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THE GENUS *MICROBISIUM* IN NORTH AND CENTRAL AMERICA (PSEUDOSCORPIONIDA, NEOBISIIDAE)

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ABSTRACT

North and Central American species of *Microbisium* were discussed. *M. confusum* (Hoff) was proposed as a junior synonym for *M. parvulum* (Banks) based on overlapping diagnostic characteristics. *t* Tests were used to compare means of palpal podomeres from different geographic regions. The type locality for *M. parvulum* was redesignated as North America. A second species, *M. brunneum* (Hagen) remained distinct based on its larger palpal podomeres.

INTRODUCTION

The pseudoscorpion genus *Microbisium* belongs to the subfamily Neobisiinae, family Neobisiidae of the suborder Diplosphyronida and is separated from other Neobisiinae by the absence of trichobothrium *sb* on the movable chelal finger and *isb* on the fixed finger. The adults of this genus retain the chaetotaxy characteristic of tritonymphs in other genera. *Microbisium* is widely distributed throughout the world and includes 13 described species, three of which are reported from North and Central America. Hagen (1869) described the type species (*Obisium brunneum*), and the genus *Microbisium* was erected by Chamberlin (1930). *Microbisium parvulum* was described by Banks (1895) on the basis of one adult and several young. No locality was known to him; however, he thought the collection must have been from Florida. The specimens were in a vial with *Mirochernes dentatus* (Banks). Hoff (1946) described *M. confusum* based on 127 females from Illinois. The first male in this genus was reported by Lawson (1969). Nelson (1982) gave a complete description of *M. confusum* in which he reported five males. However, due to the high female to male ratio in this group, it is thought that females reproduce parthenogenetically.

Banks (1895) indicated that *M. parvulum* could be separated from *M. brunneum* by the shape of the palpal tibia and the length of the chelal fingers. The palpal tibia on *M. parvulum* had a more evenly convex flexor surface than on *M. brunneum* and its chelal fingers were shorter than the length of its hand. Hoff's description (1946) of *M. confusum* was based on a re-examination of the species assigned to the genus *Microbisium* in which he reported that *M. parvulum* could be separated from *M. confusum* by a longer palpal femur (0.41 to 0.43 mm for two individuals of *M. parvulum* versus a mean of 0.357 mm for 127 individuals of *M. confusum*). Hoff stated that "Dr. Chamberlin eventually will publish methods for separation of these two forms but this seems too detailed

for the present review." No methods were published by the late Dr. Chamberlin. Hoff and Bolsterli (1956) used size and shape of palpal podomeres stating that "*M. parvulum* is separated from *M. confusum* with difficulty because of overlapping ranges in absolute sizes and ratios of the palpal podomeres of the two species." They go on to state that "the palpal tibia of *M. parvulum* usually has a less regularly convex extensor margin and the pedicel is usually relatively more slender and better separated from the rest of the podomere. This difference, like all others, is not always reliable." Hoff (1956) further separated the two species by stating that "In *M. parvulum* the femur is over 0.4 mm long, in contrast to a length of less than 0.4 mm for *M. confusum*. The femur of *M. parvulum* is stouter than that of *M. confusum*, being usually 2.9 or less in the former and 2.9 or more in the latter, but so much overlapping in the ranges of the two species occurs that this character is much less useful than others for the separation of the two species." However, Hoff (1961) stated that "unfortunately, through a transposition of species names, the statement by Hoff is entirely erroneous. Even if the statement were correctly expressed, the difference in length/width ratios would not be dependable for separation of *M. confusum* and *M. parvulum*, because recent studies make it clear that the ranges of the length/width ratios of the femur in the two species very strongly overlap. With respect to the chela, that of *M. parvulum* is 0.65 mm long. When specimens are laid side by side, it is evident that the chela is stouter in *M. parvulum* than in *M. confusum*, the length/width ratio in the former being usually less than 2.8, in contrast to a length/width ratio in *M. confusum* of more than 2.9. These measurements and ratios are given with reservation, it being understood that in any large series of specimens the size and length/width ratios of a few specimens of one species may extend into the range demonstrated by the other species. In addition to the differences in size and ratio of the palpal podomeres, there is a constant difference in the shape of the podomeres and in the color of the palps. In *M. parvulum* the palps are a deep golden color, while in *M. confusum* the palps are a light golden color. The color difference, appears definite and constant in specimens presently available for study." Finally, Hoff (1961) stated that "for Colorado specimens it is clear that identification based on the length and ratio of the chela is no more satisfactory than is identification based on the length and ratio of the femur. The most reliable criterion for the separation of *M. confusum* and *M. parvulum* lies in the shape of the palpal tibia. Unfortunately the shape of the tibia is variable in both species, and observable differences are difficult to describe verbally and virtually impossible to express mathematically. In *M. confusum* the palpal tibia has a slightly longer and more slender pedicel and the inner or flexor margin is less convex and less bulging than in *M. parvulum*. In addition, the basal portion of the extensor or outer margin in some cases is a little less convex, so that the extensor margin appears less regularly curved in *M. confusum*."

