Acarologia is a quarterly journal of acarology, since 1959
Publishing on all aspects of the Acari

All information:
http://www1.montpellier.inra.fr/CBGP/acarologia/
acarologia@supagro.fr

Acarologia is proudly non-profit,
with no page charges and free open access

Please help us maintain this system by
encouraging your institutes to subscribe to the print version of the journal
and by sending us your high quality research on the Acari.

Subscriptions: Year 2018 (Volume 58): 380 €
http://www1.montpellier.inra.fr/CBGP/acarologia/subscribe.php
Previous volumes (2010-2016): 250 € / year (4 issues)
Acarologia, CBGP, CS 30016, 34988 MONTFERRIER-sur-LEZ Cedex, France

The digitalization of Acarologia papers prior to 2000 was supported by Agropolis Fondation under
the reference ID 1500-024 through the « Investissements d’avenir » programme
(Labex Agro: ANR-10-LABX-0001-01)

Acarologia is under free license and distributed under the terms of the
Creative Commons-BY-NC-ND which permits unrestricted non-commercial use, distribution, and
reproduction in any medium, provided the original author and source are credited.
COPROZERCONIDAE, A NEW FAMILY OF ZERCONOID MITES FROM NORTH AMERICA (ACARI: MESOSTIGMATA: ZERCONOIDEA)

by Maria L. MORAZA* and Evert E. LINDQUIST**

SUMMARY: A new family of mesostigmatic mites, Coprozerconidae, is described on the basis of material collected from feces of the wood rat, Neotoma floridana magister Baird, in a cave in Kentucky, U.S.A. Coprozercon n. gen. is described as the type genus of the family, based on material representing the type species, Coprozercon scopaeus n. sp. The characteristics and relationships of this family among others of the cohort Epicriina are discussed, including a rationale for Coprozerconidae as the sister group of Zerconidae. The tocospermous genus Halozercon Wisniewski, Karg and Hirschmann, 1992, is transferred from the podospermous family Halolaelapidae to the tocospermous family Zerconidae.

RESUMEN: Se describe una nueva familia de ácaros Mesostigmata, Coprozerconidae, basada en material procedente de heces de la rata de bosque, Neotoma floridana magister Baird, de una cueva de Kentucky, E.U.A. Coprozercon gen. n. se describe como género tipo de esta familia, basándose en el material que representa a la especie tipo, Coprozercon scopaeus sp. n. Se discuten las características de esta familia con relación a las demás de la cohorte Epicriina, incluyendo una discusión de Coprozerconidae como el “grupo hermanado” de Zerconidae. Se trasladó el género Halozercon Wisniewski, Karg y Hirschmann, 1992, desde la familia podoespermica Halolaelapidae a la familia tocoespermica Zerconidae.

INTRODUCTION

In the acarine order Mesostigmata, or Gamasida, members of the cohort Epicriina sensu Johnston (1982), or “division” Epicriides sensu Evans & Till (1979), are relatively well known taxonomically but poorly known ecologically (Karg, 1993). Their diversity is centered in the Northern Hemisphere, where they occur primarily in edaphic habitats (Johnston, 1982; Karg, 1993). Epicriina is a relatively early derivative free-living group, and associations with insects and other arthropods in restricted habitats have not been reported.

Cladistically and hierarchically, the Epicriina is currently in a state of flux. It was treated as a division (equivalent to a cohort) with three families, Epicriidae, Zerconidae and Arctacaridae, by Evans & Till (1979), and as a cohort with the two families Epicriidae and Zerconidae (with Arctacaridae placed in its own cohort) by Johnston (1982). Earlier, Evans (1955) had considered the Epicriina to consist of two superfamilies, Epicrioridea with only one family, Epicriidae, and Zerconoidea with two families, Zerconidae.
dae and Arctacaridae. However, Evans (1992) placed each of these three families in its own suborder, among six other tocospermous suborders of Meso-stigmata, without considering phylogenetic relationships between them. Of these families, Zerconi- dae is by far the most disparate and speciose, with some 37 genera and nearly 100 species described. