

ECTOPARASITES FROM BEAVERS FROM MASSACHUSETTS AND MAINE

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1. Department of Life Sciences, Indiana State University, Terre Haute, IN 47809; 2. Institut Royal Des Sciences Naturelles De Belgique, 29 Rue Vautier, 1040-Bruxelles, Belgium; 3. Department of Biology, Northeastern University, Boston, MA 02115.

ABSTRACT - Seven species of beaver mites, *Schizocarpus paramingaudi* Fain & Whitaker, *indianensis* Fain et al, *postannulatus* Fain & Whitaker, *virgulatus* Fain et al, *subvirgulatus* Fain et al, *inversus* Fain et al and *spinifer* Fain et al were found on three beavers from Massachusetts. Twelve were found on five beavers from Maine, *S. mingaudi* Trouessart, *paramingaudi*, *alaskensis* Fain & Whitaker, *reductus* Fain & Whitaker, *indianensis*, *tetrapilis* Fain et al, *postannulatus*, *distinctus* Fain & Whitaker, *subvirgulatus*, *inversus*, *posticus* Fain & Whitaker, *protinus* Fain & Whitaker, and *spinifer*. Beaver mites are normally restricted to specific parts of the beaver, and 93.3% of 1162 male adult mites identified were found on the expected part of the beaver as hypothesized. The beaver mite communities from Maine and Alaska, and also from Maine and Indiana were the most similar of four compared, whereas those from Massachusetts and Maine were the least similar. This departure from the expected may have been due to transplantations of beaver by man. A key to the males of the 17 species of *Schizocarpus* currently known from North America is included.

INTRODUCTION

This is the third in a series of studies of the ectoparasitic mites of the genus *Schizocarpus* of North American beavers, *Castor canadensis* (Fain, Whitaker and Smith, 1984; Fain and Whitaker, 1988). The first study was of beavers from Indiana. There eight species of *Schizocarpus* were found, seven of them new. Five beavers from Alaska have since been examined, and on these another 9 new species have been described, although some of these have subsequently been found in Indiana (Table 1).

In addition, 33 species of *Schizocarpus* are known from the Eurasian beaver, *Castor fiber*, (Dubinina, 1964; Fain and Lukoschus, 1985). All of the oldworld species, with one exception, are different from the North American species. The one exception, and the connecting link between old and new world beaver mite communities, is *Schizocarpus mingaudi* the first of the species described (Trouessart, 1896), although it is possible that *S. mingaudi* consists of two very closely related species, one in the new and one in the old world. The result of frequent speciation within one genus on one host such as has occurred in

Schizocarpus has been termed multiple speciation (Fain and Lukoschus, 1985).

It has been stated in previous papers that the species of *Schizocarpus* exist on specific parts of the beaver. However, we can now revise this statement somewhat. The 17 North American species presently known fall into four groups (*mingaudi*, *indianensis*, *virgulatus* and *spinifer* groups). Members of the first three groups occur in specific areas on the beavers, but *S. spinifer*, the only species in its group, appears to be non-specific with regard to its location. Although the groups are site specific, species within groups are not. However, there is a good deal of homogeneity within samples (i.e., one often finds only one species in a sample from one area of a beaver). The groups are indicated below and the included species are listed in Table 1.

(1) *S. mingaudi* group - Members of this group are abundant on the head, neck and outside of the front legs of *Castor canadensis*. Four species are currently known in this group. Members of this group have two large flat suckers in the sucker plate (although the posterior one is in some highly modified). Four species are currently known in this group, *S. mingaudi*, *paramingaudi*, *alasken-*

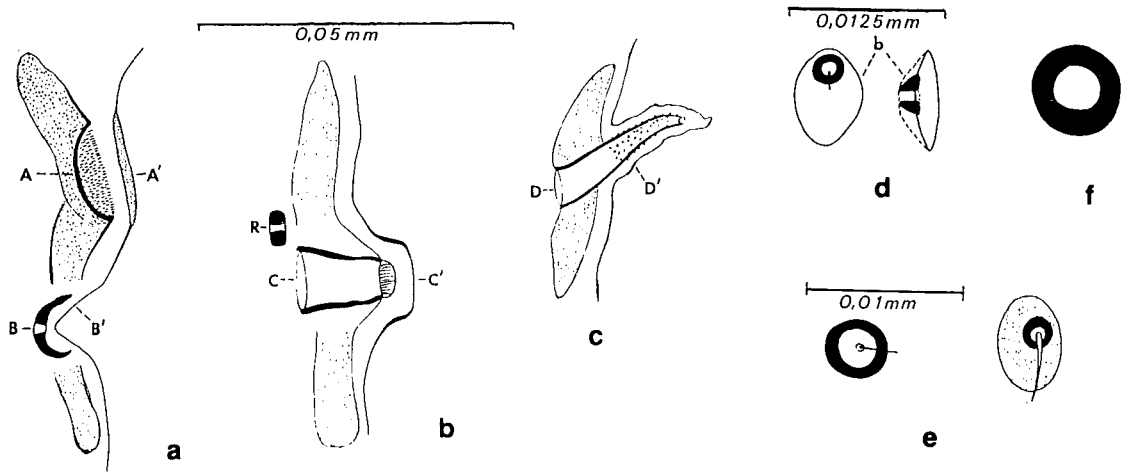


Fig. 1. Suckers, setal plates and rings of *Schizocarpus* - (a) large flat sucker types A, B; (b) tubular sucker type C; (c) elongate sucker type D; (d) small sucker type b; (e) seta n; (f) sucker ring (of *S. indianensis*).