Some confusion exists as to the actual number of *M. parvulum* specimens examined by Banks (1895). He reported that there was one adult and several nymphs. Hoff (1946) re-examined the type materials and indicated two cotypes were deposited at the Museum of Comparative Zoology at Harvard University. One of the cotypes was designated by him as the lectotype. Both specimens were adult females; however, Hoff did not mention Banks' reference to one adult and several nymphs. Perhaps Banks actually had more than one adult and that in the interim between Banks' description and Hoff's re-examination all but one of the several nymphs were removed.

Hoff (1946) stated that "*Microbisium parvulum* appears to have a range in the southwestern part of the United States. Very probably the type locality is not Florida, as questionably given by Banks (1895), but Texas or Arizona." Hoff (1958) went on to

Table 1.—Measurements (range and means in mm) for North and Central American *Microbisium* species excluding *M. brunneum*. Single individuals are reported as the mean; Nuevo Leon record based on a male; Illinois from Hoff (1946); Oklahoma inferred from Hoff and Bolsterli (1956); slash marks (/) indicate number of individuals used to measure femora/chelae.

Locality	No. Examined	Femur Length		Femur L X W Ratio		Chela Length	
		Range	Mean	Range	Mean	Range	Mean
Canada							
Manitoba	1		0.33		2.75		0.56
Ontario	1		0.36		2.77		0.62
Quebec	2	0.35	0.35	2.69-2.92	2.81	0.59-0.60	0.595
Costa Rica	1		0.37		3.08		0.61
El Salvador	1		0.36		2.77		0.63
Mexico							
Nuevo Leon	1		0.41		2.93		0.70
Tamaulipas	8	0.36-0.43	0.404	2.57-3.08	2.97	0.64-0.72	0.694
United States							
Arkansas	2	0.35-0.38	0.365	2.71-2.92	2.82	0.61-0.67	0.64
California	6	0.30-0.36	0.342	2.69-2.77	2.72	0.54-0.61	0.587
Colorado	13	0.35-0.43	0.375	2.69-3.18	2.91	0.55-0.70	0.645
Connecticut	1		0.36		2.77		0.63
Florida	30	0.30-0.35	0.33	2.58-3.00	2.79	0.51-0.67	0.573
Georgia	2	0.32-0.34	0.33	2.83-2.91	2.87	0.52	0.52
Illinois	127	0.275-0.395	0.357	2.61-2.84			
Indiana	12/11	0.31-0.39	0.345	2.53-2.83	2.71	0.56-0.69	0.617
Iowa	3	0.34-0.35	0.347	2.62-2.92	2.74	0.59-0.62	0.603
Kansas	5	0.31-0.34	0.32	2.21-2.91	2.69	0.52-0.61	0.554
Kentucky	14/13	0.31-0.38	0.341	2.58-3.17	2.82	0.57-0.65	0.595
Maine	3	0.39-0.41	0.40	2.86-3.00	2.93	0.65-0.67	0.663
Maryland	4	0.31-0.33	0.32	2.67-2.82	2.73	0.56-0.57	0.568
Massachusetts	2	0.37-0.39	0.38	2.64-2.79	2.72	0.64-0.68	0.66
Michigan	191/20	0.29-0.42	0.36	2.33-2.93	2.69	0.54-0.68	0.634
Minnesota	1		0.32		2.91		0.57
Mississippi	1		0.34		2.61		0.62
Missouri	7	0.32-0.37	0.353	2.33-3.08	2.76	0.57-0.65	0.613
Nebraska	1		0.39		2.79		0.65
New Hampshire	1		0.39		3.00		0.59
New Jersey	4	0.33-0.39	0.358	2.62-3.00	2.81	0.56-0.63	0.593
New Mexico	4	0.39-0.43	0.40	2.79-2.87	2.81	0.66-0.72	0.688
New York	25	0.33-0.40	0.365	2.57-3.08	2.78	0.55-0.67	0.636
North Carolina	18	0.31-0.37	0.339	2.58-3.00	2.84	0.53-0.67	0.587
Ohio	2	0.33-0.35	0.34	2.75-2.92	2.84	0.56-0.57	0.565
Oklahoma	3	0.32-0.42	0.37	2.67-2.96	2.81	0.56-0.76	0.647
Pennsylvania	10	0.31-0.40	0.363	2.38-2.92	2.73	0.61-0.67	0.634
South Carolina	1		0.31		2.82		0.56
South Dakota	1		0.35		2.69		—
Tennessee	7	0.34-0.39	0.366	2.43-3.08	2.89	0.54-0.66	0.607
Texas	5	0.30-0.37	0.336	2.38-2.92	2.67	0.52-0.64	0.596
Utah	5	0.33-0.40	0.366	2.85-3.00	2.91	0.57-0.68	0.624
Vermont	1		0.35		2.69		0.60
Virginia	1		0.35		2.69		0.61
Wisconsin	20	0.34-0.42	0.373	2.62-3.23	2.89	0.57-0.71	0.634
Totals	548/248	0.275-0.43		2.21-3.23		0.51-0.76	

