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THE GENUS *PSEUDOSINELLA* (COLLEMBOLA, ENTOMOBRYIDAE) IN CAVES OF THE UNITED STATES¹

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In 1934 Bonet listed two troglophile species of the genus *Pseudosinella*, *P. decipiens* and *P. sexoculata*, from caves of the United States. In 1949 Delamare described two new troglobite species, *P. hirsuta* and *P. spinosa*, and placed them in a new genus *Troglosinella*. The present work is the result of the examination of more extensive collections from caves in the United States and has resulted in the addition of four more troglophile forms and the discovery of five new troglobite species. The work covered in this paper was made possible by a National Science Foundation Grant, No. G4563. Mr. Jerry Tecklin did much of the manual labor involved in preparation and he, Mr. James Hedges and Mr. George Darland, made a collecting trip through Missouri and northern Arkansas, recovering a good deal of critical material. Most of the remaining specimens were collected by Mr. and Mrs. Thomas Barr or Mr. Carl Krekeler. I wish to thank all of these people.

Distribution

Collections are relatively complete only from the region immediately around Tennessee and Kentucky; however, we have a sufficient scattering of material from other regions to be able to discern the probable outline of the distribution of the group. The species of this genus are more widespread in caves than those of the genus *Sinella* previously reported, but the troglobite forms are still largely limited to the southeast quadrant of the country. In the troglophile forms the extensive invasion of the caves of Missouri and Arkansas is the most notable phenomenon. Generally speaking, the troglobite forms are severely restricted in distribution and, in cases of numerous collections, more or less continuous. The troglophile forms are much more wide-

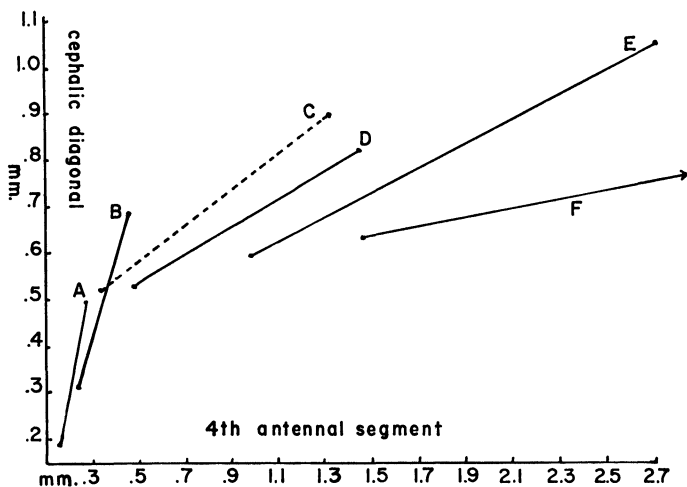
¹Published with the aid of a grant from the Museum of Comparative Zoology at Harvard College.

spread and occur in widely disjunct populations. As was true in *Sinella*, the majority of the collections of troglophile forms falls outside of the areas occupied by the troglobite species.

Biology

Little accurate, detailed information is available concerning the biology of the members of this genus. The visible gut contents indicate that fungal hyphae and spores make up the major portion of the diet of most members. The incompleteness of the data on and collections of both cave and epigeic forms of this genus makes it difficult to classify the habitat of the various species. On a basis of present data we can place the forms described here into four groups: 1) the definite troglo-

GRAPH I



Graph 1. Curves showing the differing ratios of the fourth antennal segment to the cephalic diagonal in the cave species of U. S. *Pseudosinella*. A includes: *P. argentea*, *P. folsomi*, *P. duodecimpunctata*, *P. alba*, and *P. sexoculata*; B: *P. dubia*; C (a probable average of several curves): *P. hirsuta*; D: *P. gisini*; E: *P. spinosa*; and F: *P. boneti*.

bites — including *P. spinosa*, *P. boneti*, *P. espana*, *P. hirsuta*, and *P. gisini*; 2) the doubtful troglobites — *P. dubia* and *P. orba*; 3) the doubtful troglophile — *P. argentea*; and 4) the definite troglophiles — *P. petterseni*, *P. alba*, *P. folsomi*, *P. duodecimpunctata*, and *P. sexoculata*.

Systematic Account: General Discussion

The genus *Troglosinella* was created by Delamare for the species *hirsuta* and *spinosa*. Examination of much more extensive material encompassing several new species makes it clear that the generic limits set up by Delamare are impractical. Two of the most basic characteristics used to separate the genus (the ringing of the fourth antennal segment, and the small non-lamellate teeth) are present in some forms of *hirsuta* and absent in others. Beyond this the reduced tooth structure of the unguis appears in a number of separate epigeic forms. The spines of the dens, also used to separate the genus, are found in only one species (*P. spinosa*) and the "heavy hairs" found on the dorsum of the dens in *hirsuta* are found in large specimens throughout the whole of *Pseudosinella*. In view of this, and my failure to discover any other practical way to separate the genus from *Pseudosinella*, I consider *Troglosinella* Delamare to be a synonym of *Pseudosinella* Schäffer. It is regrettable that this is unavoidable, since the species clustered around *P. spinosa* do represent an evolutionary unit.

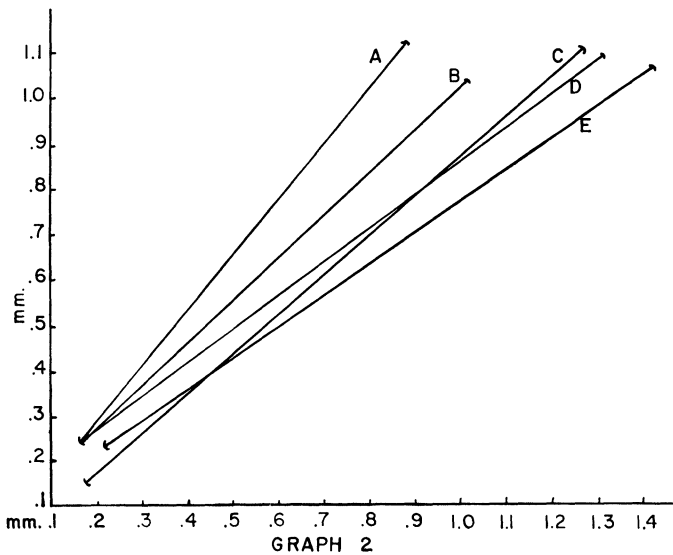
Ratios and Size

As with almost all groups of Collembola, the size of the species varies considerably. It is extremely risky to determine the size of a particular species upon anything except large samples from a variety of localities. Time and again a whole sample will be made up of small individuals, or will consist exclusively of extra-large specimens. With all this in mind it is possible to break the cave species of *Pseudosinella* of the United States into three size ranges: small (averaging around 1 mm.) — *P. espana* (?), *P. alba*, *P. folsomi*, *P. duodecimpunctata*, and *P. sexoculata*; medium (averaging between 2-3 mm.) — *P. orba* (?), *P. boneti* (?), *P. dubia*, *P. gisini*, *P. argentea* and *P. hirsuta*; and finally the large (averaging around 4 mm.) — *P. spinosa*.