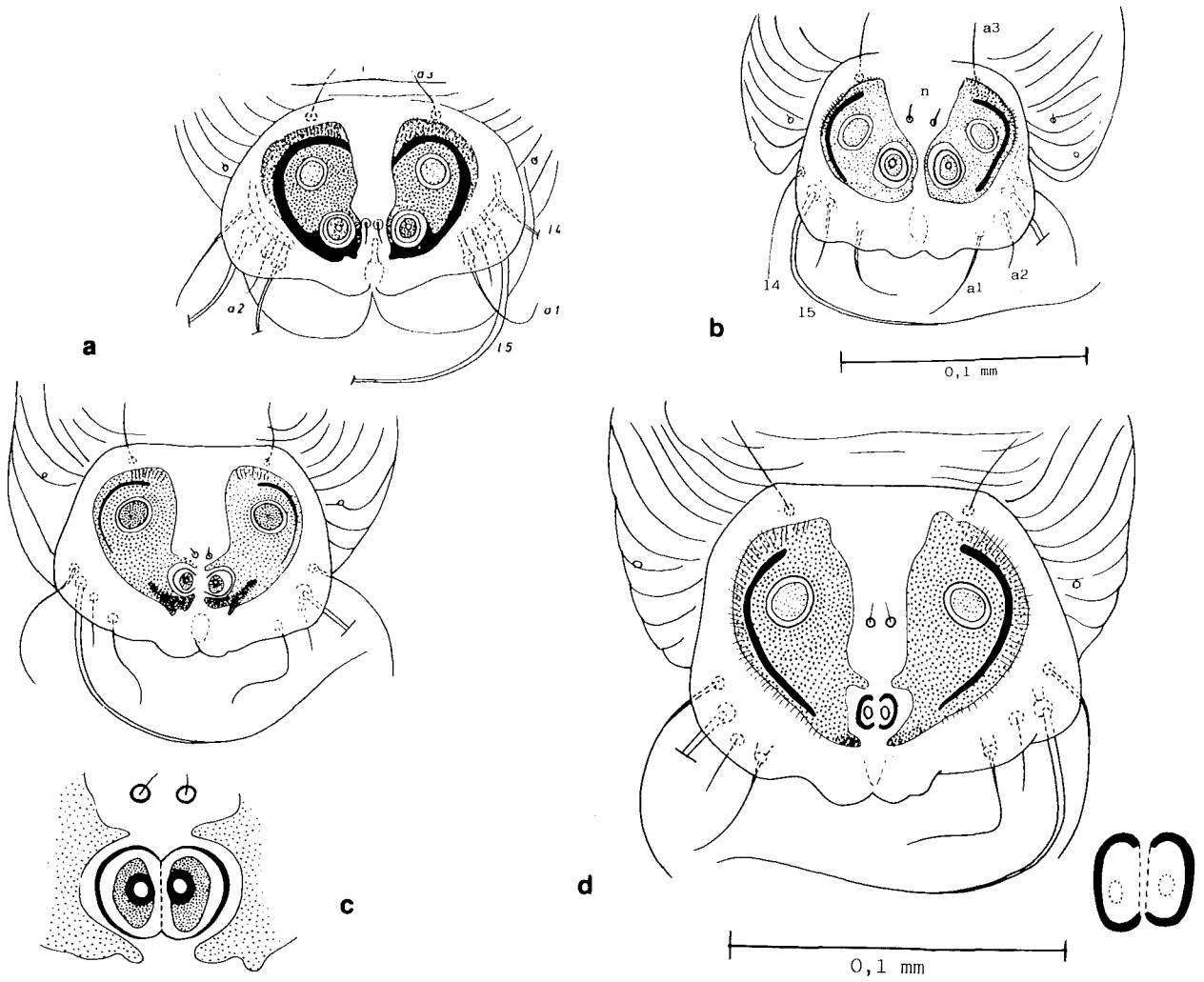


Fig. 2. Male sucker plates of *S. mingaudi* group mites - (a) *S. mingaudi*; (b) *S. paramingaudi*; (c) *S. alaskensis*; (d) *S. reductus*.

Table 1. Mites of the genus *Schizocarpus* from beavers from Massachusetts and Maine, as compared with those from Indiana and Alaska. Numbers in parentheses are the average numbers per beaver.

