WIADOMOŚCI PARAZYTOLOGICZNE
T. XXXV, NR 2: 1989

A NUMERICAL ANALYSIS OF THE AMERICAN SPECIES OF THE GENUS *RICINUS* (*PHTHIRAPTERA*: *AMBLYCERA*) *

ELŻBIETA LONC

Zakład Parazytologii Ogólnej, Instytut Mikrobiologii UWr, Wrocław

The genus *Ricinus* De Geer, 1778 (*Phthiraptera*: *Amblycera*) comprises a cosmopolitan group of the largest, haematophagous ectoparasites of passerine birds. Species of *Ricinus* appear on members of 28 of the 70 families of *Passeriformes*. Systematically, the genus presents a number of interesting and controversial problems (Eichler, 1963; Złotorzycka, 1965; Rheinwald, 1969 and Nelson, 1972). The present taxonomic status of *Ricinus* species occurring in the New World was established by Nelson (1972). He redescribed the genus and 38 species, considered as valid, divided into nine species-groups. Those species were defined on the basis of the external morphology with emphasis on the chaetotaxy. The descriptions, presented in this revision, served mainly for the current numerical treatment.

This study was undertaken in order to analyse phenetic relationships among 38 species of *Ricinus* with various methods of numerical taxonomy according to Sneath and Sokal (1973) and compare the results with Nelson's arrangement. Techniques of numerical taxonomy were successfully used in the classifications of various groups of mammal and bird ectoparasites (Moss, 1967; Herrin, 1970; Johnston and Kethley, 1973; Moss et al., 1977). The first numerical treatment of three mallophagan genera, based only on 21 quantitative characters (measurements and ratios), looked promising (Eveleigh and Amano, 1977). Another purpose of the present study was to investigate the effect of using different data sets of adult, morphological characters on the results of the phenetic classification of *Ricinus*.

* It was partly presented as a poster at the 1st European Biometric Conference in Budapest, and as a whole at the XVI Parasitological Colloquy in Berlin (1988).

TABLE 1

Species of the genus *Ricinus* used in this study

Code no.	Names of groups and species	No. of individuals examined by Nelson ♀♀	♂♂
	Brevicapitis species group (B)*		
(1)	*R. brevicapitis* Carriker, 1964	1	—
	Arcuatus species group (A)		
(2)	*R. arcuatus* (Kellogg and Mann, 1912)	46	14
(3)	*R. myiarchi*, Nelson, 1972	3	1
(4)	*R. leptosomus* (Carriker, 1903)	12	3
(5)	*R. sucinaceus* (Kellogg, 1896)	23	2
(6)	*R. pessimalis* Eichler, 1956	17	1
	Fringillae species group (F)		
(7)	*R. fringillae* De Geer, 1778	106	16
(8)	*R. japonicus* (Uchida, 1915)	7	1
(9)	*R. microcephalus* (Kellogg, 1896)	5	—
(10)	*R. elongatus* (Olfers, 1816)	32	1
	Mandibulatus species group (MN)		
(11)	*R. mandibulatus* Nelson, 1972	1	—
	Invadens species group (I)		
(12)	*R. invadens* (Kellogg, 1899)	5	5
	Serratus species group (SE)		
(13)	*R. serratus* (Durrant, 1906)	15	3
	Marginatus species group (MR)		
(14)	*R. flavicans* Carriker, 1964	1	—
(15)	*R. marginatus* (Children, 1836)	54	12
(16)	*R. frenatus* (Burmeister, 1838)	1	1
(17)	*R. polioptilus* Carriker, 1964	1	—
(18)	*R. pallens* (Kellogg, 1899)	7	3
(19)	*R. dalgleishi* Nelson, 1972	16	—
(20)	*R. picturatus* (Carriker, 1902)	32	3
(21)	*R. emersoni* Nelson 1972	19	5
(22)	*R. dendroicae* Nelson, 1972	60	12
(23)	*R. seiuri* Nelson, 1972	12	3
	Subangulatus species group (SU)		
(24)	*R. subhastatus* (Durrant, 1906)	15	6
(25)	*R. wolfi* Nelson, 1972	12	5
(26)	*R. subangulatus* (Carriker, 1903)	5	—
(27)	*R. complicatus* Carriker, 1964	2	—
(28)	*R. ramphoceli* Nelson, 1972	12	5
(29)	*R. volatiniae* Nelson, 1972	3	—
(30)	*R. vireoensis* Nelson, 1972	89	38
	Diffusus species group (D)		
(31)	*R. subdiffusus* Nelson, 1972	7	3
(32)	*R. sittae* Nelson, 1972	—	2
(33)	*R. diffusus* (Kellogg, 1896)	119	26
(34)	*R. calcarii* Nelson, 1972	11	2
(35)	*R. thoracicus* (Packard, 1870)	8	7
(36)	*R. ivanovi* Blagoveshtchensky, 1951	8	3
(37)	*R. carolynae* Nelson, 1972	6	1
(38)	*R. australis* (Kellogg, 1896)	16	2

* Abbreviations of species groups used at the figures.

Material and methods

The 38 species, identified in Nelson's revision (1972), were used as operational taxonomic units (OTUs according to Sneath and Sokal, 1973). Table 1, above, lists the species, their code number in the arrangement given by Nelson, as well as the number of adult male and female specimens examined. Of the 38 species, ten were represented by one sex only; they were included and analysed with the rest.

A total of 130 morphometric characters were selected from various body regions: head (52), thorax (26) and abdomen (52). Of these, 109 were qualitative, 17 measurements and 4 ratio characters. For the present study the characters were subdivided into four main subsets: the morphology of head, the morphology of non-head, the chaetotaxy of head, the chaetotaxy of non-head. The comparisons were made between various combinations of regions: head vs. non-head characters, morphological vs. chaetotaxy characters. Each descriptive character was coded into a convenient series of states; the maximum was five states. The zero score is given if the character is absent, one for the present state and NC (no comparison) for missing information. Among the 130 characters $\times$ 38 OTUs matrix there were forty characters containing a total of 240 NC values. Means were used for all measurement characters.

For phenetic analysis the data underwent standard taxonomic procedures using the NT-SYS system of numerical taxonomic computer programs (Rohlf et al., 1980). Characters were standardized before the computation of matrices of distance and correlation coefficients between OTUs. These matrices were clustered using the UPGMA (unweighted pair group methods with arithmetic averaging). Minimum Spanning Trees (MST) were also computed. The subset algorithm was used to find small clusters. Distortions of the original similarity matrix by the clustering procedures were estimated by computing the cophenetic correlation for each distance and correlation phenogram (subprogram MXCOMP). Q-mode factor analysis was performed by subprogram FACTOR. Relationships between 38 species points in 3-dimensional PCA space served as the initial configuration for the MDSCALE analysis.

Classifications based on various subsets of data were compared by the matrix correlations and the strict consensus index (CI_c) (Rohlf, 1970; 1982). All computations were carried out on a UNIVAC computer at the SUNY at Stony Brook using the facilities in the Department of Ecology and Evolution.

Results

Figs. 1a-5a present distance UPGMA phenograms, and figures 1b-5b correlation UPGMA phenograms. They were computed from the following sets of characters: all morphological with chaetotaxy (130), morphological (70), chaetotaxy (60), referring to head (52) and referring to non-head (78).

For the sake of clarity, the arrangement of relationships of *Ricinus*, given by Nelson (1972), will be used as the standard for comparison. The species groups recognized previously are present in the majority of phe-