The ratios of the various organs vary, but if we consider all the species, almost any organ ratio can be expressed as a straight line, with one or two notable exceptions. The only striking exceptions involving several species concern the first and second abdominal segments and the length of the antennae. The latter is illustrated in graph 1, which shows the most sensitive segment, the fourth, plotted against the cephalic diagonal. It can be seen that the most highly evolved cave forms develop progressively longer antennae. For most of the other organs a single straight line can express the growth changes and encompass all species. Graph 2 shows a summary of such growth lines for organs of the various parts of the body. There are a few varia-

tions from the norm in several of these curves. The most striking is in connection with one population of *P. hirsuta* which has a longer fourth abdominal segment than is normal, and in all of the specimens examined of *P. duodecimpunctata* which have the manubrium, longer than is normal in the remaining species. It is quite probable that more exhaustive analysis will point out more such exceptions; however, it is apparent that there is little difference among the various species in most organ ratios.

The genus *Pseudosinella* under any definition is a patently polyphyletic group with characteristics largely determined by a particular ecology; it can be distinguished from its ancestral genus *Lepidocyrtus* upon only one basis — the reduction in the number of eyes. *Pseudosinella* usually shows additional characteristics in the loss of pigment and the modification of the unguis structure, either through great elongation and reduction in the size and number of inner teeth and/or through the enlargement of the basal inner unguis teeth. Within the North American cave forms there are three and possibly four separate evolutionary lines involved. Only one of these, the group including



Graph 2. Curves for five different organ ratios, each curve being a composite of all species. In the key below the ordinate is given first in each case. A: cephalic diagonal/second thoracic segment; B: cephalic diagonal/third tibiotarsus; C: manubrium/mucrodens; D: cephalic diagonal/mucrodens; E: cephalic diagonal/fourth abdominal segment.

P. spinosa, has gone through extensive evolution within the caves. In spite of the diverse origins of the species of this genus the forms are normally quite similar. The thorax has a somewhat enlarged second segment and the mucro is bidentate with a basal spine. The chaetotaxy is very uniform with macrochaetae on the head being commonly numerous only along the antennal bases, between the antennae, and on the anterior half of the ventral surface. The mesothorax has a series of rows along the anterior margin, and the lateral surface of the fourth segment and the last two segments have sparse coverings. Scattered macrochaetae and groupings of from two to four odd, short, feathered setae and one long filamentous ciliate seta occur on the third and fourth abdominal segments (See figure 11). The scales are hyaline, finely striate and apically rounded. On the whole we have an artificial but readily separated genus.

Key to the Cave Species of *Pseudosinella* of the United States

- | | | |
|-----|--|---------------------------------|
| 1) | Empodial appendage with a clear wing-like tooth at the end of a separate outer lamella | 2 |
| 1') | Empodial appendage with a small outer tooth or toothless | 4 |
| 2) | Mucro without basal spine | <i>P. espana</i> n. sp. |
| 2') | Mucro with basal spine | 3 |
| 3) | Unguis with median unpaired inner tooth | <i>P. petterseni</i> |
| 3') | Unguis without median unpaired inner tooth | <i>P. folsomi</i> |
| 4) | Dens with spines | <i>P. spinosa</i> |
| 4') | Dens without spines | 5 |
| 5) | With eyes | 6 |
| 5') | Eyeless | 11 |
| 6) | Two or fewer eyes per side | 7 |
| 6') | Three or more eyes per side ² | 9 |
| 7) | All inner unguis teeth small | 8 |
| 7') | Basal, and sometimes all inner teeth large, two eyes per side | <i>P. alba</i> |
| 8) | Tenant hair weakly clavate and/or median unpaired inner unguis tooth absent | <i>P. gisini</i> n. sp. |
| 8') | Tenant hair acuminate, median unpaired inner unguis tooth present | eyed forms of <i>P. hirsuta</i> |
| 9) | Three eyes per side on two separate eyepatches | <i>P. sexoculata</i> |
| 9') | Some members of each population with more than three eyes per side, always on one eyepatch | 10 |
| 10) | All inner unguis teeth subequal, typically five eyes per side | <i>P. dubia</i> n. sp. |

²Occasional members of a population with four or more eyes may be eyeless.

- 10') Basal inner unguual teeth clearly larger than others, typically six eyes per side *P. duodecimpunctata*
- 11) Fourth antennal segment more than two times as long as cephalic diagonal *P. boneti* n. sp.
- 11') Fourth antennal segment less than one and seven-tenths times as long as cephalic diagonal 12
- 12) Distance from distal base of largest inner unguual tooth to base of unpaired inner tooth less than half that from unpaired tooth to apex of unguis (See figure 44), macrochaetae present in median field of dorsum of head *P. orba* n. sp.
- 12') Distance from largest basal inner tooth to median unpaired tooth at least half as great as distance from apical tooth to apex of unguis, macrochaetae absent from median field of dorsum of head 13
- 13) One or both basal inner unguual teeth large and prominent (See figure 31), ratio of fourth antennal segment to cephalic diagonal less than .8 *P. argentea*
- 13') Both basal inner unguual teeth small (See figure 47), and/or ratio of fourth antennal segment to cephalic diagonal greater than .8 eyeless forms of *P. hirsuta*

