. All those ratios are calculated from one of the parameters, namely body length. Therefore, body length was used multiple times in analysis and could affect the result.

The growing number of species in *Longidorus* has increased the difficulty of new species diagnosis and the determination of close relationships. Using cluster analysis as a computer-based approach, morphometric relationships among species were elucidated. Therefore, the diagnosis for new species becomes less arbitrary. This study constructed a dendrogram for all 137 published *Longidorus* species by hierachical cluster analysis using L, VL, lip width, odontostyle length, DGR, esophagus length, body width, tail length, and ABW. Thus, the species were grouped and separated by only these morphometric characters. The dendrograms generated in this study do not reflect the phylogenetic relationships of *Longidorus* species. Five species described from Arkansas and aided by cluster analysis

were diagnosed and relationships elucidated (Ye and Robbins, 2003a, 2003b, 2004).

Roca (1996) described a new species *L. apuloides* because it was thought to be close to *L. apulus* by hierarchical cluster analysis, and less close to *L. vineacola* and *L. proximus*. Brown et al. (1997) synonymized *L. apuloides* with *L. vineacola* due to its closer relationships with *L. vineacola* as shown by their cluster analysis. From our dendrogram (Fig. 2), *L. apuloides* is closest to *L. cohni*. Other similar species include *L. arenosus*, *L. balticus*, *L. vineacola*, *L. paravineacola*, *L. lusitanicus*, *L. grandis*, and *L. glycines*, whereas *L. apulus* is located in another cluster with *L. dunensis*, *L. euonymus*, *L. artemisiae*, and *L. protae*. The conflicting results among various sources are probably caused by using different data sets.

Some recently described new species were investigated for their diagnosis. Zheng et al. (2001) found L. hangzhouensis and L. belondiroides to be most similar, and they are in the same cluster in our dendrogram and are thus quite similar. Our dendrogram confirms that L. balticus closely resembles L. vineacola in the diagnosis as indicated by Brzeski et al. (2000). Rubtsova et al. (1999) considered L. artemisiae to be closest to L. elongatus, L. attenuatus, L. proximus, L. apulus, L. euonymus, and L. dunensis. In our dendrogram L. artemisiae was found in the same cluster with the last three species but was different from the first three species. Rubtsova et al. (2001) considered L. sturhani most similar with L. seinhorsti and L. artemisiae, but in our dendrogram L. breviannulatus, L. kakamus, L. pawneensis, and L. unedoi are in the same cluster with L. sturhani. Lamberti et al. (2001) compared L. helveticus with L. macrosoma, L. poessneckensis, L. picenus, and L. neves; however, in our dendrogram L. helveticus is closer to L. magnus, L. vinearum, L. macrosoma, and L. major. Longidorus camelliae is much closer to L. laevicapitatus, L. congoensis, and L. moniloides in our dendrogram than it is to L. jiangsuensis, L. belloi, and L. belondiroides as given in the description (Zheng et al., 2000). Krnjaic et al. (2000) com-



FIG. 1. Hierachical cluster dendrogram of 68 populations of nine Arkansas Longidorus species.

pared only *L. igoris* with *L. moesicus*, but in our dendogram it is grouped with *L. iranicus* and *L. trapezoides*. Krnjaic et al. (2000) compared *L. uroshis* with *L. saginus* and *L. apulus*, but it is closer to *L. silvae* in our dendogram. Barsi and Lamberti (2001) reported *L. pius* dissimilar to all other species, but in our dendrogram it is



FIG. 2. Hierachical cluster dendrogram of 137 published Longidorus species.

closer to *L. caespiticola* than to *L. picenus* and *L. nevesi*, the species they suggested. New species diagnoses are often primarily based on geographical distribution and the author's experience. Therefore, cluster analysis provides a computerized statistical approach to aid in selecting which species to compare in new species diagnosis.