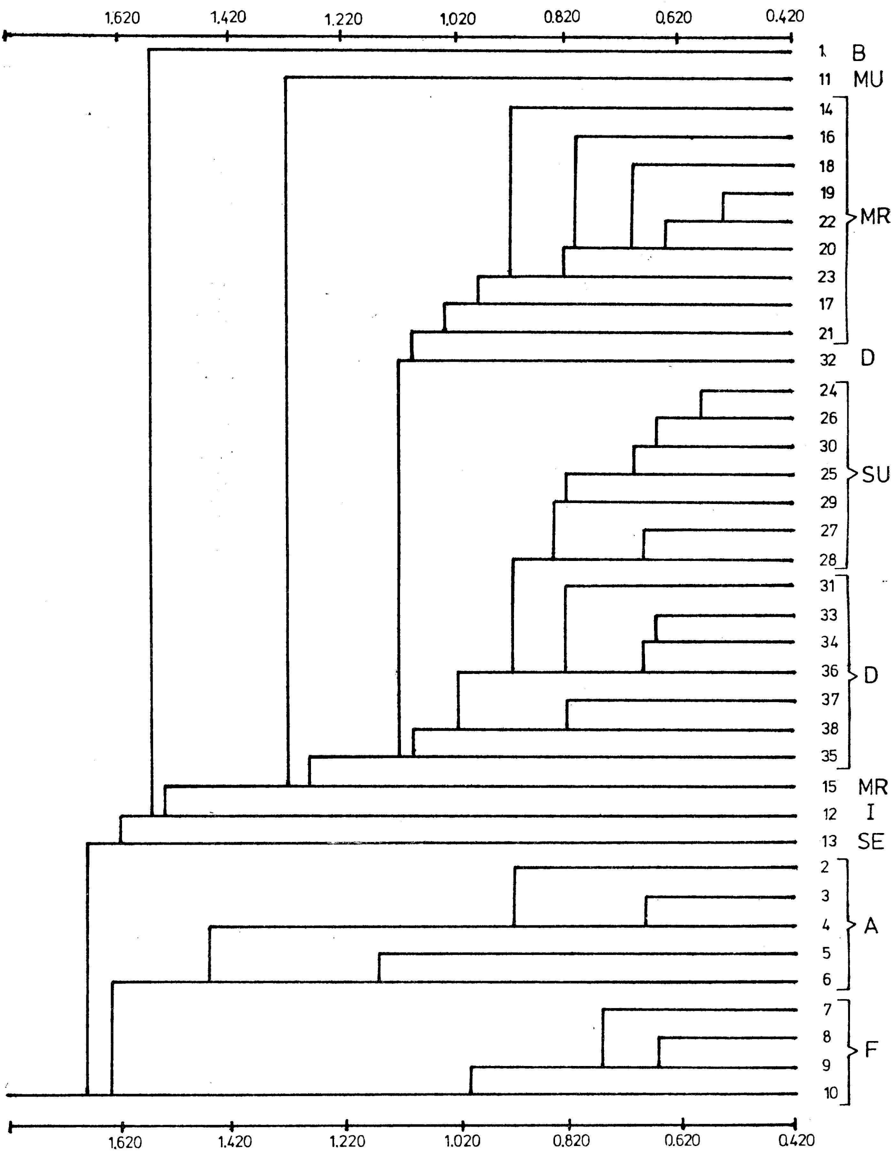

Fig. 1a. UPGMA phenogram of a distance Q-matrix on all (130) characters. Species code and species groups assignments are given in tab. 1

nograms. In all cases the arcuatus species group (OUTs 2-6) and the fringillae (OTUs 7-10) remain as distinct clusters and the compositions of taxa within each cluster are the same. Four single species groups: the brevicapitis (OTU 1), the mandibualtus (OTU 11), the invadens (OTU 12) and the serratus (OTU 13) occupy isolated positions, but sometimes join different stems. The species from the marginatus group (OTUs 14-23) usually form a cluster, except for *R. marginatus* (OTU 15), which is

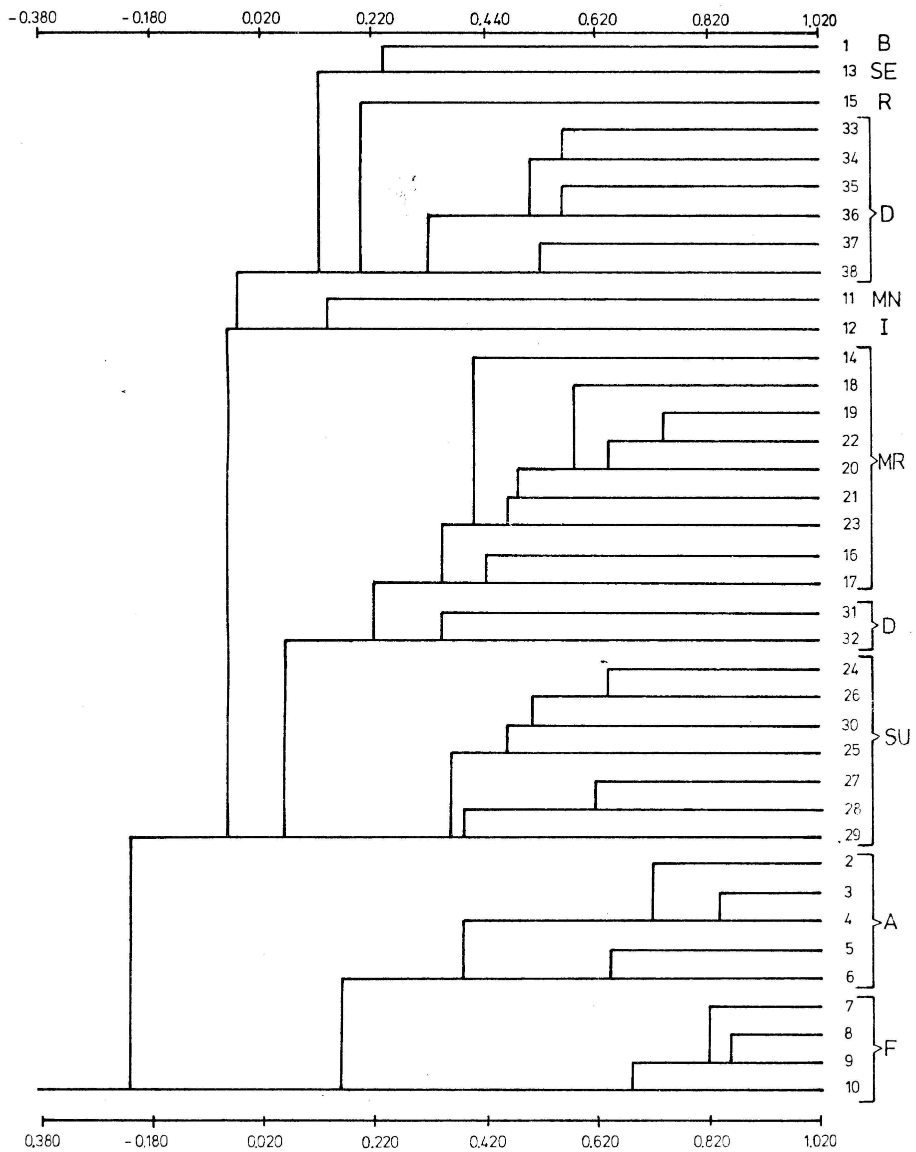

Fig. 1b. UPGMA phenogram of a correlation Q-matrix on all (130) characters

separated from the rest in all phenograms, as well as *R. polioptilus* (OTU 17) and *R. emersoni* (OTU 21) separated in chaetotaxy phenograms. The subangulatus species group (OTUs 24-30) is also a unit, except in the phenogram based on chaetotaxy. OTUs 31-38 correspond entirely to the diffusus group only on the correlation phenogram of head. On the remaining phenograms, however, there is no absolute correspondence to this type.