METHODS AND MATERIALS

More than 400 individuals assigned to the genus *Microbisium* including types were examined morphologically with emphasis on the size and shape of palpal podomeres. The specimens were collected in North and Central America and were obtained from the American Museum of Natural History, the Illinois Natural History Survey, the Museum of Comparative Zoology at Harvard University and the Smithsonian Institution along with personal collections and the collections of Dr. William B. Muchmore of the University of Rochester. Specimens, not previously mounted were prepared for microscopic examination using the methods described by Hoff (1949), though clove oil was used in place of beechwood creosote for clearing and dehydrating the specimens.

Mounted pseudoscorpions were examined in terms of morphological differences with regard to chaetotaxy, shape and dimensions. *t* Tests were used to determine if differences between palpal measurements of different geographic samples were due to chance or to actual sample differences.

RESULTS AND DISCUSSION

Hoff's (1961) statement that "the most reliable criterion for the separation of *M. confusum* and *M. parvulum* lies in the shape of the palpal tibia" is indefensible when he goes on to state that "unfortunately the shape of the tibia is variable in both species, and observable differences are difficult to describe verbally and virtually impossible to express mathematically."

Other parameters such as femur length, femur length times width ratios and chela length can be expressed mathematically. However, care must be exercised when comparing small population sizes. Results are given in Tables 1-6 and illustrated in Maps 1 and 2.

Map 1 illustrates means for femur length for both *M. confusum* and *M. parvulum*. In general, regional differences in mean femur length exist. For example, northeastern

Table 2.—Measurements (ranges and means in mm) for *M. brunneum*; slash marks (/) indicate number of individuals used to measure femora/chelae.

Locality	No. Examined	Femur Length		Femur L X W Ratio		Chela Length	
		Range	Mean	Range	Mean	Range	Mean
Canada							
Manitoba	4	0.47-0.53	0.49	2.94-3.13	3.06	0.78-0.86	0.82
Ontario	1		0.48		3.20		0.78
United States							
Illinois	8/9	0.43-0.50	0.464	2.69-3.12	2.93	0.77-0.84	0.807
Massachusetts	1		0.46		3.07		0.84
Michigan	21/3	0.43-0.51	0.467	2.87-3.2	3.00	0.78-0.84	0.81
New Jersey	1		0.49		3.06		0.81
New York	4/3	0.48-0.50	0.485	3.00-3.13	3.03	0.79-0.84	0.823
South Carolina	1		0.55		3.06		0.90
Utah	2	0.45-0.48	0.465	2.81-3.00	2.91	0.74-0.84	0.79
Wisconsin	6	0.44-0.51	0.482	2.94-3.19	3.08	0.75-0.88	0.81
Totals	49/31	0.43-0.55		2.69-3.20		0.74-0.90	

Table 3.—Values of the *t* statistic for comparison of femur length in North and Central American *Microbisium* species excluding *M. brunneum*.