EXPLANATION OF PLATE I

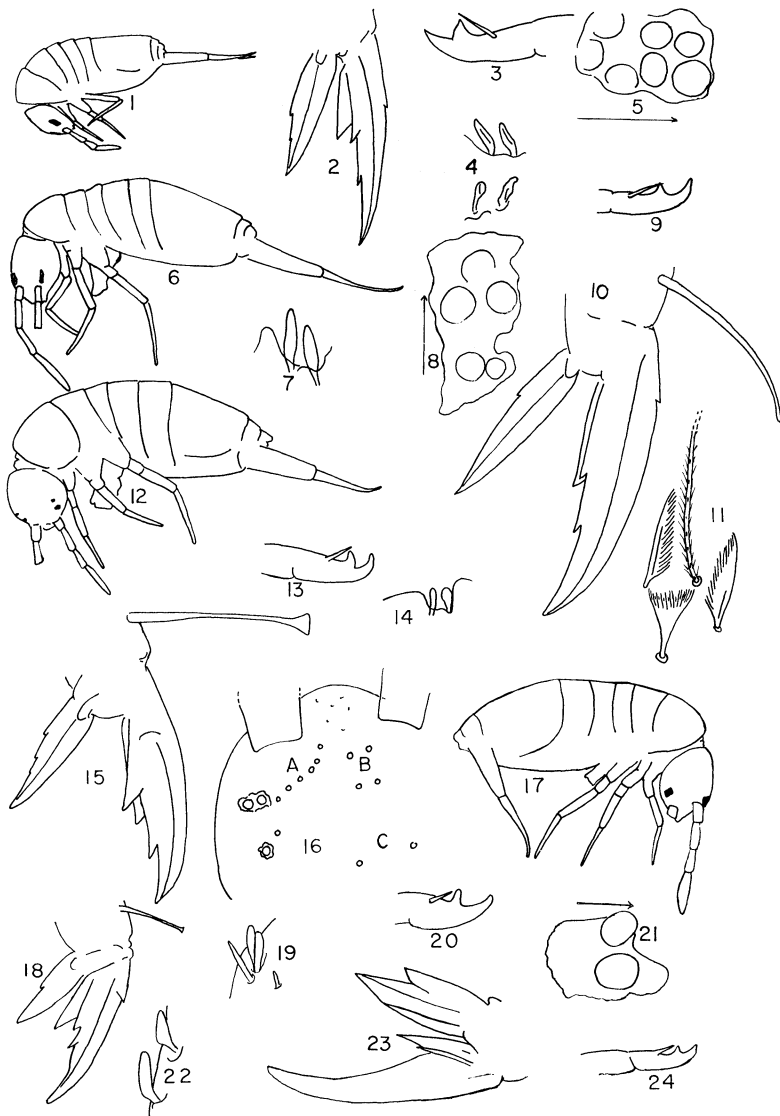
Figures 1-5: *Pseudosinella duodecimpunctata*. 1. Habitus, specimen from New River Cave, Giles Co., Va.; setae and pigment omitted; 19 X. 2. Hind claw, same specimen; 900 X. 3. Mucro, same locality; 900 X. 4. Apical organs, third antennal segments two different specimens, same locality; 900 X. 5. Eyes and eye patch, same locality; 900 X.

Figures 6-11: *P. dubia* n. sp. 6. Habitus, specimen from Granny Dean Cave, Washington Co., Ark.; setae and pigment omitted; 18 X. 7. Apical organ, third antennal segment, same specimen; 900 X. 8. Eye patch right side, same specimen; 250 X. 9. Mucro, same specimen; 500 X. 10. Hind claw, same specimen; 500 X. 11. Typical setae association of fourth abdominal segment, paratype; 900 X.

Figures 12-16: *P. sexoculata*. 12. Habitus, specimen from Carlsbad Caverns, N. Mex., setae omitted, 30 X. 13. Mucro, same specimen, 900 X. 14. Apical organ third antennal segment, same specimen; 900 X. 15. Hind claw, same specimen; 900 X. 16. closeup of head, same specimen, A.-interantennal setae, B.-antennal base setae, C.-median field setae; 150 X.

Figures 17-21: *P. alba*. 17. Habitus, specimen from Niagra Cave, Fillmore Co., Minn.; 30 X. 18. Hind claw, same specimen; 900 X. 19. Apical organ, third antennal segment, same specimen; 900 X. 20. Mucro, same specimen; 900 X. 21. Right eye patch, specimen from Mystery Cave, Fillmore Co., Minn.; 300 X.

Figures 22-24: *P. folsomi*. 22. Apical organ, third antennal segment, specimen from Limberlost Valley Cave, Newton Co., Mo.; 900 X. 23. Hind claw, same specimen; 900 X. 24. Mucro, epigeic specimen from Harahan, La.; 500 X.



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Descriptions of Species

Pseudosinella duodecimpunctata Denis

Figures 1-5

Pseudosinella duodecimpunctata Dennis 1931, Mem. Soc. Ent. Ital. 10:82.

P. (Pseudosinella) duodecimoculata Bonet 1931, Mem. Soc. Esph. N.H. 14:324-6.

Facies typical of genus *Lepidocyrtus*. Background color yellowish white, with scattered blue pigment, particularly heavy along the sides of the thorax and head. Head broadly oval in shape with a clear V-shaped dorsal area marked off by pigment; six eyes per side on trapezoidal eye patches. Antennae 1.2-1.4 times as long as cephalic diagonal with third antennal segment in the form of a truncate cone clearly shorter than the second segment; apical organ of third segment with two irregular oval pegs in separate deep folds. Second thoracic slightly humped. Fourth abdominal segment about four times as long as third. Unguis with a clear external tooth and three inner teeth; basalmost of these usually salient and larger than remainder. Empodial appendage lanceolate, with one or more minute external teeth. Tenent hair curved and clearly clavate. Mucro with apical tooth weakly upturned and longer than anteapical, basal spine attaining the apex of the anteapical tooth. Anterior macrochaetae as follows: on dorsum of head a group of four interantennal setae near the anterior margin and a curved row of seven setae along each antennal base, the anterior three being distinctly smaller; ventral surface with a few scattered setae near the anterior margin of the median and lateral areas. Second thoracic segment has a double row along the anterior margin.

Type locality: Buco de Piombo, Italy. Distribution: widespread in southern Europe in caves and epigeic. In North America the species has been taken in Florida, Massachusetts, and North Carolina as an epigeic form. In caves of the United States it has been taken from New River Cave, Giles County, Virginia; Wind Cave, Jackson County, Kentucky; Old Spanish Cave, Stone County, Missouri; Panther Cave, Newton County Missouri; and Foster's Cave, Montgomery County, Tennessee.

Discussion

The most striking variations seen in this troglophile species are in the number of eyes and amount of pigment. Most specimens have the twelve eyes characteristic of the species; but forms with ten eyes

are common; rarely, specimens appear with fewer, as can be seen in those from Tennessee which have from none to six per side. The tibiotarsus of this population is slightly longer than is normal for the species, but they are otherwise similar to forms seen elsewhere. This would appear to be an example of cave evolution proceeding within a population and would be worth additional study. Pigment may be uniformly distributed over the whole body or limited to the head region. The apical organ of the third segment varies from the condition described to two subcylindrical pegs.

The identity of this species with the European specimens is still in doubt as no comparisons could be made; however, there appears to be good agreement between the descriptions and the specimens at hand. This species may very well be the same as *P. collina*, which was described by Wray (1952) as having only two internal unguis teeth; but until this can be checked the two species must be considered separate.

Pseudosinella dubia, new species

Figures 6-11

Facies typical of genus. Background color white with an overall scattering of blue pigment, particularly dark on dorsum of head where it forms a diamond shaped mark between the eye patches. Head broadly oval; eyepatches elongate trapezoids, each bearing five eyes in two groups, an anterior group of three and a posterior group of two. Antennae about one and one half times as long as the cephalic diagonal; first three segments subcylindrical and fourth segment fusiform. Fourth segment dorsally with numerous blunted smooth setae of several different sizes and shapes; apical organ of third segment with two irregular flattened elliptical rods in a fold, and about fifteen additional blunt curved setae scattered over the inner ventral surface of the segment. Second thoracic segment markedly humped forcing the head into a slightly hypognathous position. Fourth abdominal segment about five times as long as third. Unguis with minute basal external tooth and three small internal teeth, with basal-most inner tooth on a level and frequently appearing as one under low magnification. Empodial appendage lanceolate, with a small but clear external teeth, exceeding the level of the unpaired internal unguis tooth. Tent hair weakly clavate. Mucro with apical tooth about twice as long as subapical, and markedly upturned; basal spine exceeding the apex of subapical tooth. Anterior macrochaetae as follows: on dorsum of head four interantennal setae, the posterior pair closer together, and

a curved row of eleven setae around each antenna base; ventral surface with a few scattered setae on the anterior median portion.