	Mass.	Maine	Indiana	Alaska
n=	3	6	11	5
(1) <i>S. mingaudi</i> group:				
<i>S. mingaudi</i> Trouessart		2 (0.3)	1219 (110.8)	
<i>S. paramingaudi</i> F & W	179 (59.7)	2 (0.3)	5 (0.5)	19 (3.8)
<i>S. alaskensis</i> F & W		5 (0.6)		40 (8.0)
<i>S. reductus</i> F & W		401 (66.8)		362 (72.4)
(2) <i>S. indianensis</i> group				
<i>S. indianensis</i> FW & S	4 (1.3)	21 (3.5)	226 (20.5)	21 (4.2)
<i>S. tetrapilis</i> FW & S		10 (1.7)	70 (6.4)	2 (0.4)
<i>S. postannulatus</i> F & W	46 (15.3)	54 (9.0)	57 (5.2)	376 (75.2)
<i>S. distinctus</i> F & W	9 (3.0)	3 (0.5)		7 (1.4)
<i>S. centralis</i> F & W				18 (3.6)
<i>S. contrarius</i> F & W			1 (0.1)	2 (0.4)
(3) <i>S. virgulatus</i> group				
<i>S. virgulatus</i> FW & S	2 (0.7)		453 (41.2)	67 (13.4)
<i>S. subvirgulatus</i> FW & S	53 (17.7)	372 (62.0)	571 (51.9)	219 (43.8)
<i>S. furcatus</i> FW & S			79 (7.2)	2 (0.4)
<i>S. inversus</i> FW & S	114 (38.0)	29 (4.8)	5 (0.5)	13 (2.6)
<i>S. posticus</i> F & W			15 (1.4)	11 (2.2)
<i>S. protinus</i> F & W		1 (0.2)		28 (5.6)
(4) <i>S. spinifer</i> group				
<i>S. spinifer</i> FW & S	12 (4.0)	21 (3.5)	3 (0.3)	9 (1.8)
Number species	9	12	12	15

F & W = Fain & Whitaker, 1988 (1989)

FW & S = Fain, Whitaker & Smith, 1984

sis and *reductus*. These four form a graded series from two sucker plates far apart in *mingaudi*, to the sucker plates close together posteriorly in *paramingaudi*, to increased reduction of the posterior large sucker in *alaskensis* and *reductus*.

(2) *S. indianensis* group - Mites of this group currently include six species; they occur primarily on the posterior dorsum and sides of the North American beaver. They are characterized by having one large sucker which is elongate or tubular rather than flat and broad throughout its length. Species in this group are *S. indianensis*, *postannulatus*, *tetrapilis*, *centralis*, *contrarius*, and *distinctus*. They differ in the placement of the small suckers and the na and np setae.

(3) *S. virgulatus* group - Mites of this group occur primarily on the venter. Six species have been described. Members of this group have one large flat sucker on each sucker plate. Species currently recognized in this group

are *S. virgulatus*, *subvirgulatus*, *inversus*, *furcatus*, *protinus* and *posticus*. They are characterized primarily by the position of the small suckers on the sucker plate.

(4) *S. spinifer* group - This group contains only one species, *S. spinifer*. It differs from members of the other groups in being relatively uncommon, in not being as restricted to specific locations on the beaver, and in having the large sucker highly modified as an elongate slender pointed tube. Further, all stages have the 1 2 developed as a broad lateral spine rather than as a seta.

The purposes of this paper are to present information on the beaver mites, genus *Schizocarpus*, from beavers from Massachusetts and Maine, to compare the *Schizocarpus* communities from these two areas with each other and with the communities from beavers from Indiana and Alaska, and to test the hypotheses of site specificity and sample homogeneity stated above.