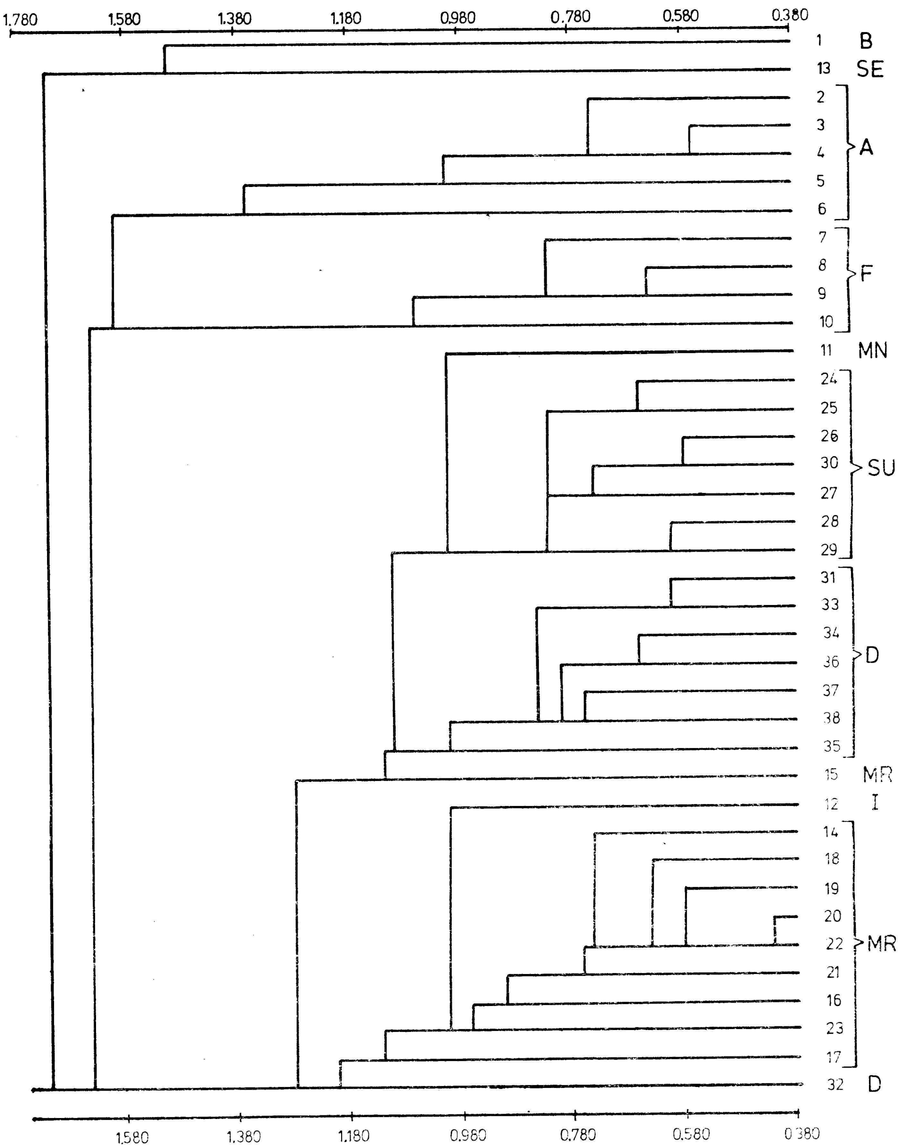

Fig. 2a. UPGMA phenogram of a distance Q-matrix on 70 morphological characters

Distance as well as correlation phenograms present highly similar relationships within *Ricinus*. But the cophenetic correlations of matrices based on distance are greater (0.960-0.769) than those based on correlation coefficients (0.902-0.687) (tab. 3). For this reason, further discussion deals primarily with results based on matrices of distance coefficients (figs. 1a-5a).

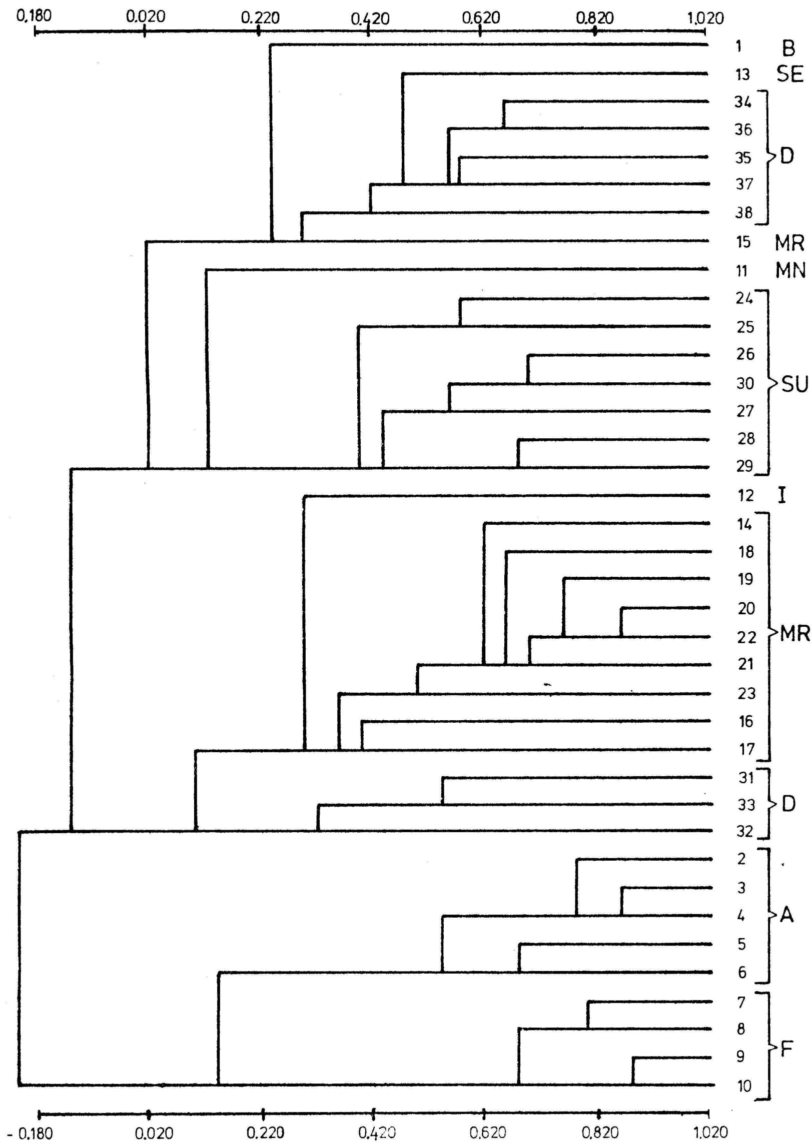

Fig. 2b. UPGMA phenogram of a correlation Q-matrix on 70 morphological characters

Comparison phenograms based on head and non-head characters. Figs. 1a, 4a and 5a show the distance phenograms based on all characters, as well as those of head and non-head. Head and total phenograms are very close to the previous, conventional classification. In particular, there is a perfect agreement in the case of the first three species groups with dimorphic mandibles, presented in the head phenogram (fig. 4a). Beginning at the top, the brevicapitis (1), the arcuatus (2-6) and the fringillae

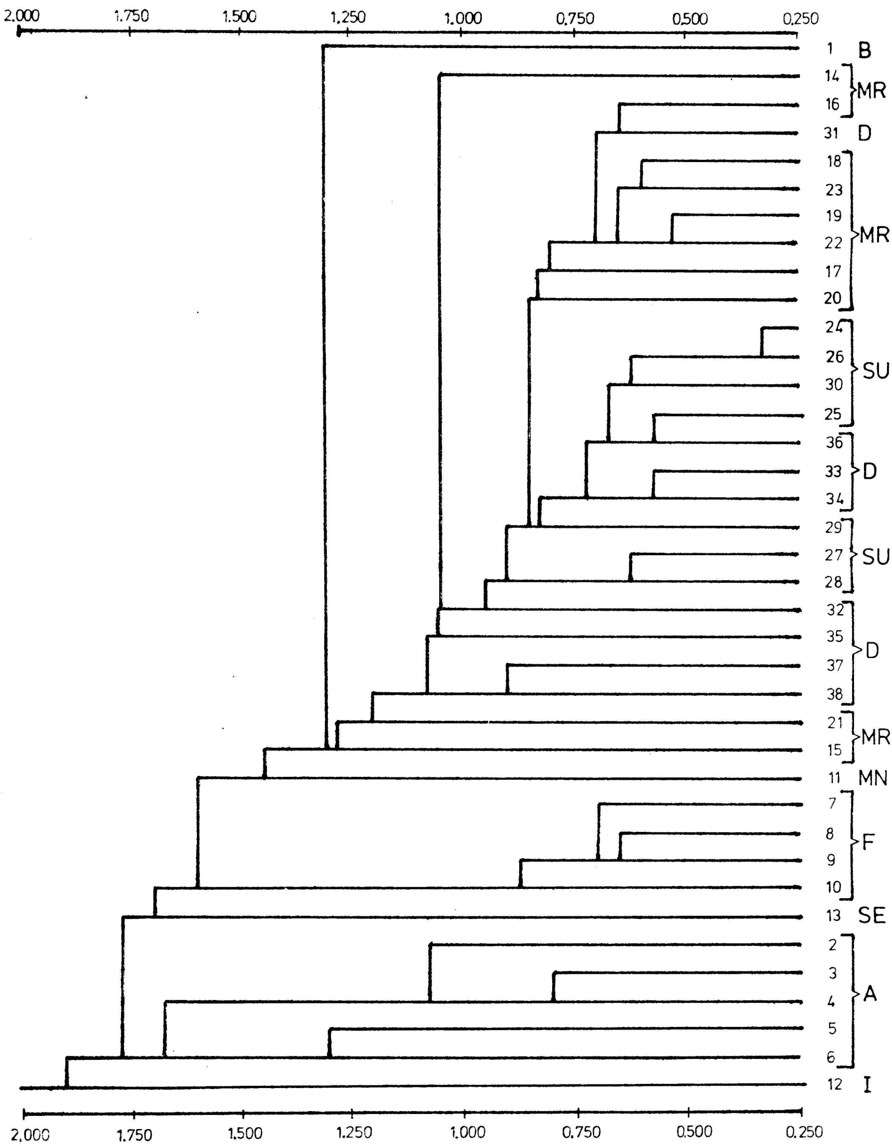

Fig. 3a. UPGMA phenogram of a distance Q-matrix on 60 chaetotaxy characters

(7-10) form together a distinct cluster, which is subdivided into three smaller ones. The brevicapitis, consisting of a single species *R. brevicapitis* (1), occupies an isolated position. *R. brevicapitis* links closely related to *R. arcuatus* (2), before joining the fringillae (7-10), which are known as the most advanced of species with dimorphic mandibles. *R. mandibulatus* (11), intermediate between species with dimorphic and monomorphic mandibles links *R. marginatus* (15), the most similar in the shape of head