Type locality: Devils Den Kitchen Cave, Washington County, Arkansas, IX-9-'59, Tecklin, Hedges and Darland coll. Also taken from Granny Dean and Devils Den Caves, Washington County, Arkansas.

Discussion

The number of eyes varies considerably, most specimens having five per side. However, many have four per side; in such cases it is the posteriormost eye of the anterior three which is missing, and the position of this eye is variable even when it is present. The tenent hair varies from acuminate to markedly clavate.

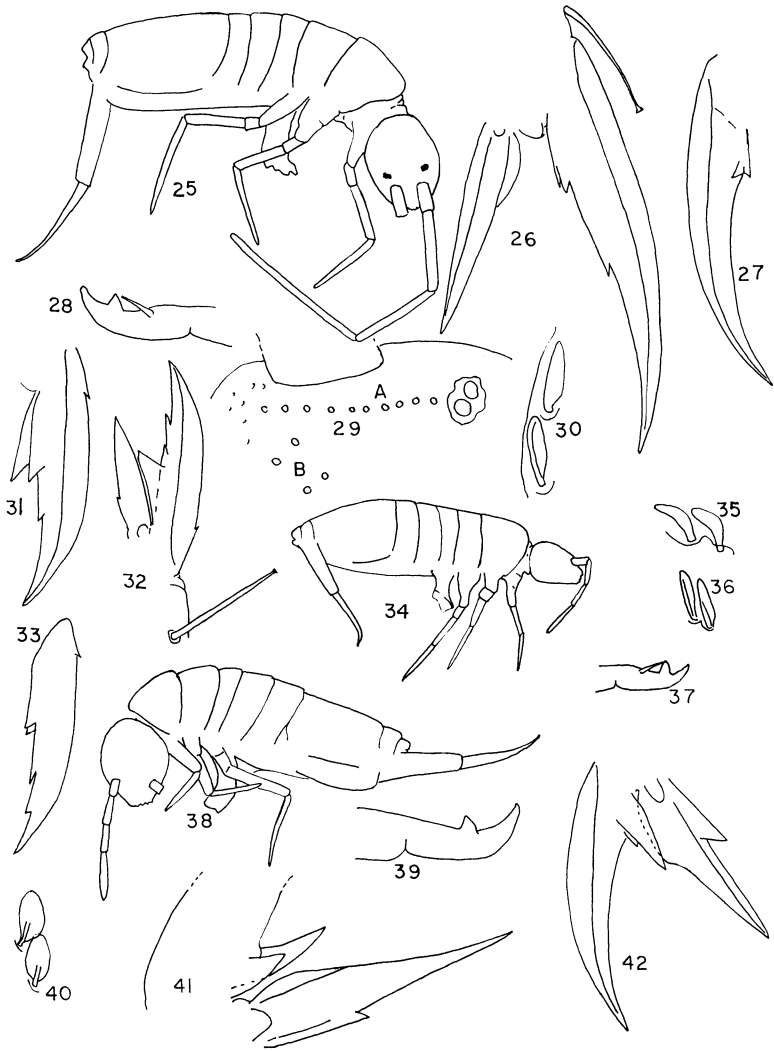
The taxonomic position, name and limits of this species are all moot. The species is clearly distinguished from the form called here *P. duodecimpunctata*. The antennae of *dubia* are longer, and the eye number typically different. The shape of the eye patch and distribution of the eyes are also different, as is the structure of both mucro and unguis. The question of the relationship between this form and Wray's *collina* or Guthrie's *Lepidocyrtus decemocolatus* is less easily settled. The present species appears to differ from *collina* in (1) the number of eyes (six vs. five per side typically); (2) the relative lengths of abdominal segments three and four (*collina* one: four, *dubia* one: five +); (3) antennal ratios; and (4) the comparison of lengths of the manubrium and dens. In addition, Wray's figures show the basal spine of the mucro not reaching the antepical tooth and the unguis

EXPLANATION OF PLATE 2

Figures 25-30: *P. gisini* n. sp. 25. Habitus, specimen from Higgenbotham Cave, Greenbrier Co., W. Va., setae and pigment omitted; 12 X. 26. Hind claw, paratype; 350 X. 27. Hind unguis, specimen from McFerrin Cave, Greenbrier Co., W. Va.; 250 X. 28. Mucro, same specimen; 250 X. 29. Dorsal setae and eyes right side, paratype, Greenbrier Co., W. Va.; A.-inter-antennals, B.-antennal base setae; 120 X. 30. Apical organ, third antennal segment, specimen from McClung Cave, Greenbrier Co., W. Va.; 350 X.

Figures 31-37: *P. argentea*. 31. Typical hind unguis, specimen from Eli Reed Cave, Larue Co., Ky.; 350 X. 32. Hind claw showing unusually large basal tooth, specimen from Rankin Cave, Jefferson Co., Mo.; 350 X. 33. Hind unguis showing unusually small basal teeth, specimen from Crownover Saltpeter Cave, Franklin Co., Tenn.; 350 X. 34. Habitus, specimen from Mammoth Cave, Ky., setae omitted; 17 X. 35. Apical organ, third antennal segment, specimen from Rankin Cave, Jefferson Co., Mo.; 900 X. 36. Same organ, specimen from Sparkman Cave, White Co., Tenn.; 900 X. 37. Mucro, same specimen; 500 X.

Figures 38-42: paratypes of *P. espasa* n. sp. 38. Habitus, setae omitted; 30 X. 39. Mucro; 900 X. 40. Apical organ, third antennal segment; 900 X. 41. Base of hind claw; 900 X. 42. Claw smaller specimen; 900 X.



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with two inner teeth. Both conditions differ in *dubia*. *Lepidocyrtus decemoculatus* is very poorly described, but every major described feature except the eye number would appear to indicate a separate species. The distribution of the eyes, the shape of the eyepatch, the hinted antennal ratios, and ratio of manubrium to dens all are different from those seen in *dubia*.

In any case, I feel that it is impossible to fit the present form into the descriptions of either species at this time. It is quite possible that close examination will show that this form is in fact synonymous with one or both of the species mentioned above.

Pseudosinella sexoculata Schött

Figures 12-16

Pseudosinella sexoculata Schött 1902, Bib. Kong. Sv. Vet.-Akad. Handl. 28: 34-5.

Lepidocyrtus sexoculatus Guthrie 1903, Publ. Geol. Nat. Hist. Survey Minn. Zool. Series 4: 86-7.

P(seudosinella) sexoculata Bonet 1934, Arch. Zool. Exp. Gen. 76: 370.