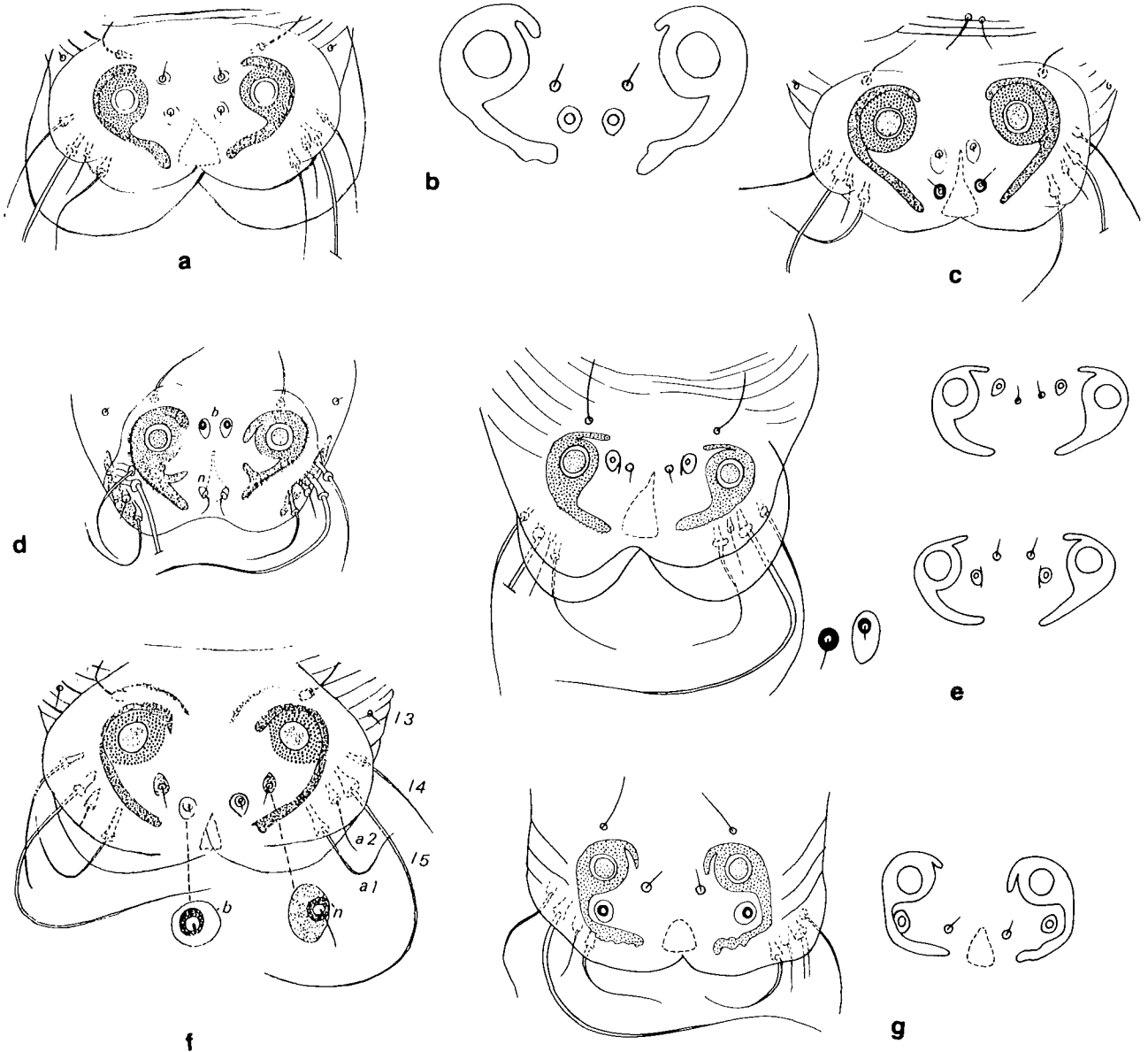


Fig. 3. Male sucker plates of *S. virgulatus* group mites - (a) *S. subvirgulatus*; (b) *S. subvirgulatus* (variant or new); (c) *S. inversus*; (d) *S. furcatus*; (e) *S. protinus*; (f) *S. virgulatus*; (g) *S. posticus*.

MATERIALS AND METHODS

Methods are outlined in more detail in Fain et. al (1984) and Fain and Whitaker 1988, but briefly the beavers were skinned and samples of mites were taken of approximately 2x2 cm squares in each of 23 different areas of the beaver. Estimates were made of the number of mites in each sampling area. Male mites were mounted and identified from each sample, since classification is based entirely on males; it is not possible to identify other

life stages to species at this time. The five beavers from Massachusetts were from The Connecticut River Valley of Franklin County. Those from Maine were taken April 26 to 29, 1986 at Dexter, in Penobscot County.

RESULTS

Seven species were found on the five beavers from Massachusetts, and 12 from the six beavers from Maine, as compared with 12 from Indiana and 14 from Alaska