	N	1	2	3	4	5	6	7	8	9	10	11	12	13
California (1)	6	-	1.49	1.64	0.276	0.10	1.97	1.12	3.03	0.33	1.70	2.45	4.10	5.67
Florida (2)	30		-	6.41	2.60	2.05	7.19	3.79	8.60	1.87	5.10	5.94	8.40	13.86
Illinois (3)	127			-	1.80	2.59	1.19	0.47	1.73	3.30	0.82	1.07	2.93	9.35
Indiana (4)	12				-	0.47	2.27	0.85	3.10	0.78	1.74	2.16	3.48	6.91
Kentucky (5)	14					-	3.11	1.33	4.00	0.28	2.29	2.77	3.35	9.89
Michigan (6)	191						-	0.83	1.09	3.88	0.41	0.71	2.41	8.98
Missouri (7)	7							-	1.75	1.71	0.90	1.54	2.59	5.07
New York (8)	25								-	4.84	0.38	0.15	1.34	6.43
North Carolina (9)	18									-	2.79	3.29	4.97	9.25
Pennsylvania (10)	10										-	0.27	1.11	4.26
Tennessee (11)	7											-	0.78	3.72
Wisconsin (12)	20												-	4.01
<i>M. parvulum</i> (13)	26													-

Table 4.—Values of the *t* statistic for comparison of femur length X width ratios in North and Central American *Microbisium* species excluding *M. brunneum*.

	N	1	2	3	4	5	6
Florida (1)	30	-	2.95	0.35	1.54	3.02	2.53
Michigan (2)	191		-	3.65	5.19	7.20	7.22
New York (3)	25			-	1.73	3.12	2.64
North Carolina (4)	18				-	1.23	0.76
Wisconsin (5)	20					-	0.51
<i>M. parvulum</i> (6)	26						-

species have longer femora than southeastern species. The same could be said for the mean total length of the chela, illustrated in Map 2. However, means may not represent the true mean of a population. A *t* Test could possibly determine if the differences between two means were simply differences within a single population or whether different populations exist. Tables 3-5 represent *t* values. These values represent approximately the number of standard deviations from the means.

The *M. parvulum* category in Tables 3-5 represent *t* values obtained from specimens identified by Hoff and personally examined by me including types or from information obtained from the literature (Hoff and Bolsterli 1956). Also included are individuals from El Salvador, Costa Rica and Mexico that agreed with the *M. parvulum* description. Initially a *t* Test was made to determine if significant differences existed in femur length, femur length times width ratios, and chela length between specimens identified as *M. parvulum* by Hoff and those from El Salvador, Costa Rica and Mexico. No significant differences occurred at the 0.01 confidence level. Subsequently the two groups were combined to be used for comparison with individuals from other regions.

Differences do exist when *M. parvulum* is compared to species recognized as *M. confusum* from other geographic regions. However, these differences, at times, are less significant than differences in two populations of *M. confusum* from different geographic regions. Care must be exercised when comparing small population sizes. Table 3 gives *t* values for populations from 12 states; however, only those states with population sample sizes of 18 or more will be given serious consideration. A *t* of 9.35 occurs between Illinois individuals and those of *M. parvulum*. The Illinois sample was based on Hoff's (1946) original description of *M. confusum*. When the Wisconsin sample was compared to *M. parvulum* a *t* value of 4.01 was obtained. Greater differences (8.40) occurred between the Wisconsin and Florida populations, a species recognized as *M. confusum*, than between the Wisconsin population and *M. parvulum*. The greatest difference was between the Florida population and *M. parvulum* (13.86). The Florida population was most similar to that from North Carolina (1.87). The California sample size was inadequate to draw solid conclusions, but with the limited data that were available there is a closer affinity to Eastern populations than to the more southwestern *M. parvulum*.

The *t* values for length times width ratios of the femur when sample sizes of 18 or more are compared, are given in Table 4. No pattern is evident from this parameter. Table 5 gives *t* values for comparison of chela length for populations of 18 or more. The Illinois sample is not included as Hoff's (1946) description did not include measurements of chela length. The chela length of other regions compares favorably with that data obtained for femur length.

Table 5.—Value of the *t* statistic for comparison of chela length in North and Central American *Microbisium* species excluding *M. brunneum*.

	N	1	2	3	4	5	6
Florida (1)	30	—	4.83	5.63	0.89	4.92	9.73
Michigan (2)	191	—	—	0.21	4.23	0.00	5.07
New York (3)	25	—	—	—	4.90	0.23	5.45
North Carolina (4)	18	—	—	—	—	4.56	9.18
Wisconsin (5)	20	—	—	—	—	—	5.36
<i>M. parvulum</i> (6)	26	—	—	—	—	—	—

Table 6.—*Microbisium* males compared to females. Measurements for femur and chela length in mm. Female data given as ranges.