Longidorus diadecturus was described as a vector of peach rosette mosaic virus in Ontario, Canada (Eveleigh and Allen, 1982). It is the most widely distributed species in Arkansas, with 36 populations found. A total of 5 L. diadecturus populations from Oklahoma, Iowa, Indiana, and Minnesota also were found in our study. In our species identification of populations, our specimens are similar with L. diadecturus, L. macromucronatus, L. martini, L. fursti, and L. jagerae in having the guide ring located posteriorly, a moderately flanged odontophore base, small body size, a slightly expanded head, similar odontostyle length, a short rounded tail and parthenogenetic reproduction. Our specimens also come close to L. jonesi, L. himalayensis, and L. doonensis but differ in the head shape, slightly expanded head in our populations vs. rounded, continuous head in the latter species. However, this difference could be intraspecies variation. Two species described from South Africa, L. fursti and L. jagerae, were not appropriately diagnosed. Longidorus fursti was compared with L. pisi, L. mobae, and L. latocephalus (Heyns et al., 1987). Longidorus jagerae was compared with L. fursti, L. pisi, L. mobae, and L. latocephalus (Heyns and Swart, 1998). Instead of comparing with those much closer species L. macromucronatus, L. martini, L. jonesi, L. diadecturus, L. himalayensis, and L. doonensis. Heyns et al. (1987) studied the ultrastructure of the flanged odontophore base of L. fursti. The same structure was also observed by Cho and Robbins (1990) in studying L. diadecturus from Arkansas. Longidorus diadecturus is similar to L. macromucronatus. Eveleigh and Allen (1982) distinguished the two species by the shape and length of the corpal mucro (sagittate, 1-2 µm in L. diadecturus vs. conoid, which is more than 5 µm in L. macromucronatus), length of odontophore (55-66 µm in L. diadecturus vs. 67-77 µm in L. macromucronatus). The corpal mucro was usually not found in our specimens and is a difficult structure to observe due to its small size and the clouding of the esophagus in fixed specimens. The odontophore length of our various populations ranges from 55 µm to 78 µm, in the combined range of both species. Therefore, could L. diadecturus described from Canada possibly be synonymous with L. macromucronatus, described from halfway around the world in India? Cluster analysis of all Longidorus species showed that L. diadecturus, L. martini, L. fursti, L. jagerae, L. macromucronatus, L. mobae, L. himalayensis, and L. doonensis are in one cluster. Moreover, paratypes of L. macromucronatus from India measured by us had a close relationship with L. diadecturus based on our unpublished dendrogram. Whether

L. diadecturus, L. martini, L. fursti, and L. jagerae are synonymous with L. macromucronatus, and whether L. himalayensis, and L. doonensis are synonymous with L. jonesi, or whether they are all synonymous with L. macromucronatus is not clear and will remain unclear without examining all the type specimens or comparing DNA sequences.

Longidorus crassus was frequently found in Arkansas. The specimens of various populations generally conform to the original description (Thorne, 1974) and redescription of this species (Robbins and Brown, 1995) but show a large morphometric variation between populations. Specimens of population Long-10 have a longer body and shorter odontostyle compared with the other populations in Arkansas. Specimens of population Long-80 have longer odontostyle, longer tail, and more posteriorly located guide ring. The body length of one female of population Long-63 is 8,074 µm, but the body length of the other 34 females range from 4,370 µm to 6,315 µm. Some females of many populations (Long-12, Long-14, Long-40, Long-75, Long-90, Long-157, Long-214) are less than 4,000 µmmuch smaller than the type specimens (5,000-6,000 µm). Without observing any other morphological difference, we considered those differences as intraspecific variation and identified them as L. crassus. Due to the high intraspecies morphometric variation, L. crassus populations are in several clades, as shown in Fig. 1.

The cluster analysis dendrogram illustrated the grouping and morphometric relationships of all 137 published Longidorus species. Morphometrically similar species are grouped in the same cluster and separated from the other species. This approach has proven useful in establishing relationships among species by examining our populations and published species. The hierachical cluster analysis on test samples together with all the published Longidorus morphometric data appears to provide a reliable means for distinguishing and identifying Longidorus species, for establishing relationships among species, and for assisting new species diagnosis. However, the conclusive identification must also refer to quantitative morphology (head shape, amphid shape, tail shape, etc.), presence or absence of males, geographical distribution, DNA sequences, and comparison with type specimens, if possible. The cluster analysis approach is better than using keys in the following ways: (i) it has no need to transform the data into code, (ii) resulting dendrograms clearly demonstrate the relationships of the species without user prejudice, and (iii) JMP software has a Windows-based interface and is easy to use without any complicated programming.