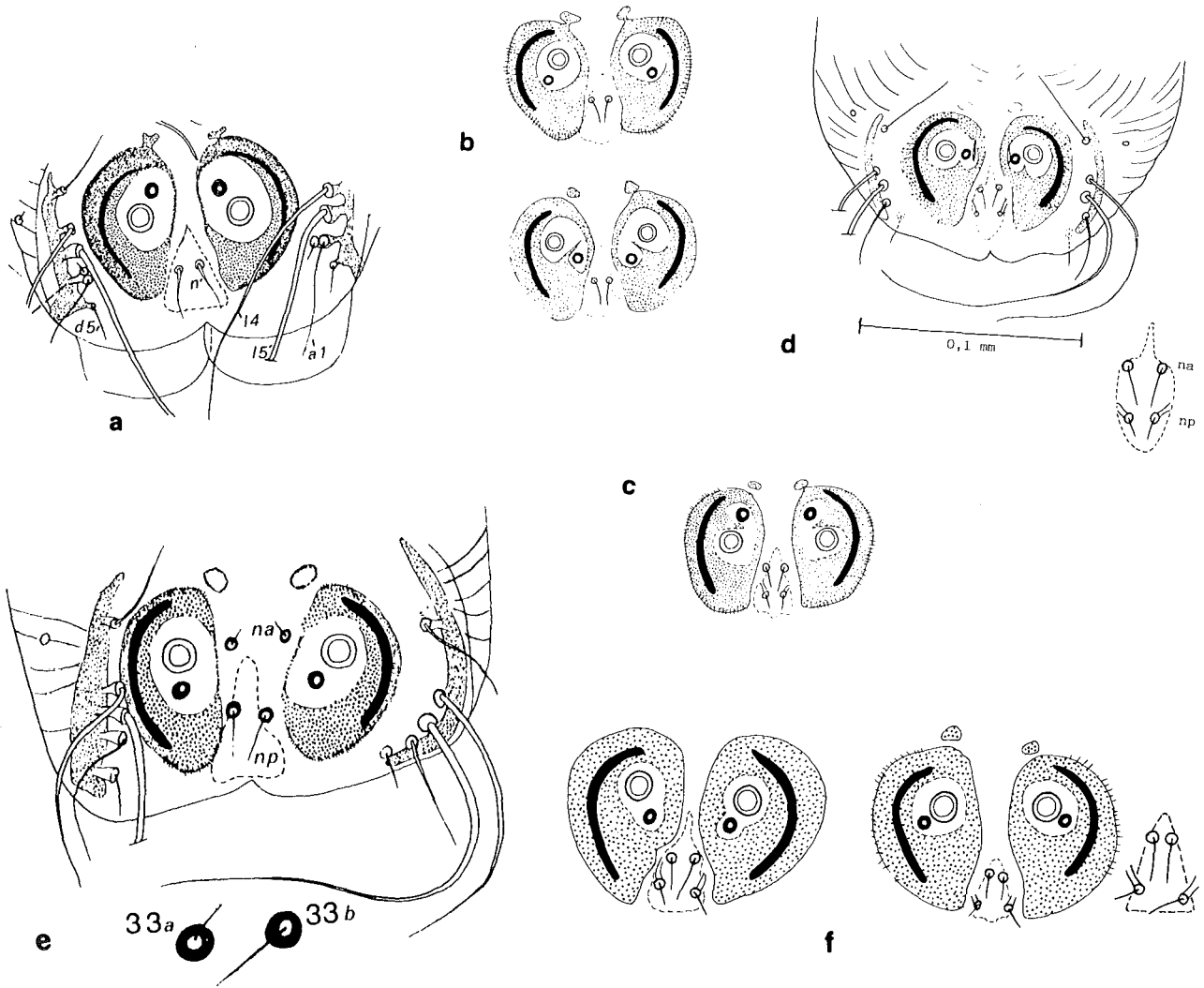


Fig. 4. Male sucker plates of *S. indianensis* group mites - (a) *S. indianensis*; (b) *S. postannulatus*; (c) *S. contrarius*; (d) *S. centralis*; (e) *S. tetrapilus*; (f) *S. distinctus*.

(Table 1). No new species were included in this material.

Four species occurred on hosts from all four localities, two in the *S. indianensis* group, *S. indianensis* and *postannulatus*. *S. subvirgulatus* in the virgulatus group, and *S. spinifer*, in the spinifer group.

The *Schizocarpus* species in the *S. mingaudi* group varied considerably between states, with *S. paramingaudi* being the only species found in Massachusetts, *S. reductus* and *S. alaskensis* both being abundant in Maine, *S. mingaudi* greatly outnumbering the only other species in the group, *paramingaudi* in Indiana, and *S. reductus* being by far the most abundant species in Alaska.

In the *S. indianensis* group, *S. postannulatus* was the most abundant species in Massachusetts, Maine, and Alaska, whereas *S. indianensis* was the most abundant

species, followed by *S. tetrapilis* and finally *postannulatus* in Indiana.

In the *S. subvirgulatus* group, *S. subvirgulatus* was the most abundant species in Maine, Indiana and Alaska, and was second to *S. inversus* in Massachusetts. *S. virgulatus* occurred in relatively large numbers and was second in abundance in Indiana and Alaska.

DISCUSSION

The data are arranged by major portion of the beaver (Table 2). Indicated in this table are the results expected and obtained according to our hypothesis of the relationship of the mites to the various areas. The hypothesized groups are listed in parentheses after the areas, and the

Table 2. *Schizocarpus* on different parts of three beavers from Massachusetts and six beavers from Maine. Numbers in parentheses refer to areas on beavers.