Facies typical of genus *Lepidocyrtus*. Background color dull yellow, pigment limited to eyepatches. Head circular, eyes three per side on two separate eye patches, two eyes in front and one behind. Antennae with fourth segment fusiform, second and third segments truncately conical and first segment subcylindrical; third segment strikingly shorter than the second and with an apical organ consisting of two basally constricted oval pegs in a deep fold. Second thoracic segment not strikingly humped, so that the head is prognathous. Fourth abdominal segment about three times as long as the third segment. Unguis without external teeth, the basal pair arising at different levels. Empodial appendage lanceolate with outer margin serrate. Tenent hair large and clearly clavate. Mucro with apical tooth slightly larger than antepical and markedly upturned at its apex; basal spine exceeding apex of antepical tooth. Anterior macrochaetae as follows: dorsum of head with a curved row of six setae along each antennal base and a single seta between the two eyepatches on either side; four interantennals, more posterior than normal; a medium pair of setae between and slightly in back of the two posterior eye patches; ventral surface of head with scattered setae along the anterior one-fourth. Second thoracic with a double row of setae along the anterior margin.

Type locality: epigeic greenhouses, Linköping, Sweden and Rosendal, Norway.

Distribution: a common epigeic form on the Pacific coast. Cave collections in the United States: Reids Cave, Fayette County, Kentucky; and Carlsbad Caverns, Eddy County, New Mexico.

Discussion

This form appears to be a rare troglophile in caves in the United States. Further exploration and collecting in western caves may show it to be more common than presently appears.

Pseudosinella alba (Packard)

Figures 17-21

Lepidocyrtus albus Packard 1873, Peabody Acad. Sci. 5th Ann. Rept: 37.

Sira (*Pseudosinella*) *alba* Schäffer 1900, Jahrb. Ver. Vaterl. Natur. 56: 269.

Pseudosinella alba Börner 1901, Zool. Anz. 24: 707.

Facies typical of genus *Lepidocyrtus*. Background color dull yellow white with scattered bluish or brownish pigment. Eyes two per side on square black pigment patches. Fourth antennal segment fusiform, third segment truncately conical and remainder subcylindrical; third segment noticeably shorter than second and with apical organ of two short subcylindrical pegs. Second thoracic segment slightly enlarged, with head prognathous. Fourth abdominal segment about four times as long as third. Unguis with three inner teeth with basal-most tooth being the largest. The empodial appendage is lanceolate with a small but clear external tooth. Tenent hair clavate. Mucro with apical tooth about twice as long as antepical and not strikingly upturned; basal spine barely attaining apex of antepical tooth. Anterior macrochaetae as follows: on the dorsum of head a group of four setae along the base of each antenna, and a group of four interantennal setae forming the corners of a narrow rectangle; in the center are four more setae marking the sides of a triangle which has its apex just anterior to the anterior pair. Ventral surface of head sparsely covered with setae over the anterior median portion. Anterior margin of second thoracic segment with a double row of setae.

Type locality: epigeic but uncertain, probably Massachusetts. A common epigeic form in the United States known from Mystery and Niagra Caves in Fillmore County, Minnesota and Christian Cave in Robertson County, Tennessee.

Discussion

I have examined and measured a considerable number of epigeic forms of this species and can find no significant differences between

these and the cave forms. The coloration is the most variable characteristic; some specimens are white save for the eyespots, while all others are almost totally blue.

Pseudosinella gisini, new species

Figures 25-30

Facies typical of genus. Color white with a scattering of blue pigment particularly clear upon the dorsum of the head. Head elongate oval with two eyes per side located upon a single dark eyepatch. Antennae about three and one half times as long as cephalic diagonal with all segments subcylindrical in shape; fourth antennal segment without apical cone and showing definite signs of ringing; third segment with apical organ of two curved, narrow, paddle-shaped setae with supporting rods along one margin. On the opposite side of the apex of third segment are five blunt finger-like setae. Second thoracic segment not humped. Fourth abdominal segment about four times as long as third. Unguis long and curved with external and lateral teeth minute and three inner teeth, basal pair small but clear and on a level, median unpaired tooth minute, visible only under highest magnification. Empodial appendage with slight basal internal swelling. Tenent hair finely clavate. Mucro with teeth subequal, apical tooth not sharply upturned, basal spine heavy, reaching apex of anteapical tooth. Anterior macrochaetae as follows: dorsum of head with four interantennal setae forming the corners of a rectangle, and a row of eight setae forming a straight line along each antenna base; ventral surface with scattered setae over the anterior half of the median and lateral surfaces. Second thoracic segment with two to three rows of setae along the anterior margin and a single row along the lateral margin.

Type locality: Foxhole Cave no. 1, Greenbrier County, West Virginia, VIII-19 '58. Barr coll. Also known from eight additional caves, all in Greenbrier County.

Discussion

The most prominent variation seen in the species concerns the median unpaired tooth of the unguis which may be entirely absent. In such forms the tenent hair is very weakly clavate so that this is visible only under highest magnification and with phase contrast. Although the typical form of this species is strikingly distinct from the typical form of *P. hirsuta* there are some specimens of the latter species which approach *gisini* in one or more characteristics (see discussion under *P. hirsuta*); however, the two can always be distinguished on a basis of the cephalic chaetotaxy and the tenent hair.

Pseudosinella petterseni Börner

Pseudosinella petterseni Börner 1901, Zool. Anz. 24: 707-8.

Facies typical of genus. Color silvery white without trace of pigment. Head circular and eyeless. Antennae with fourth segment fusiform, third segment truncately conical and remainder subcylindrical; apex of fourth segment rounded; apical organ of third segment with two subcylindrical pegs. Second thoracic segment not humped and the head prognathous at rest. Fourth abdominal segment about three and one half times as long as the third segment. Unguis with a small external tooth, and three well developed internal teeth; the basal pair not on a level and the basalmost one considerably larger than the remainder. Empodial appendage with a large outer wing tooth on a distinct lamella. Tenent hair strikingly clavate. Mucro with apical tooth twice as long as anteapical; basal spine exceeding the apex of anteapical tooth. Anterior macrochaetae as follows: dorsum of head with a row of six setae along each antenna base, the setae in each row being alternately large and small, the posteriormost seta of each row is displaced inward; interantennal setae are concentrated near the anterior margin of the head so that only two are clearly visible; ventral surface with scattered large setae on anterior one third of surface. Anterior margin of second thoracic segment with from two to four rows of setae.

Type locality: epigeic, Frauenberg bei Marburg, Germany.

Distribution: one of the commonest epigeic species in the United States; known in caves from Kendall and Burnett Counties, Texas, and Linn County, Iowa.

Discussion

The specimens seen from the Texas caves differ slightly from the epigeic forms seen in most of the country; in the former the basal unguinal tooth is smaller, the tenent hair clavate and the basal spine of the mucro shorter; however, these variations are probably geographical since epigeic specimens seen from New Mexico indicated similar modifications. Further collections from western caves will probably show this to be a much more common cave inhabitant than is presently indicated.