		Femur Length	Femur Length X Width Ratio	Chela Length
Maine	male	0.33	2.70	0.56
	female	0.39-0.41	2.86-3.00	0.67-0.67
Mexico	male	0.41	2.93	0.70
	female	0.36-0.43	2.57-3.08	0.64-0.72
Michigan	male	0.33 & 0.37	2.40 & 2.78	0.58 & 0.64
	female	0.29-0.42	2.33-2.93	0.54-0.68
New York	male	0.345	2.87	0.60
	female	0.33-0.40	2.57-3.08	0.55-0.67
South Carolina	male	0.311	0.288	0.513
	female	0.31	2.82	0.56

The *Microbisium* male collected in Nuevo Leon, Mexico in general agreed with the description of males given by Nelson (1982) in body proportions and chaetotaxy. When males from each region are compared to their female counterparts the proportions, except for the Maine male, agree. These data are given in Table 6.

Microbisium brunneum, a species usually collected in bog-like habitats, appears distinct from *M. parvulum* or *M. confusum*. Measurements for *M. brunneum* are given in Table 2. *M. brunneum* has a femur length that ranges from 0.43 to 0.55 as compared to non *M. brunneum* populations of 0.275-0.43. The range in chela length for *M. brunneum* is 0.74-0.90 as compared to 0.51-0.76 for non *M. brunneum*. The 0.76 was reported by Hoff and Bolsterli (1956) of *M. parvulum* from Oklahoma. No other non *M. brunneum* had chela with a length of more than 0.72.

Morphological variability in species that reproduce parthenogenetically is often reduced when compared to interbreeding species. However, parthenogenesis is usually a transitory condition with interbreeding occurring periodically. In the genus *Microbisium* males do occur and the potential for genetic recombination exists. However, the number of males relative to females reported appears insignificant. Nelson (1973) and (1982) found no males in a total of 881 individuals collected in ecological studies concerning this genus. Samples were taken approximately twice monthly over entire year periods from two separate localities in Michigan and New York. According to Mayr (1969), "In the case of permanently uniparentally reproducing lines the species category is applied on the basis of morphological difference. Morphological difference between clones can be used as an indication of the underlying genetic difference and this in turn for an inference on probable species status." Based on the relative numbers of each sex, species of *Microbisium* may be less diverse than other parthenogenetic species. The question is whether the morphological differences in North and Central American species of *Microbisium* are enough to recognize them as different species.

Banks (1895) was most likely incorrect in speculating that the type locality for *M. parvulum* was Florida based on the data obtained from Florida specimens. No femora of Florida specimens examined exceeded 0.36 mm, whereas the femora of the lectotype and cotype were 0.42 (0.43) and 0.41 mm, respectively. However, Hoff's (1958) arbitrary designation of Bernalillo County, New Mexico was just as speculative. The type specimens may have been collected somewhere in the southwest or perhaps another region such as Maine or Wisconsin. As the types were in the same vial as *Microchernes dentatus*, a species

reported from Arkansas, Connecticut, Florida, Illinois, Indiana, Michigan, North Carolina, Oklahoma, and Virginia, it is less likely the type locality was somewhere in the southwest. The records of *M. dentatus* for Connecticut and Oklahoma are based on unpublished information obtained from Dr. W. B. Muchmore. In any case one can only state with reasonable certainty that the type locality for *M. parvulum* is North America.

CONCLUSION

When Hoff described *Microbisium confusum* from Illinois in 1946, clear-cut differences were evident in separating the species of *Microbisium* from each other. *M. confusum* in Illinois was indeed different from *M. parvulum* in terms of palpal dimensions. Likewise, Florida specimens when compared to *M. confusum* from Illinois and *M. parvulum* would be different enough to perhaps recognize them as different species. Given more individuals the same could be said for samples from California. Small sample sizes or samples restricted to certain regions often show marked differences. As samples are obtained from wider areas and in larger numbers, overlap occurs and trends begin to emerge which approximate a continuum. Partitioning a continuum, in the case of parthenogenetically reproducing species, is not sound systematically. Theoretically parthenogenesis, in the absence of males, leads to reproductive isolation whether individuals are found in the same locality or some entirely different geographic region. Therefore, distinct diagnostic characteristics should be used when biological speciation is inferred.

Based on the above, it is recommended that *M. confusum* be considered a junior synonym of *M. parvulum* and that the type locality be designated as North America. *Microbisium brunneum*, on the other hand, remains distinct from *M. parvulum* and is separated by the diagnosis given in the Results and Discussion.

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