		Massachusetts		Maine	
		Number of mites		Number of mites	
		Total No./sq.cm		Total No./sq.cm.	
HEAD AND NECK (mingaudi group expected)					
<i>S. paramingaudi</i>	*	89	2.47	2	0.33
<i>S. alaskensis</i>	*			3	0.04
<i>S. subvirgulatus</i>		1	0.03	1	0.01
<i>S. postannulatus</i>		1	0.03		
<i>S. inversus</i>		16	0.44	3	0.04
<i>S. reductus</i>	*	1	0.03	258	3.58
<i>S. mingaudi</i>	*			2	0.03
<i>S. spinifer</i>	*			1	0.01
(356 of 378 or 94.2% fit hypothesis)					
ANTERIOR DORSUM (mingaudi group expected)					
<i>S. paramingaudi</i>	*	29	0.81		
<i>S. postannulatus</i>		3	0.08	2	0.03
<i>S. subvirgulatus</i>		10	0.28	15	0.21
<i>S. spinifer</i>	*	6	0.17		
<i>S. reductus</i>	*			2	0.03
<i>S. indianensis</i>				5	0.07
<i>S. tetrapilis</i>				1	0.01
(37 of 73 or 50.7% fit hypothesis)					
MID-DORSUM (transition area, mingaudi, indianensis groups expected)					
<i>S. postannulatus</i>	*	24	2.00	28	1.17
<i>S. paramingaudi</i>	*	11	0.92		
<i>S. distinctus</i>	*	9	0.75		
<i>S. indianensis</i>	*	3	0.25	16	0.67
<i>S. reductus</i>	*			1	0.04
(92 of 92 or 100% fit hypothesis)					
POSTERIOR DORSUM (indianensis group expected)					
<i>S. postannulatus</i>	*	17	0.71	16	0.33
<i>S. inversus</i>		8	0.33		
<i>S. paramingaudi</i>		1	0.04		
<i>S. indianensis</i>	*	1	0.04		
<i>S. spinifer</i>	*			1	0.02
<i>S. tetrapilis</i>	*			9	0.19
(44 of 53 or 83.0% fit hypothesis)					

ABDOMEN (subvirgulatus group expected)

<i>S. inversus</i>	*	71	0.99	15	0.10
<i>S. subvirgulatus</i>	*	31	0.43	306	2.13
<i>S. paramingaudi</i>		1	0.01		
<i>S. virgulatus</i>	*	1	0.01		
<i>S. protinus</i>	*	2	0.03	1	0.007
<i>S. spinifer</i>	*	2	0.03	9	0.06
<i>S. postannulatus</i>		1	0.01	1	0.007
<i>S. posticus</i>	*	1	0.01		
<i>S. reductus</i>				1	0.007

(436 of 440 or 99.1% fit hypothesis)

INSIDE OF FRONT LEGS (subvirgulatus group expected)

<i>S. subvirgulatus</i>	*	7	0.29	62	1.29
<i>S. inversus</i>	*	2	0.08	8	0.17
<i>S. paramingaudi</i>		2	0.08		
<i>S. spinifer</i>	*	1	0.04	1	0.02
<i>S. virgulatus</i>	*	1	0.04		

(82 of 85 or 96.5% fit hypothesis)

INSIDE OF HIND LEGS (subvirgulatus group expected)

<i>S. inversus</i>	*	14	0.58	3	0.06
<i>S. subvirgulatus</i>	*	6	0.25	11	0.23
<i>S. spinifer</i>	*	1	0.04	6	0.13

(41 of 41 or 100% fit hypothesis)

OUTSIDE OF FRONT LEGS (mingaudi group expected)

<i>S. paramingaudi</i>	*	46	1.92		
<i>S. spinifer</i>	*	1	0.04		
<i>S. inversus</i>		1	0.04		
<i>S. reductus</i>	*			10	0.21
<i>S. alaskensis</i>	*			2	0.04
<i>S. subvirgulatus</i>				7	0.15

(59 of 67 or 88.1% fit hypothesis)

OUTSIDE OF HIND LEGS (indianensis group expected)

<i>S. inversus</i>		2	0.08		
<i>S. spinifer</i>	*	1	0.04	3	0.06
<i>S. distinctus</i>	*			3	0.06
<i>S. postannulatus</i>	*			7	0.15

(14 of 16 or 87.5% fit hypothesis)

 OVERALL TOTAL: 1162 OF 1246 OR 93.3% FIT HYPOTHESIS

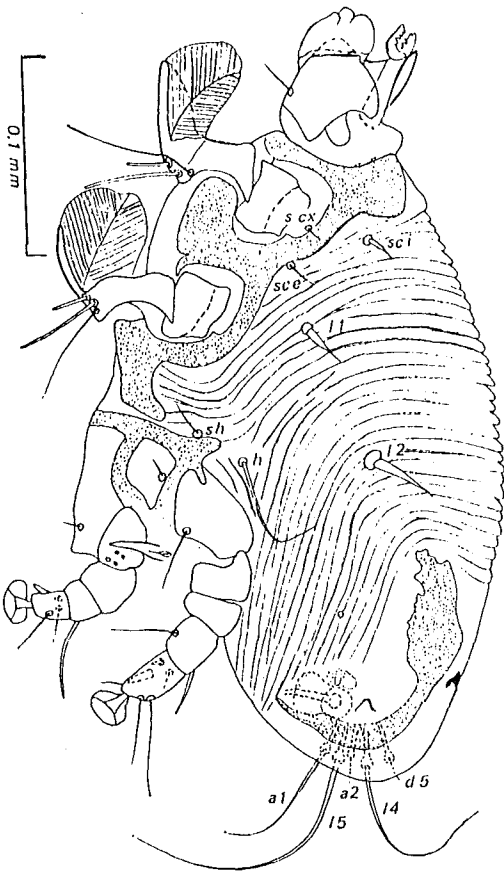


Fig. 5. Male of *Schizocarpus spinifer*.