LITERATURE CITED

Adams, B. J. 1998. Species concepts and the evolutionary paradigm in modern nematology. Journal of Nematology 30:1–21.

Barsi, L., and F. Lamberti. 2001. Longidorus pius sp. n. (Nematoda:

Longidoridae) from Macedonia. Nematologia Mediterranea 29:207–213.

Bravo, M. A., and F. Roca. 1998. Two *Longidorus* species (Nematoda: Longidoridae) occurring in the rhizosphere of olive trees in northeastern Portugal. Agronomia Lusitana 46:101–121.

Brown, D. J. F., R. Neilson, T. Connolly, and B. Boag. 1997. An assessment of morphometric variability between populations of *Longidorus vineacola* Sturhan & Weischer, 1964 (Nematoda: Longidoridae) and morphologically related species. Systematic Parasitology 37:93–103.

Brzeski, M. W., V. Peneva, and D. J. F. Brown. 2000. *Longidorus balticus* sp. nov. (Nematoda: Longidoridae) from coastal sand dunes in northeast Poland. Nannales Zoologici 50:321–325.

Chen, Q. W., D. J. Hooper, P. A. A. Loof, and J. H. Xu. 1997. A revised polytomous key for the identification of species of the genus *Longidorus* Micoletzky, 1922 (Nematoda: Dorylaimoidea). Fundamental and Applied Nematology 20:15–28.

Cho, M. R., and R. T. Robbins. 1990. Scanning electron microscopy of Xiphinema, Longidorus, and Californidorus stylet morphology. Journal of Nematology 22:162–169.

Cho, M. R., and R. T. Robbins. 1991. Morphological variation among 23 *Xiphinema americanum* populations. Journal of Nematology 23:134–144.

Eveleigh, E. S., and M. W. Allen. 1982. Description of *Longidorus diadecturus* n. sp., a vector of peach rosette mosaic virus in peach orchards in southwestern Ontario, Canada. Canadian Journal of Zoology 60:112–115.

Georgi, L. L. 1988. Morphological variation in *Xiphinema* spp. from New York orchards. Journal of Nematology 20:47–57.

Griesbach, J. A., and A. R. Maggenti. 1990. The morphometrics of *Xiphinema americanum sensu lato* in California. Revue de Nématologie 13:93–103.

Heyns, J., A. Coomans, M. Hutsebaut, and A. Swart. 1987. *Longidorus fursti* n. sp. from South Africa with a discussion of its relationships (Nematoda: Longidoridae). Revue de Nématologie 10: 381–385.

Heyns, J., and A. Swart. 1998. *Longidorus jagerae* sp. n., another longidorid species with globular inclusions in the pre rectum. (Nematoda: Longidoridae). Koedoe 41:31–36.

Krnjaic, D., F. Lamberti, S. Krnjaic, A. Agostinelli, and V. Radicci. 2000. Three new Longidorids (Nematoda: Dorylaimida) from Montenegro. Nematologia Mediterranea 28:235–248.

Lamberti, F. 1975. Taxonomy of *Longidorus* (Micoletzky) Filipjev and *Paralongidorus* Siddiqi, Hooper & Khan. Pp. 71–90 *in* F. Lamberti, C. E. Taylor, and J. W. Seinhorst, eds. Nematode vectors of plant viruses London: Pleunum Press.

Lamberti, F., and A. Ciancio. 1993. Diversity of *Xiphinema america-num*-group species and hierarchical cluster analysis of morphometrics. Journal of Nematology 25:332–343.

Lamberti, F., and A. Ciancio. 1994. The relationship between species within the *Xiphinema americanum*-group (Nematoda: Dorylaimida). EPPO Bulletin 24:475–484.

Lamberti, F., P. Kunz, J. Grunder, S. Molinari, F. de Luca, A. Agostinelli, and V. Radicci. 2001. Molecular characterization of six *Longidorus* species from Switzerland with the description of *Longidorus helveticus* sp. n. (Nematoda, Dorylaimida). Nematologia Mediterranea 29:181–205.