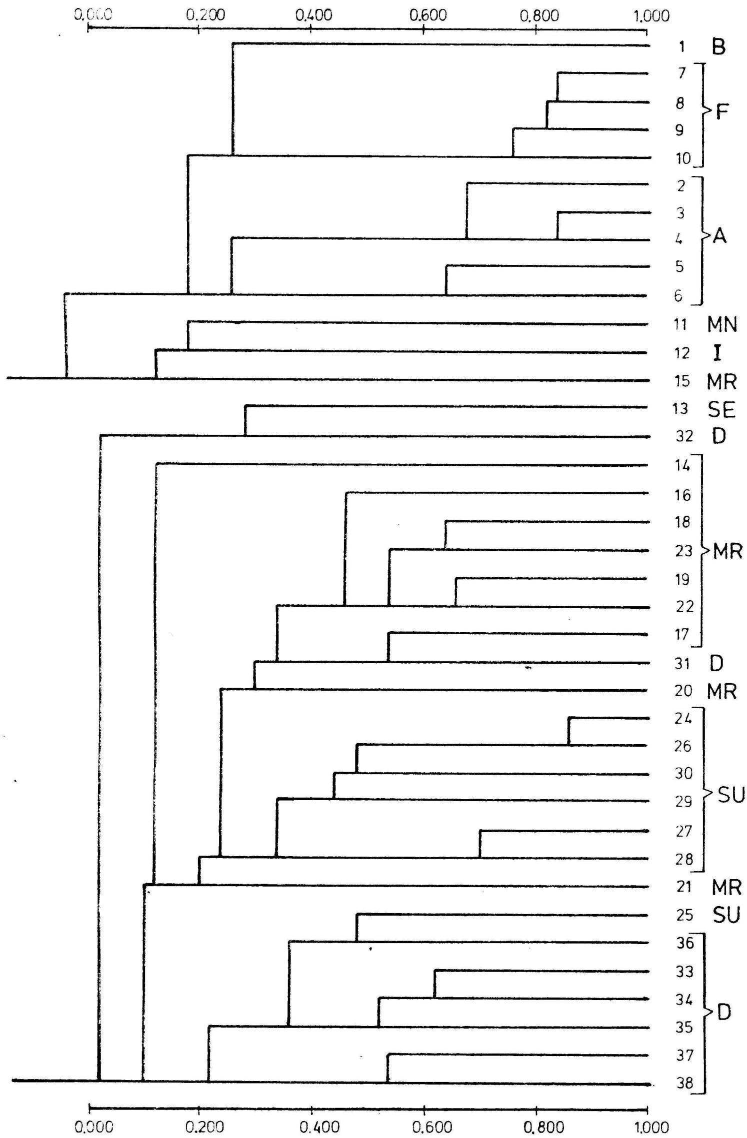

Fig. 3b. UPGMA phenogram of a correlation Q-matrix on 60 chaetotaxy characters

and prothorax. The second intermediate species *R. invadens* (12) is quite separated and joins the marginatus group (14-23). As expected, the remaining species, with monomorphic mandibles, are found together as three recognizable single clusters. The latter reflect the division into the subangulatus (14-23) species group, the diffusus (31-38) and the marginatus (14-23). Both the head and total phenograms show general agreement with the placement of all members into nine species groups. Only

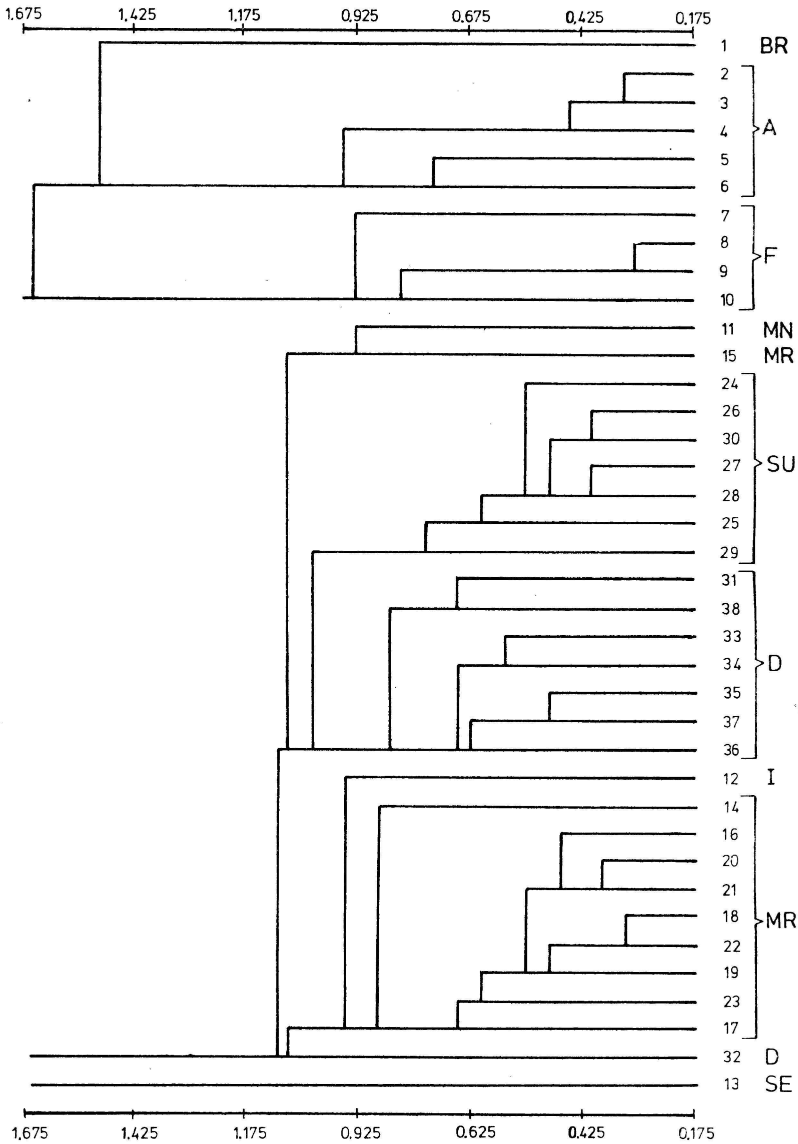

Fig. 4a. UPGMA phenogram of a distance Q-matrix on 52 head characters

R. marginatus (15), representative of the marginatus group, and *R. sittae* (32) from the diffusus group, are removed from the previous groups and link different stems. Matrix correlation between two versions of similarity coefficients is the highest (0.924) for distance (d) phenograms based on head and all characters (tab. 4).

The phenogram based on non-head characters (fig. 5a) does not match well with either the total phenogram (fig. 1a) or the head phenogram