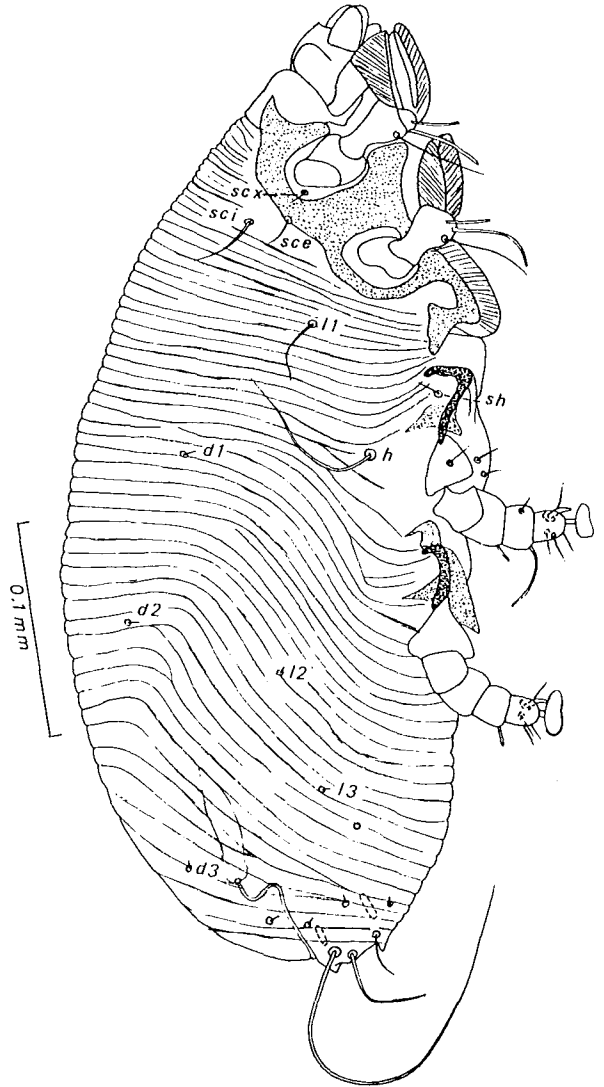


Fig. 6. Female of *Schizocarpus mingaudi*.

members of those groups are indicated by asterisk.

Schizocarpus spinifer occurred in relatively low numbers in all states. Previously it appeared that *S. spinifer* was not site specific in contrast to all other North American species, but it was not known if this was truly the case or if it appeared to be because so few individuals had been collected. Present data bear out the lack of site specificity of this species (Table 2) as it occurred in most of the major sites on beaver from both states, varying, when it occurred, from 0.01 to 0.17 per area.

Since *Schizocarpus spinifer* is not site specific, it is not listed in each of the parentheses, but is marked with an asterisk. Thus if the hypothesized distribution was 100% correct, all mites listed on the sheet would be marked with an asterisk, or conversely, mites not so marked do not fit the hypothesis.

At the end of each grouping by area are parentheses with the numbers of mites in the group that fit the hypothesis. The "% fit" ranged from a low of 50.7 in the anterior dorsum to 100%, and the overall fit was 1162 of

1246 or 93.3% of the mites examined were in the areas where expected, which we considered as a fairly good fit of the hypotheses.

As a test of our sample homogeneity hypothesis, samples containing more than 5 identified *Schizocarpus* males were examined since that criterion was used for the Indiana materials. From Indiana, 63 of 92 (68%) of the samples contained only one species, 13 were predominantly one species, and 16 were mixed (Table 3). There was much more mixing of samples from Maine, Massachusetts and Alaska, than from Indiana (Table 3), with 52%, 47% and 24% homogeneous samples, and 30%, 37% and 48% mixed samples. Comparable data using samples with at least ten unidentified males per sample are given also for Maine, Massachusetts and Alas-

Table 3. Number and percentage of samples with only one, predominantly one, or mixed samples of mites from Alaska, Maine and Massachusetts, as compared to those from Indiana.

	Indiana	Maine	Mass.	Alaska
With at least five individuals per sample:				
One species	63 (68.5%)	26 (52%)	14 (47%)	16 (24%)
Predominantly one species	13 (14.1%)	9 (18%)	5 (17%)	19 (28%)
Mixed	16 (17%)	15 (30%)	11 (37%)	32 (48%)
Total samples	92	50	30	67
With at least 10 individuals per sample:				
One species		14 (48%)	9 (41%)	14 (28%)
Predominantly one species		5 (17%)	3 (14%)	16 (32%)
Mixed		10 (34%)	10 (45%)	20 (40%)
Total samples		29	22	50

ka (Table 3).