Pseudosinella argentea Folsom

Figures 31-37

Pseudosinella argentea Folsom 1902, Psyche 9: 366.

P(sseudosinella) dccipiens (?) Bonet 1934, Arch. Zool. Exp. Gen. 76: 370-3.

Facies typical of genus. Color white with scattered blue pigment particularly upon head. Head almost round when seen from above, often with traces of pigmentation on eyespot region; eyeless; antennae with third segment sub-conical in shape; fourth antennal segment much shorter than cephalic diagonal and with apex rounded, without apical cone. Apical organ of third segment of two strongly curved blunt pegs with an additional pointed peg off to one side. Thorax not humped and head prognathous. Fourth abdominal segment about four times as long as the third segment. Unguis with one or both basal teeth enlarged and a single median tooth prominent and projecting. Empodial appendage lanceolate with a very small external tooth. Tenent hair weakly clavate. Mucronal teeth subequal and basal spine attaining the apex of the median tooth. Anterior macrochaetae as follows: dorsum of head with four interantennal setae arranged in a narrow rectangle and with a small seta located in the center of this rectangle. Antennal bases with seven setae arranged 6-1 in a straight line along the base. Venter of head with a few scattered setae near the anterior margin. Second thoracic segment with three to four rows along the anterior margin and a single row of smaller setae along the lateral margin.

Type locality: a grave, Washington, D. C. Range: known from caves in Missouri, Central Tennessee, and single localities in Kentucky, Virginia, Arkansas, Georgia and Washington, D. C.

Discussion

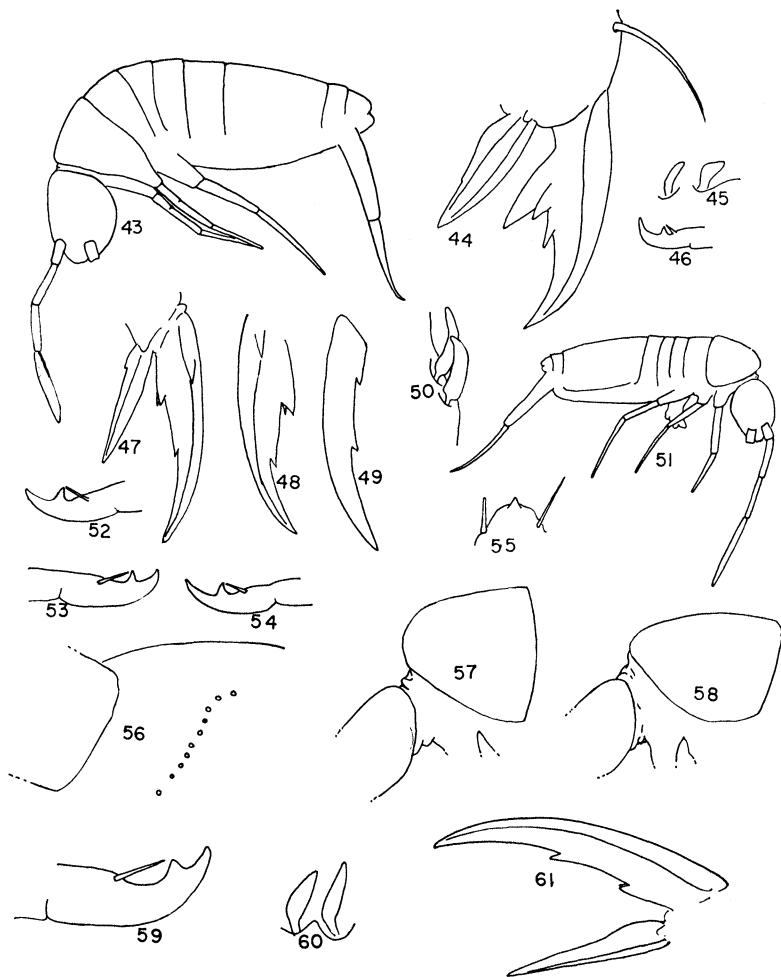
This species is almost as variable as *P. hirsuta* and in some forms the basic structure is very similar. The two species can always be sep-

EXPLANATION OF PLATE 3

Figures 43-46: holotype of *P. orba* n. sp. 43. Habitus, setae omitted; 30 X. 44. Hind claw; 500 X. 45. Apical organ, third antennal segment; 900 X. 46. Mucro; 500 X.

Figures 47-58: *P. hirsuta*. 47. Hind claw, specimen from Ward Cave, Bedford Co., Tenn.; 350 X. 48. Unguis, another specimen same locality; 350 X. 49. Hind unguis, specimen from Mill Creek Cave, Davidson Co., Tenn.; 250 X. 50. Apical organ, third antennal segment, same specimen as fig. 47; 900 X. 51. Habitus, topotype; 18 X. 52. Mucro, same specimen as fig. 47; 900 X. 53. Mucro, topotype; 900 X. 54. Mucro, same specimen as fig. 49; 900 X. 55. Apical cone fourth antennal segment, specimen from Piper Cave, Smith Co., Tenn.; 900 X. 56. Antennal base setae, same specimen; 250 X. 57. Thoracic profile, specimen from Gassaway Cave, Metcalfe Co., Ky.; 30 X. 58. Thoracic profile, specimen from Pratt Cave, Pickett Co., Tenn.; 30 X.

Figures 59-61: *P. spinosa*. 59. Mucro, specimen from Jared Hollow Cave, Putnam Co., Tenn.; 900 X. 60. Apical organ, third antennal segment, specimen from Payne Saltpeter Cave, Grundy Co., Tenn.; 900 X. 61. Hind claw, same specimen; 250 X.



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arated on a basis of the cephalic chaetotaxy and the apex of the antenna. The variations of the unguis structure are most striking. Typically the median tooth is large, but it may be small (see figures); also the basal teeth are normally staggered and of different sizes, but they may be of equal size and/or at the same level. The external tooth is usually present but may be folded and virtually invisible. A small apical tooth may be present. The tenent hair varies from strikingly clavate to acuminate. Some forms are totally without pigment while others are clearly colored. The cephalic diagonal, fourth antennal segment and head also vary considerably in size. The antennal base setae also vary with size (as is normal for the genus) but the huge majority of specimens examined had the number noted.

First examination of this material led to the belief that two or three species were involved; but, with larger series of specimens from many localities and careful analysis of the variation, it became apparent that no clear boundaries could be drawn within the whole group and that the combinations of characteristics were virtually at random. It appears that some of the variation is geographic in nature (example: large median tooth more common in northern populations) but an analysis of this must await further and more complete collections.