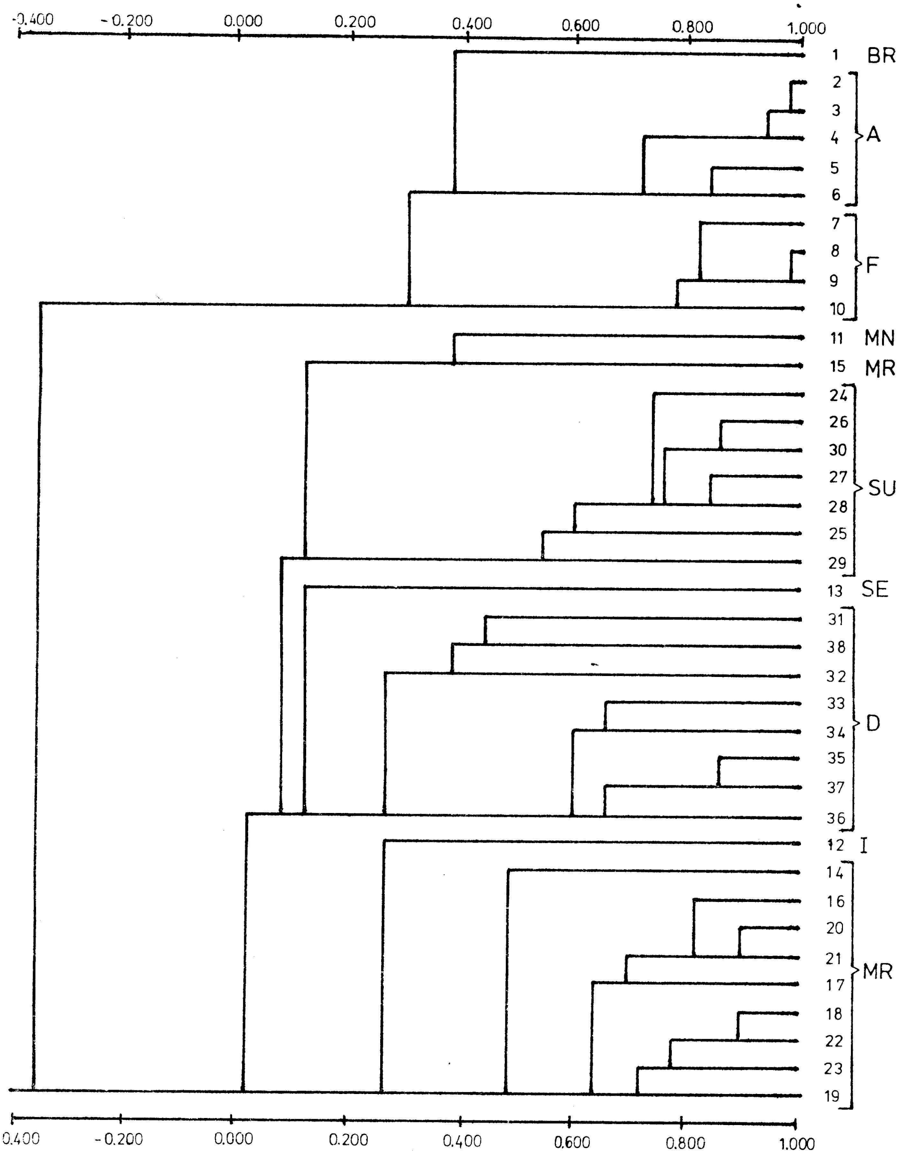

Fig. 4b. UPGMA phenogram of a correlation Q-matrix on 52 head characters

(fig. 4a). Cophenetic correlation of head and non-head distance matrices is only 0.699 and the strict consensus index (IC_c) is the lowest 0.111 (tab. 4). Although in figs. 4a and 5a two species groups: the arcuatus and the fringillae, form identical cluster, their placement on those phenograms is different. The first group, the brevicapitis (1), remains intact on the non-head phenogram, but joins the single group of the serratus (13), the most isolated species of *Ricinus*, instead of the expected link

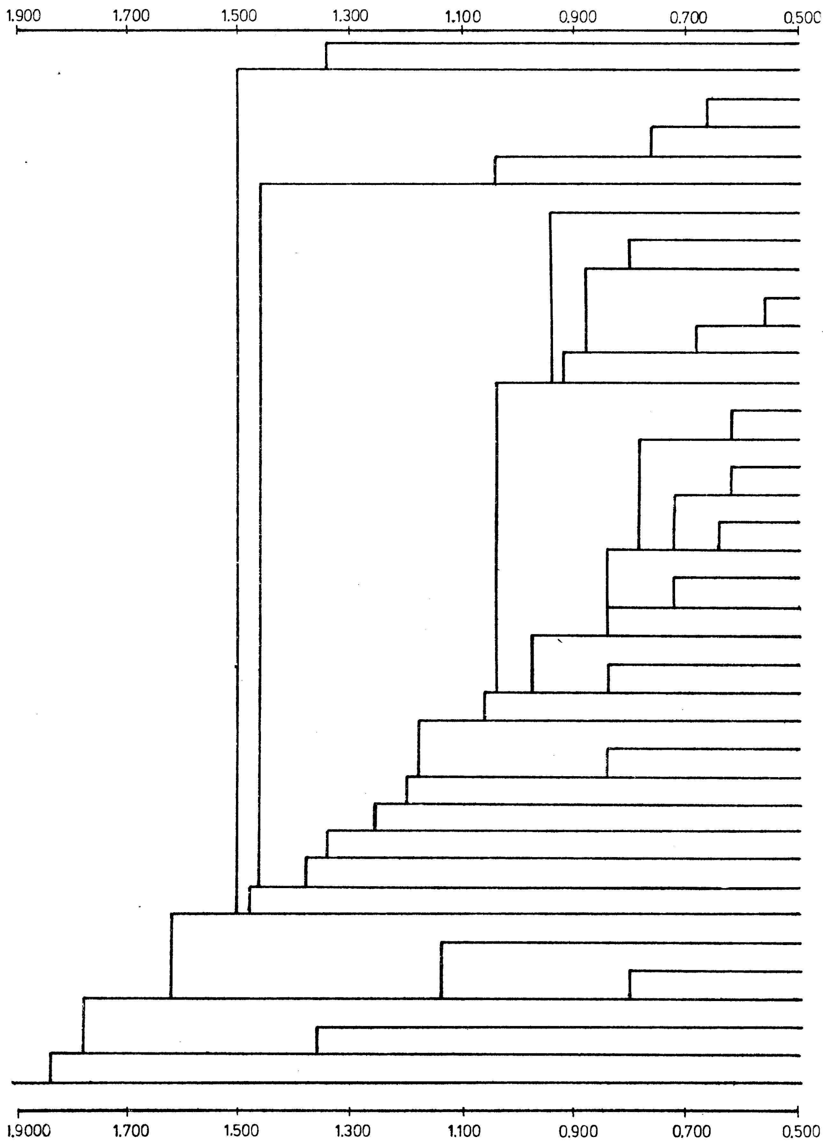

Fig. 5a. UPGMA phenogram of a distance Q-matrix on 78 non-head characters

with the arcuatus group. The previously separated position of *R. serratus* (13) is occupied by *R. invadens* (12), the only member of the invadens species group. Among species with monomorphic mandibles the marginatus is the only evident cluster. Members of the two remaining groups (the subangulatus and diffusus) are intermixed (fig. 5a).

Comparison of phenograms based on morphological and on chaetotaxy characters. — Phenograms based on distance coefficients with all chara-