One would likely hypothesize on the basis of geography, that the mite communities from Maine and Massachusetts would show the greatest degree of similarity, and that these communities would be much more similar to that from Indiana than to that from Alaska. One would further think that the Alaska and Indiana mite communities would differ much more from each other than the Indiana community would from that of the New England communities.

However, this was not the pattern observed. A simple similarity index (S) was calculated as 2C over A + B, where A = the number of species in sample A, B = the number of species in sample B and C = the number of species common to both samples. Results of these calculations in order of decreasing indication of community relationships were:

The mite communities from Maine and Alaska showed the greatest degree of similarity, and those from Massachusetts and Indiana showed the second greatest degree of similarity. Those from Massachusetts and Maine were merely tied for 4th place in this hierarchy, indicating much less relationship than expected based on their geography. We suspect that this indicates reintroduction of west coast beavers into Maine at some time in the recent past. The first beaver to appear in Massachusetts after their early extirpation, were introduced to Lenox from Michigan. It would be interesting to examine *Schizocarpus* from Michigan. Additional beaver moved into Massachusetts from adjacent states, including Ver-

mont and New York. Beavers have become extirpated in many areas in the last century and early in this century, and then a number of reintroductions have been made. We suspect that the numerous transplantations of beavers by man have confused the existing evidence concerning geographical distribution of beaver mites, but that it has hastened and modified the process of speciation in this group of mites.

Another piece of evidence linking the Alaska and Maine beaver mite communities is that the most abundant species in each group are the same, *S. reductus* in the *mingaudi* group, *S. postannulatus* in the *indianensis* group, and *S. subvirgulatus* in the *virgulatus* group. However, the fact that two of the more abundant species from Alaska, *S. virgulatus* and *S. alaskensis*, are scarce or lacking in Maine, weakens this argument.

Key to North American Beaver mites, genus *Schizocarpus* (based entirely on sucker plates of males)

1. One or two large flat suckers in each sucker plate of type A and B or just A; (Fig. 1a) 2
- One elongate sucker of Type C (Fig 1b) or D (Fig 1c) 12
2. Sucker plates oval with an anterior A and a posterior B sucker and a pair of small setae n between sucker plates (Fig 2) *S. mingaudi* group . . . 3
- Sucker plates comma-shaped and bearing one

A type sucker; soft skin between suckers bears a pair of small suckers b and small setae n *S. virgulatus* group 6

3. Posterior suckers B completely within the sucker plate 4

- Posterior suckers B incompletely surrounded 5

4. Setae n between posterior suckers B (Fig. 2a) *S. mingaudi*

- Setae n anterior to posterior suckers B (Fig. 2b) *S. paramingaudi*

5. Suckers B open on internal side, but otherwise complete; Setae n generally behind suckers A; shields wide anteriorly (Fig. 2c) *S. alaskensis*

- Suckers B elongate, reduced to 2 rings open internally; Setae n usually between suckers A, shields narrowed anteriorly (Fig. 2d) *S. reductus*

6. Suckers b and setae n roughly equidistant apart forming a square, either between or behind suckers A 7

- Suckers b and setae n forming a different pattern 9

7. This square between suckers A (Fig. 3a) and with setae n ahead of suckers b *S. subvirgulatus*

- This square behind suckers A 8

8. Setae n ahead of suckers b (Fig. 3b) (*subvirgulatus* or variant)

- Setae n behind suckers b (Fig. 3c) *S. inversus*

9. Suckers b near anterior margin of A, n behind; b and n about equidistant apart; postero-lateral prolongation of opisthogastric shield furcate (Fig. 3d) *S. furcatus*

- Not as above; b and n different distances apart 10

10. Setae n farther apart than suckers b (Fig. 3f) *S. virgulatus*

- Suckers b farther apart than setae n 11

11. Setae n and suckers b behind A, the b widely apart and close to lateral arms of the shield (Fig 3g) *S. posticus*

- Setae n and suckers b between A, either on a line or with n slightly ahead or behind b (Fig 3e) *S. protinus*

12. Elongate and spinose type sucker D (Fig 1c); lateral setae spinose rather than setiform. *S. spinifer* group *S. spinifer*

- Tubular, non-spinose type sucker C in oval sucker plates (Figs 1b and 4); lateral setae setiform. *S. indianensis* group 13

13. With one set of setae (n) between sucker plates 14

- With two sets of setae, an anterior one (an)

and posterior one (pn) between sucker plates 15

14. With small sucker rings ahead of large suckers (Fig. 4a) *S. indianensis*

- With small sucker rings behind large suckers (Fig. 4b) *S. postannulatus*

15. With small sucker rings ahead or inside of large suckers 16

- With small sucker rings behind large suckers 17

16. Small suckers ahead of large suckers (Fig 4c) *S. contrarius*

- Small suckers behind large suckers (Fig 4d) *S. centralis*

17. Setae na ahead of large suckers (Fig 4e) *S. tetrapilis*

- Setae na behind large suckers (Fig 4f) *S. distinctus*

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