Specimens taken from caves in Virginia and identified by Bonet as *P. decipiens* (1934) are almost certainly *argentea*. It is quite possible that *P. argentea* is in fact synonymous with *P. decipiens*. The unguis in particular appears to have much the similar sort of variation in the European forms as in *argentea*. The figures for this species given by Denis, Bonet and Gisin would appear to indicate considerable variation; however, there are certain striking differences. First, in *argentea* a common form has both teeth arising at the same level, and this apparently is never true with *decipiens*. Second, Denis indicates the apical organ of the third antennal segment in *decipiens* as consisting of two cylindrical, straight pegs, whereas in *argentea* they consist of two basically constricted, strongly curved elliptical pegs. The fourth antennal segment is relatively longer in *argentea* than Bonet indicates for *decipiens*, and the fourth abdominal segment is from four to five times as long as the third rather than 3 to 3.5 times longer as indicated by Bonet for *decipiens*. In view of all of these I feel it wiser to maintain *argentea* until such time as a careful comparative study can be made between this form and *decipiens*.

Pseudosinella folsomi Denis

Figures 22-24

Pseudosinella folsomi Denis 1931, Mitt. Mus. Hamburg 44: 226-8.

Facies typical of genus. Color white without vestige of pigment. Head round, eyeless. All antennal segments subcylindrical; apex of fourth segment blunt; apical organ of third segment with two large elliptical pegs, constricted basally. Second thoracic segment slightly humped, head more or less prognathous. Fourth abdominal segment about three times as long as third. Unguis with only two strong basal internal teeth, arising at about same level and with one greatly enlarged. Empodial appendage with inner margin slightly truncate, and outer margin equipped with a prominent tooth on a distinct lamella. Tenent hair short and clavate. Mucro with apical tooth slightly longer than antepical; basal spine not attaining apex of antepical. Anterior macrochaetae as follows: dorsum of head with a group of five at each antenna base and four interantennals. Another pair of setae can be seen near the lateral margins of the middle of the dorsum; ventral surface with numerous scattered setae on the anterior third of the lateral and median portions. Anterior margin of the second thoracic segment with four to five rows of setae and a single row along the lateral margins.

Type locality: epigeic "Station No. 36," Massachusetts. Also recorded as an epigeic form from several places in the vicinity of Boston and New Orleans. Cave distribution: known only from Limberlost Valley Cave, Newton County, Missouri.

Discussion

Recent collections from South America would seem to indicate that this species is widespread in Chile at least. The fact that the epigeic collections in the United States have been limited to the vicinity of major ports makes it seem probable that this is an imported form here. Its one collection in a cave was in association with another troglophile species, *Sinella caeca*. Further collections will have to be made before anything can be said about the significance of this invasion.

***Pseudosinella espana*, new species**

Figures 38-42

Facies typical of genus. Color white without trace of pigment. Head oval, eyeless. Antennae one and one half times as long as cephalic diagonal, with the first three segments subcylindrical and fourth segment ellipsoidal; apical organ of third segment with two paddle-shaped setae having central supporting rods. Second thoracic segment not strikingly humped. Fourth abdominal segment slightly more than three times as long as third. Unguis narrow and sickle-

shaped with only two large basal internal teeth. Empodial appendage with a basal internal swelling and a large external tooth upon a distinct lamella. Tenent hair small and acuminate. Mucro with apical tooth gradually curved and more than twice as long as anteapical; basal spine absent. Anterior macrochaetae as follows: dorsum of head with five interantennal setae and a row of six setae near each antenna base and a pair near the center of the dorsal field; a diagonal row of three and group of four setae near each latero-posterior margin of the dorsum; ventral surface with two mid-lateral patches of densely packed setae. Second thoracic segment with three to four rows of setae along the anterior margin and a single row along the lateral margins.

Type locality: Old Spanish Cave, Stone County, Missouri, VI '59, Tecklin, Darland, and Hedges coll. Also known from Coleman's Cave, Montgomery County, Tennessee. It is probably widespread but uncollected in caves between these two points.

Discussion

This species is the only Nearctic member of the genus to lack a basal spine. Except for this remarkable feature it is very similar to *P. folsomi* although it shows a number of cave adaptations not found in this last species.

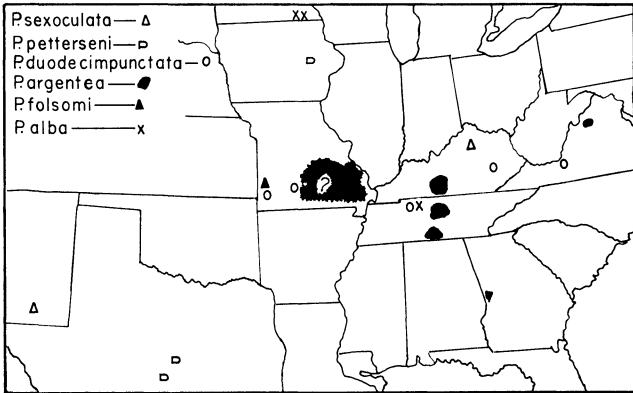
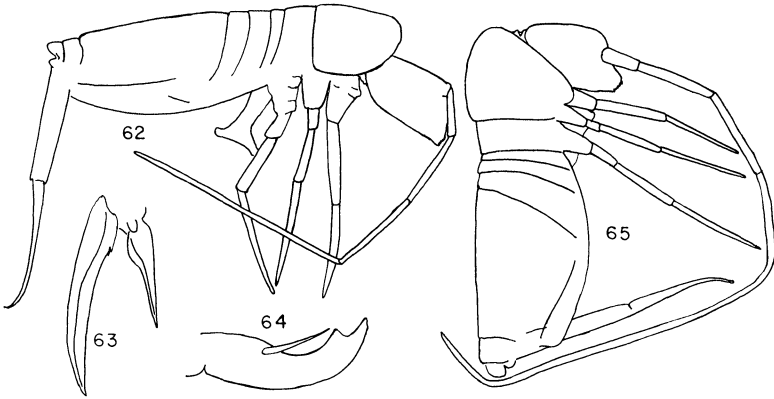
***Pseudosinella orba*, new species**

Figures 43-46

Facies typical of genus. Color white without trace of pigment. Head circular, eyeless. Antennae about twice as long as cephalic diagonal, all segments slightly ellipsoidal; second and third segments subequal in size; apical organ of third segment with two blunt oval pegs. Second thoracic segment slightly humped. Fourth abdominal segment about three times as long as third. Unguis broad, apically slightly hooked, basal internal teeth large, subequal, and arising well above the base of the claw; median unpaired tooth prominent and about at mid-level of unguis; a pair of small lateral teeth are near the base. Empodial appendage lanceolate, with external margin serrate and basally expanded. Tenent hair slender and acuminate.

EXPLANATION OF PLATE 4

Figure 62: *P. spinosa*, Habitus, specimen from Payne Saltpeter Cave, Grundy Co., Tenn., setae omitted; 18 X. Figures 63-65: *P. boneti* n. sp. 63. Habitus, holotype; 18 X. 64. Mucro, holotype; 350 X. 65. Hind claw, paratype; 250 X. Figure 66: Map showing known cave locations of six troglophile species of *Pseudosinella* in the U. S. Figure 67: Map showing cave distribution of seven troglomite species of *Pseudosinella* in the U. S.