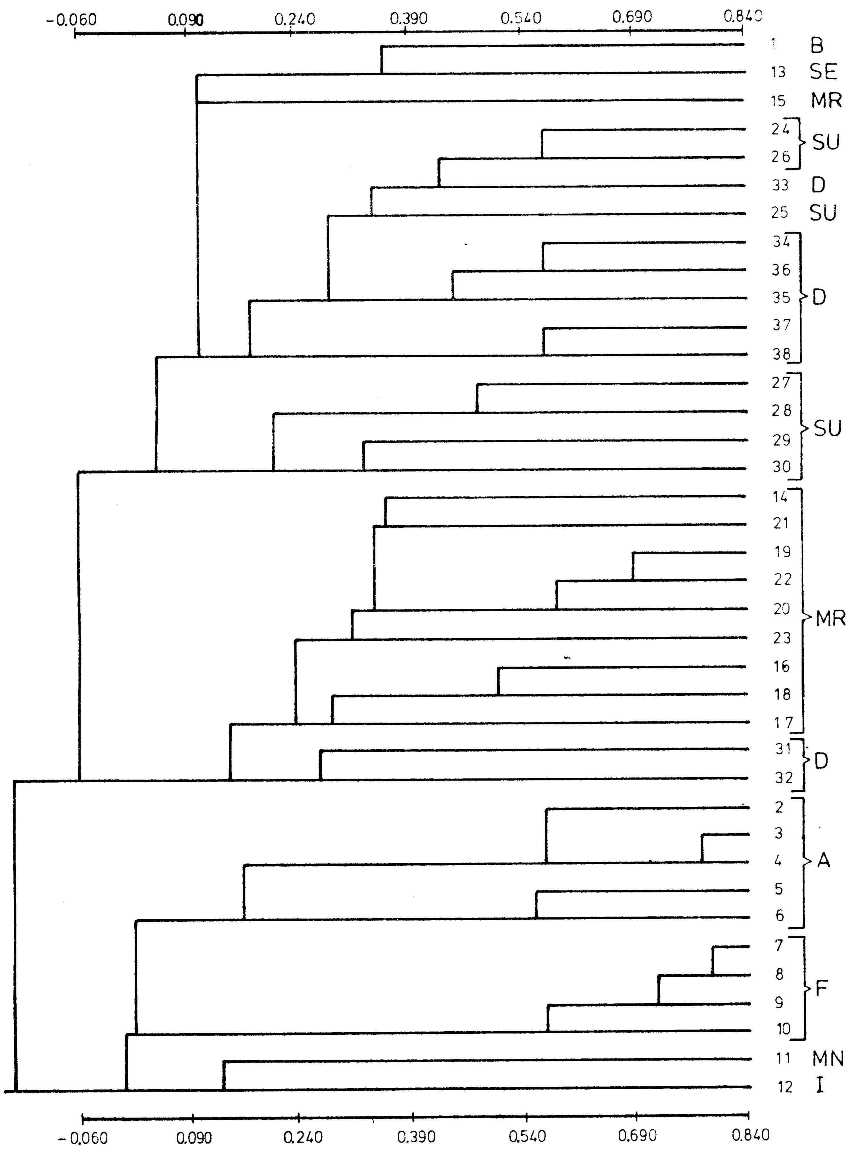

Fig. 5b. UPGMA phenogram of a correlation Q-matrix on 78 non-head characters

TABLE 2

Characters used in this study

Character names	Character states
Head characters	
Shape of head	conical — subconical — spatulate
Lateral margins of head	straight — slightly concave
Development of tentorium	strongly developed — well — poorly — reduced
Shape of frons	broadly elliptical — rounded — truncate
Margin of frons and margin of marginal carina	continuous — not continuous
Transverse carina	present — absent
Shape of transverse carina	straight — convex — arched
Eyes	protruded — slightly raised or reduced
Shape of occipital margin	elliptical — concave — biconcave
Shape of occipital nodus	biconcave — concave
Shape of head's articulation	rodlike — narrowly lobelike — broad lobe
Shape of temples	triangular — subtriangular
Lunar nodi	present — absent
Size of lunar and tentorial nodi	lunar nodi larger than tentorial — equal — smaller
Type of mandibles	dimorphic — intermediate — monomorphic
Shape of mandibular tips	needlelike — moderately thin — short, thick
Shape of right mandibular tip	hooked not notched — notched
Size of maxillary palpi	equal — unequal
Shape of maxillar plated	large, rectangular — wide, sausage shaped — narrow
Appearance of maxillary palpi	straight — weekly genticuloid — genticuloid
Pigment pattern on maxillary palpi	present — absent
Size of sclerites on maxillary palpi	equal — unequal
Ovoid sclerites of hypopharynx	evident — not evident
Ornamentation of hypopharynx	heavily ornamented — ornamented with pitlike holes — finely pitted — not ornamented
Shape of margin of labium	rounded — medially concave — concave
Shape of gular plate	without posterior extension — small extension — long extension
Pigmented mental plate	evident — not evident
Head length of male and female	(metric characters)
Head width of male and female	
Head index of male and female	
Labral width of male and female	
Non-head characters	
Shape of prothorax	hexagonal — subchordate — unique

Epimera III fused with ventral pleurites	evident — not evident
Shape of sternal plates	pear shaped, wide — regular — narrow
Shape of margins of sternal plates	concave — slightly biconcave — biconcave
Apex of sternal plates	broadly rounded — narrow — truncate
Size of sternal plates	reaching past of margin — more — long
Shape of abdomen	margins parallel — slightly ovoid
Thickness of pleural nodi	thick, wide — medium — narrow
Shape of pleural nodi	margins notched — not notched
Pigmentation of pleurites	not pigmented — partly pigmented — completely
Colour of abdomen pleurites	brown — black — golden — brown golden — oxblood
Colour of sternites	brown — golden brown — gold
Pigmentation of sternites	lack — slightly pigmented — pigmented
Pigmentation of tergites	present — absent
Shape of parameres	elongate — short, acute — short, obtuse apices — rounded
Shape of mezosome	entire — pointed — large plate
Shape of preputial sac	a bouquet of cut flowers — a flower with petallike lobes — amorphous
Pigmentation of mezosome	present — absent
Total length of male and female	(metric characters)
Greatest width of male and female	
Ratio of body length to body width of male and female	
Ratio of body length to head length of male and female	
Prothorax length of male and female	
Prothorax width of male and female	
Ratio of prothorax width to prothorax length of male and female	
Distance between prosternals in male and female	
Width of male genitalia	

Chaetotaxy

Number of setae in cf series	10 — 12
Number of setae in a series	6 pairs — absent a4 — absent a3
Size of setae m1—m3	equal — unequal
Position of mental setae	laterally — anterio-posteriorly
Basic number of gular setae	2 pairs — 3 — from 4 to 9
Setae of series df	present — absent
Number of labial setae	less than 14 — 14 — more than 14
Number of setae along antennal lappets	less than 9 — from 9 to 15 — more than 15
Number of sensilla associated with a1	one sensillum — two

Distance of sensilla from a1	equal — unequal
Setae a6	present — absent
Type of preantennal setae	spinose — pilose
Size of setae a1 according to m4	a1 shorter than m4 — equal
Size of seate m4 according to pa series	shorter than pa series — equal — longer
Number of postocular series	two setae — three — four
Size of setal pair po2	po2 equal po1 and po3 — slightly larger — po2 twice of po1
Position of setae m2	on marginal carinae — on inner margin of marginal carinae — off
Setae L3	present — absent
Setae L6	present — absent
Size of setae L5 in relation to L4—L6	equal — L5 longer than L4—L6
Size of setae L9 in relation to L7—L8	equal — slightly shorter — shorter
Setae c4	present — absent
Size of c3 in relation to c4	equal — c4 longer than c3 — c4 twice as c3
Size of c1 in relation to c2	nearly equal — c1 longer
Kind of setae c2	spinose — pilose
Setae of w series	similar — not similar
Number of setae in w series	5, 6 — more than 6
Present of setae in q series	q2 — (q2+q3) — (q2+q5) — (q1+q5) — (q2+q3+q4)
Appearance of setae q2	strongly spinose — weakly spinose
Size of q2 in relation to w series	q2 shorter than w — equal — q2 longer
Size of setae b1 in relation to b2	b1 shorter than b2 — equal
Number of sternal medial setae	one pair — two — three
Size of sternal medial setae	moderately long — long
Size of sternal posterior setae	short — medium sized
Type of setae on ventral abdominal pleurite II	spinose — mixed — pilose
Size of setae on pleurite II	small — small and large — only large

Type and size of setae on pleurite III—VIII

Number of tergal setae on segment VIII	one pair — two pairs
Number of tergal setae on segments II—VIII	one pair — two pairs
Size of tergal setae	medium sized — long
Size of sternal setae	short — long
Size of sternocentrales vs. sternolaterales	equal — sternocentrales longer
Number of setae along midvulval margin	0 — (4-15) — (16-25) — (26-32)
Size of anal fringe setae	equal — unequal
Setae on parameres	present — absent
Setae on margines of parameres	present — absent
Number of setae on parameres	1 or 2 pairs — 3 — 4 or more
Number of tactile setae on coxa I	one — two
Tactile setae on femora	present — absent

TABLE 3
Cophenetic correlation coefficients for distance and correlation phenograms (UPGMA) based on various combinations of characters

Data sets	Phenograms	
	distance	correlation
Total	0.928	0.861
Morphological	0.863	0.829
Chaetotaxy	0.960	0.847
Head	0.952	0.902
Non-head	0.909	0.769
Morphology of head	0.939	0.899
Morphology of non-head	0.769	0.687
Chaetotaxy of head	0.955	0.882
Chaetotaxy of non-head	0.951	0.800

cters (fig. 1a), morphological characters (fig. 2a) and the comparable chaetotaxy phenogram (fig. 3a) show greater similarity to one another than the head vs. non-head phenograms (figs. 4a and 5a). The comparison of total — chaetotaxy and total — morphological show that matrix correlations are high: 0.923 and 0.904, respectively, while for morphological — chaetotaxy it is lower: 0.726 (tab. 4). The morphological phenogram

TABLE 4
Matrix correlations and strict consensus index (CI) resulting from comparisons of distance (d) and correlation (r) phenograms (UPGMA) based on different subsets of data

Comparisons of data sets	Matrix correlations		CI_c	
	d	*r*	*d*	r
Total and morphological	0.904	0.890	0.333	0.361
Total and chaetotaxy	0.924	0.794	0.417	0.361
Total and head	0.924	0.882	0.305	0.278
Total and non-head	0.880	0.847	0.417	0.472
Morphological and chaetotaxy	0.726	0.628	0.194	0.167
Head and non-head	0.699	0.719	0.111	0.194

closely reflects the division of *Ricinus* into the known species groups. Each of the five main clusters includes all members of a given species group. The only isolated species are *R. marginatus* (15) and *R. sittae* (32), which are the most remote from their groups.

On the chaetotaxy phenogram, the arcuatus and the fringillae remain intact and cluster together. Members of the remaining groups — clusters of the morphological phenogram, are rearranged into two different groups. The first one includes the majority of the marginatus, except *R. subdiffusus* (31). The second cluster consists of the subangulatus and the diffusus mixed together.