Lamberti, F., S. Molinari, M. Moens, and D. J. F. Brown. 2002. The *Xiphinema americanum*-group. II. Morphometric relationships. Russian Journal of Nematology 1:99–112.

Loof, P. A. A., and Q. Chen. 1999. A revised polytomous key for the identification of species of the genus Longidorus Micoletzky, 1922 (Nematoda: Dorylaimoidea). Supplement 1. Nematology 1:55–59.

McHenry, M. 1987. Letter to the editor. Plant Disease 70:864.

Rey, J. M., M-Fe. Andres, and M. Arias. 1988. A computer method for identifying nematode species. 1. Genus *Longidorus* (Nematoda: Longidoridae). Revue de Nématologie 11:129–135.

Robbins, R. T., and D. J. F. Brown. 1995. Amended description of Longidorus sylphus Thorne, 1939, L. crassus Thorne, 1974, and L. fragilis Thorne, 1974 (Nematoda: Longidoridae). Journal of Nematology 27:94–102.

Roca, F. 1996. Longidorus apuloides n. sp. (Nematoda: Longidoridae) from Italy with a hierarchical cluster analysis of the closely related species. Fundamental and Applied Nematology 19: 315–320.

Romanenko, N. D. 1978. A polytomous key for determining species of nematodes of the genus *Longidorus* Micoletzky, 1992. Fitogel' mintologicheskie Issledovaniya, Moscow, Russia, "Nauka": 111–114.

Rubtsova, T. V., V. N. Chizhov, and S. A. Subbotin. 1999. *Longidorus artemisiae* sp. n. (Nematoda: Longidoridae) from roots of Artemisia sp., Rostov Region, Russia. Russian Journal of Nematology 7:33–38.

Rubtsova, T. V., S. A. Subbotin, D. J. F. Brown, and M. Moens. 2001. Description of *Longidorus sturhani* sp. n. (Nematoda: Longidoridae) and molecular characterization of several longidorid species from Western Europe. Russian Journal of Nematology 9:127– 136.

Taylor, C. E., and D. J. F. Brown. 1997. Nematode vectors of plant viruses Wallingford, UK: CAB International.

Thorne, G. 1961. Principles of nematology. New York: McGraw-Hill.

Thorne, G. 1974. Nematodes of the Northern Great Plains. Part II. Dorylaimoidea in part (Nemata: Adenophorea). Technical Bulletin 41. South Dakota Agricultural Experiment Station.

Tiefenbrunner, A., M. Tiefenbrunner, W. Tiefenbrunner, and A. Wahra. 2002. A software tool as an aid to the identification of species of Longidorus Micoletzky, 1922 (Nematoda: Dorylaimoidea). Nematology 4:845–852.

Ye, W. M. 1996. Applying Microsoft Works Spreadsheet in statistics for morphometric data of nematode identification. Afro-Asian Journal of Nematology 6:203–211.

Ye, W. M., and R. T. Robbins. 2003a. *Longidorus grandis* n. sp. and *L. paralongicaudatus* n. sp. (Nematoda: Longidoridae), two parthenogenetic species from Arkansas. Journal of Nematology 35:375–387.

Ye, W. M., and R. T. Robbins. 2003b. *Longidorus paravineacola* n. sp. (Nematoda: Longidoridae), a new species from Arkansas. Journal of Nematology 35:388–394.

Ye, W. M., and R. T. Robbins. 2004. *Longidorus biformis* n. sp. and *L. glycines* n. sp. (Nematoda: Longidoridae), two amphimictic species from Arkansas. Journal of Nematology 36, in press.

Zheng, J., V. Peneva, and D. J. F. Brown. 2000. *Longidorus camelliae* n. sp. (Nematoda: Longidoridae) associated with ornamental cultivars of *Camellia japonica* L. growing in a nursery at Fuyang, Zhejiang Province, eastern China. Systematic Parasitology 47:119–125.

Zheng, J. W., R. T. Robbins, and D. J. F. Brown. 2001. Description of *Longidorus hangzhouensis* sp. n. (Nemata: Longidoridae) from Zhejiang province, new geographical records of *L. henanus* Xu & Cheng, 1992, and an identification key for *Longidorus* species occurring in China. Nematology 3:219–227.

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