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Mucro with apical tooth much larger than anteapical; basal spine slender but reaching the apex of the anteapical tooth. Anterior macrochaetae as follows: dorsum of head with an interantennal pair, and then in the anterior half of the median field six more arranged along the sides of a triangle with its apex near the interantennals; a straight row of eight setae along each antenna base; ventral surface with scattered setae along the anterior third. Second thoracic segment with two rows along the anterior margin and a transverse row of eight setae along the posterior margin.

Type locality: Morril Cave, Sullivan County, Tennessee. X '56, T. Barr coll. Also taken from Hamilton Cave, Bland County, Virginia.

Discussion

This striking species is quite unique in the chaetotaxy of the head and the structure of the unguis. In both characteristics it appears to be related to *P. alba* and may well represent a cave derivative of this species. The fact that the modifications for cave life are relatively slight makes it entirely possible that this is in fact a troglophile form which is so far undescribed from epigeic habitats.

Pseudosinella hirsuta Delamare (new combination)

Figures 47-58

Troglosinella hirsuta Delamare 1949, Notes Biosp'e., 4: 121-2.

Facies typical of genus. Background color yellowish white with slight touches of blue or reddish (?) pigment, particularly in the region of the antennal bases. Head elliptical, normally without eyes. Antennae elongate with all segments subcylindrical; fourth segment usually showing signs of ringing with a definite small conical projection at the apex; apical organ of third segment with two curved elliptical paddles, constricted basally. Second thoracic segment slightly humped. Fourth abdominal segment about six times as long as the third. Unguis elongate with a small external and three small internal teeth, the basal pair being on the same level. Empodial appendage narrow and lanceolate with a small external tooth. Tenent hair small and acuminate. Mucro with apical tooth about twice as long as anteapical and weakly upturned at the apex; basal spine just reaching the apex of the anteapical tooth. Anterior macrochaetae as follows: dorsum of head with an interantennal group marking the corners of a narrow rectangle; a row of nine setae along each antenna base with the posterior one or two in each row displaced inward; ventral surface

with scattered setae along the anterior half. Two to three rows of setae along the anterior margin of the second thoracic segment.

Type locality: Tennessee caverns, Tennessee, H. Henrot coll. Distribution: major distribution in south-central Kentucky, central Tennessee and northeast Alabama; isolated populations in eastern Tennessee and Kentucky.

Discussion

This species is the most abundant and most variable troglobite form of the genus in North America. No single description can apply to all of the available specimens, but the characteristics listed above apply to about 60% of the specimens and with one or another major alteration would fit all save about 1% of the specimens seen. The variation is extensive and can be seen in virtually all characteristics so that some specimens resemble *P. argentea* while others are superficially similar to *P. gisini*; indeed single specimens are often hard to place. Analysis of the variable characteristics shows that they are definitely geographically determined; however, since there is no similarity among the distribution of the various characteristics, the subspecies concept is clearly not applicable.

In general there are six characteristics which vary strikingly and these and their limits of variation are listed below:

- A) Second thoracic segment, strongly humped to virtually flat.
- B) Unguis, condition seen in *argentea* to condition seen in *gisini*.
- C) Empodial appendage, lanceolate to clearly basally expanded.
- D) Ratio of fourth antennal segment to cephalic diagonal, 3:6-5:3.5.
- E) Mucro, anteapical tooth middle to near apical tooth.
- F) Eyes, eyeless to two eyes per side.
- G) Pigment, totally white to head and thorax medium blue.

All in all the majority of the specimens are very similar to the form in the description and no one specimen carries very many of the variant characteristics.

Pseudosinella spinosa Delamare (new combination)

Figures 59-62

Troglosinella spinosa Delamare 1949, Notes Biosp'e., 4: 122-4.

Body elongate with attenuate appendages. Background color dull yellowish white with occasional flecks of reddish (?) pigment around the bases of the antennae. Head elliptical, strikingly longer than broad. Antennae with all segments subcylindrical, and fourth segment showing signs of ringing and subsegmentation; apex of antenna

with a small apical cone; apical organ of third segment with two flattened, fusiform, basally constricted paddles, in separate shallow folds. Second thoracic segment strongly humped forcing head into an opisthognathous position. Fourth abdominal segment about seven times as long as third. Unguis strikingly elongate, without external teeth but with three very small internal teeth, the basal pair being on a level and slightly smaller than the median unpaired tooth. Empodial appendage lanceolate, slender and with a striking internal basal expansion. Tenent hair small and acuminate. Mucro with antepical tooth displaced toward apex; teeth subequal in size; basal spine not attaining level of antepical tooth. Dens with one or two rows of heavy finely ciliate spines along anterior two thirds. Anterior macrochaetae as follows: dorsum of head with an interantennal group of five setae; a curved row of nine setae along each antennal base; ventral surface covered with numerous setae. Second thoracic segment with two to three rows of setae along anterior margin and a single row along the lateral margins.

Type locality: Alladin's Cave, Madison County, Alabama, H. Henrot coll. Distribution: limited to central Tennessee and north-east Alabama. Abundant within these limits.

Discussion

This is by far the most stable of the common troglobite species of this genus. The only striking variation is seen in the mucro, which has occasional populations with the antepical tooth much more basal than is normal. Other variations are minor; for example, some forms are entirely white while others have a scattering of pigment over the whole body. The inner unguis teeth are often so minute as to be invisible under low magnifications. The dental spines are often difficult to observe.

***Pseudosinella boneti*, new species**

Figures 63-65

Body elongate, appendages very attenuate. Color white without trace of pigmentation. Head oval without eyes. Antennae four or more times as long as head with all antennal segments subcylindrical; apical organ of third antennal segment with two paddle-shaped setae having the supporting rod along one margin. Second thoracic segment greatly enlarged, forcing the head into a hypognathous or opisthognathous position. First abdominal segment strikingly compressed; fourth abdominal segment almost seven times as long as third. Unguis extremely thin and elongate having only a single pair of in-

ternal basal teeth. Empodial appendage thin and basally swollen. Tenent hair minute and acuminate. Dens without spines. Mucro with apical and anteapical teeth close together and near apex, subequal in size; basal spine not attaining level of anteapical tooth. Anterior macrochaetae as follows: dorsum of head with seven interantennal setae and a row of eight setae along each antenna base; ventral surface with numerous densely packed setae along median and lateral area. Anterior margin of second thoracic segment with two to three rows of densely packed setae.

Type locality: Pumps Cave, White County, Tennessee, III '57 T. Barr coll. Also taken from Dairyhouse Cave in the same county; Wolf Cave, Morgan County, Alabama; and Wind Cave, Pulaski County, Kentucky.

Discussion

This well marked species represents the apogee of cave evolution in the Nearctic *Pseudosinella*. The series available is limited and little variation has been seen. In some forms the unguis teeth are entirely absent, and in the specimens from Alabama and Kentucky the median tooth of the mucro is less apical than in the Tennessee specimens. The specimens from Kentucky sometimes have a very small median internal unguis tooth.

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