Results of Q-mode factor analysis in total study (130 characters). — Principal component analysis was employed to calculate the projections (coordinates) of each of 38 species of *Ricinus* into the first five principal components axes. The percentage of variation (ca. 50) for the first three factors in most analyses based on various subsets of data is not satisfactory (tab. 5). The highest degree of fit (lack of distortion) between

TABLE 5

Percent of variations in species matrix accounted for by each factor in five analyses based on different subsets of data

Factor	Total		Morphology		Chaetotaxy		Head		Non-head	
	%[1]	C%[2]	%	C%	%	C%	%	C%	%	C%
I	24.2	24.2	24.1	24.1	26.4	26.4	36.2	36.2	17.9	17.9
II	14.8	39.0	22.8	46.9	11.0	37.4	14.8	51.0	14.8	32.7
III	10.8	49.8	11.8	58.7	9.4	46.8	13.5	64.5	9.3	42.0
IV	5.4	55.2	6.3	65.0	6.8	53.6	6.3	70.8	7.0	49.0
V	4.9	60.1	4.9	69.9	6.1	59.7	5.4	76.2	5.5	54.5

[1] per cent of each trace
[2] cumulative percent

the original matrix of similarity coefficients and the pattern of similarity performed by PCA appears in the analysis based on head and morphological characters (64.5% and 58.7% of the trace, respectively). Only four of ten variations (38.99%) are explained by the first two components in the total study. Since the third factor accounts for a mere 10.79% of the trace, it has been chosen to depict two dimensional view of 38 OTUs (fig. 6) only. It suggests the existence of two major clusters of OTUs, designated as the species of *Ricinus* with dimorphic mandibles (to the left) and those with monomorphic, rather dispersed, to the right. *R. invadens* and *R. serratus* form phenetic intermediates between those groupings. *R. brevicapitis*, with monomorphic mandibles, is tied to the arcuatus and fringillae species groups, established earlier by Nelson.

In general, the relationships given of fig. 6 resemble the UPGMA phenograms on fig. 1a and 1b, even in exclusion of *R. marginatus* (15) from the marginatus group. It appears to be close to the members of the diffusus.˙ On the other hand, *R. subdiffusus* (31) and *R. sittae* (32), seem to be linked to the marginatus (contrary to the expected linking to the diffusus).

Fig. 7 presents the MDSCALE analysis applied to the total study (130 characters). The final stress value (S) — was 0.246, which is considered to correspond to a fairly good fit. For the same data, the first three principal component axes explained half of variations (49.78%) among

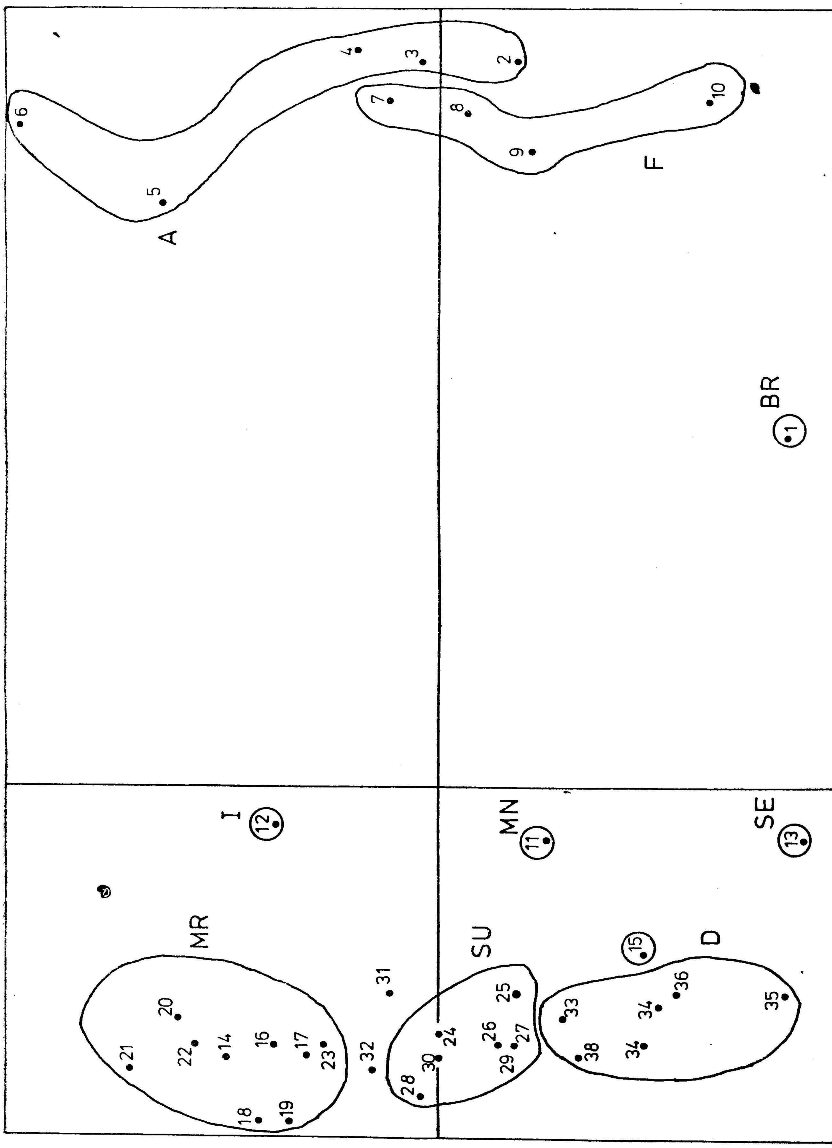

Fig. 6. Results of PCA based on all (130) characters

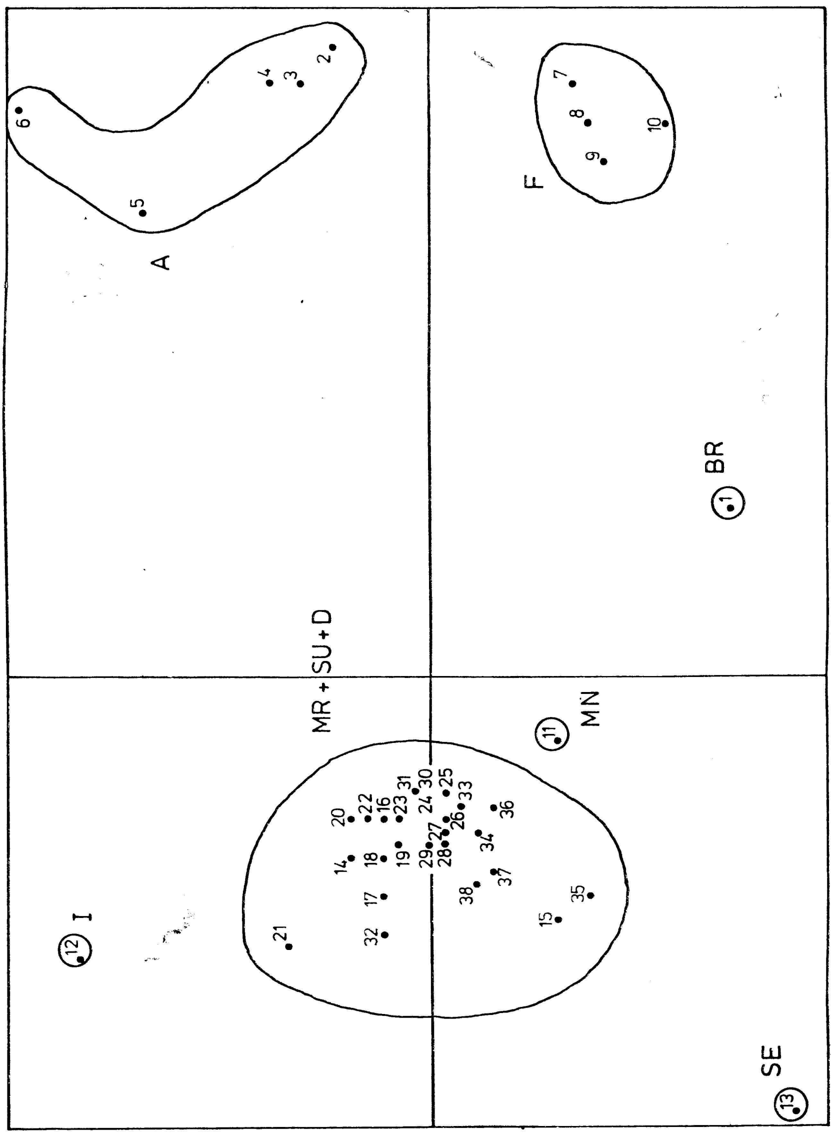

Fig. 7. Results of MDSCALE based on all (130) characters

the considered species. The pattern on fig. 7 is very similar to that of PCA (fig. 6) and analogous on UPGMA phenograms (fig. 1a and 1b). There is, however, a lack of phenetic gaps between species with monomorphic mandibles. Members of three groups, defined as a non-numerical way, are now close to each other and form one group. Fig. 7 shows clearly the arcuatus and fringillae as quite separated. The isolated positions of single species groups are also confirmed.

Discussion

The results of Q-mode cluster and factor analysis show a clear difference between two recognized groups of *Ricinus*: species with dimorphic mandibles, treated as primitive, and more specialized forms with monomorphic mandibles. The species with dimorphic mandibles were divided by Nelson (1972) into three groups: the brevicapitis, arcuatus and fringillae. In his taxonomic revision he considered the first two species groups to be closely related and more primitive than the third one.

In the present study *R. brevicapitis* is a clearly separated species, but not always connected with the arcuatus. It is difficult to determine accurately its closest relative because it links *R. invadens* as well as *R. serratus*. The only phenogram based on head characters shows its closeness to the arcuatus.

The arcuatus group, in turn, clusters consistently throughout all analyses. Within this complex *R. myiarchi* and *R. leptosomus* are closely associated but, at the same time, they are separated from *R. sucinaceus* and *R. pessimalis*. It seems, that the latter two should be regarded as a separate group. Next, the fringillae appears to be more homogenous. Three members (*R. japonicus*, *R. microcephalus* and *R. fringillae*) are very near neighbours. Rheinwald (1968) considered the first two species as synonyms of *R. fringillae*, but it seems that they are phenetically different and form distinct species as it was stated by Nelson (1972).

Species groups with monomorphic mandibles form a fairly compact complex. In particular, species within the subangulatus and the diffusus occupy the same general region on fig. 6 and 7, and they are very similar to one another. Only the marginatus group appears to be a more distinct species group, although some of its members are near neighbours of the diffusus species group mixed with the subangulatus. It is interesting to note that in all analyses *R. marginatus* is indicated as being one of the most separated species, which links rather the diffusus, instead of, as traditionally stipulated, the marginatus group. Three single species groups, represented by *R. mandibulatus*, *R. invadens* and *R. serratus* are, without any doubt, excluded from the remaining species. Only *R. mandi-*

bulatus seems to be close to the species with monomorphic mandibles. The phenetic position of both *R. invadens* and *R. serratus*, in the sense of closeness to one of the groups, can not be exactly determined.

The data presented here provided an opportunity for a test of the non-specificity hypothesis. Namely, characters sampled randomly from different regions of body should give equivalent relationships. However, classifications based on various subsets of data are usually not completely congruent (Rohlf, 1963; Erlich and Erlich, 1966; Michener and Sokal, 1966; Hendrickson and Sokal, 1968; Crovello, 1969). The comparison of two large sets of characters of *Ricinus*, i.e. morphological without chaetotaxy vs. chaetotaxy and head vs. non-head, shows slightly different but fairly highly correlated patterns of relationships. As noted above, the phenetic connections of *Ricinus* with dimorphic mandibles were stable in all analyses. It seems, that as phenetic differentiation is more clearly defined than those with monomorphic, which are less closely adapted to particular habitats on their hosts and, consequently display smaller divergence (Johnston and Kethley, 1973). In general, the matrix correlation values of tab. 4 were greater for distances than for correlation phenograms. Similarly, the cophenetic correlation of matrices based on distance were higher than those based on correlation coefficients (tab. 3).

Acknowledgments

This paper has been prepared during an exchange visit to the Department of Ecology and Evolution, the State University of New York, at Stony Brook. I am especially indebted to Professors R. R. Sokal for help and encouragement and J. F. Rohlf for methodological advice. Helpful suggestion was provided by Professor J. Złotorzycka (Wrocław University). Much computational advice was given by Mrs B. Thomson (SUNY) to whom my special thanks are due. This study would not have been possible without the generous allowance of computator time and facilities provided by the Department of Ecology and Evolution SUNY at Stony Brook.

Received on: 29 VI 1988

Author's address:
51-148 Wrocław, ul. Przybyszewskiego 63/77

LITERATURE

1. Crovello, T. J.: Effects of change of characters and of number of characters in numerical taxonomy. — *Am. Midland. Natural.*, 81, 68-86, 1969.

2. E i c h l e r, W d.: Dr. H. G. Bronns Klassen und Ordnungen des Tierreichs fünfer Band: *Arthropoda* III. Abteilung: *Insecta*, 7 Buch, b) *Phthiraptera*, 1. *Mallophaga*, Leipzig, 1963.
3. E r l i c h, P. R., E r l i c h, A. H.: The phenetic relationships of the butterflies. I. Adult taxonomy and the nonspecificity hypothesis. — *Syst. Zool.*, 16, 301-317, 1967.
4. E v e l e i g h, E. S., A m a n o, H.: A numerical taxonomic study of the Mallophagan genera *Cummingsiella* (=*Quadraceps*), *Saemundssonia* (*Ischnocera*: *Philopteridae*), and *Austromenopon* (*Amblycera*: *Menoponidae*) from alcids (*Aves*: *Charadriiformes* of the northwest Atlantic with reference to host-parasite relationships. — *Can. J. Zool.*, 55, 1788-1801, 1977.
5. H e n d r i c k s o n, J. A., S o k a l, R. R.: A numerical taxonomic study of the genus *Psorophora* (*Diptera*: *Culicidae*). — *Ann. Entomol. Am.* 61, 385-392, 1968.
6. H e r r i n, C. S.: A systematic revision of the genus *Hirstionyssus* (*Acari: Mesostigmata*) of the Nearctic region. — *J. Med. Entomol.*, 7, 391-437, 1970.
7. J o h n s t o n, D. E., K e t h l e y, B. J.: A numerical phenetic study of the quill mites of the family *Syringophilidae* (*Acari*). — *J. Parasitol.*, 59, 520-530, 1973.
8. M i c h e n e r, C. D., S o k a l, R. R.: Two tests of the hypothesis of nonspecificity in the *Hoplitis* complex (*Hymenoptera*: *Megachilidae*). — *Ann. Entomol. Soc. Am.* 59, 385-392, 1966.
9. M o s s, W. W.: Some new analytic and graphic approaches to numerical taxonomy, with an example from the *Dermanyssidae* (*Acari*). — *Syst. Zool.*, 16, 177-201, 1967.
10. M o s s, W. W., P e t e r s o n, P. C., A t y e o, T. W.: A multivariate assessment of phenetic relationships within the feather mite family *Eustathiidae* (*Acari*). — *Syst. Zool.*, 26, 386-409, 1977.
11. N e l s o n, B. C.: A revision of the New World species of *Ricinus* (*Mallophaga*) occurring on *Passeriformes* (*Aves*). University of California Press, 175 pp., 1972.
12. R h e i n w a l d, G.: Die Mallophagengattung *Ricinus* De Geer, 1778. Revision der außeramerikanischen Arten. — *Mitt. Hamburg. Zool. Mus. Inst.*, 65, 181-326, 1968.
13. R o h l f, J. F.: Congruence of larval and adult classification in *Aedes* (*Diptera*: *Culicidae*). — *Syst. Zool.*, 12, 97-117, 1963.
14. R o h l f, J. F., Adaptive hierarchical clustering schems. — *Syst. Zool.*, 19, 58-82, 1970.
15. R o h l f, J. F.: Consensus indices for comparing classifications. — *Math. Biosci.*, 59, 131-144, 1982.
16. R o h l f, J. F., K i s h p a u g h, J. D., K i r k, D.: NTSYS, numerical taxonomy system of multivariate statistical programs. Tech. Rep. State Univ. New York, Stony Brook, 1980.
17. S n e a t h P. H. A., S o k a l, R. R.: Numerical taxonomy. W: H. Freeman and comp., 547 pp., 1973.
18. Z ł o t o r z y c k a, J.: *Mallophaga* parasitizing *Passeriformes* and *Pici*. IV. *Menacanthinae, Ricinidae, Degeeriellinae.* — *Acta Parasitol. Pol.*, 13, 41-69, 1965.

NUMERYCZNA ANALIZA AMERYKAŃSKICH GATUNKÓW Z RODZAJU *RICINUS* (*PHTHIRAPTERA*: *AMBLYCERA*)

E. LONC

Fenetyczne zależności między 38 gatunkami wszołów z rodzaju *Ricinus* występujących na ptakach wróblowatych Nowego Świata analizowano metodami taksonomii numerycznej. 130 cech, podzielonych na zestawy, badano za pomocą analizy skupień oraz analizy czynnikowej (technika Q). Wyniki prezentowane w formie UPGMA fenogramów korelacji i odległości oraz dwuwymiarowych diagramów, w ogólnym zarysie okazały się zgodne z dotychczasowymi poglądami. Klasyfikacje oparte obecnie na różnych kombinacjach cech (morfologiczne z wyłączeniem chetotaksji vs. chetotaksja, cechy głowy vs. cechy reszty ciała) prezentowały wysoce skorelowane wzory podobieństwa i potwierdziły w znacznym stopniu hipotezę „niespecyficzności".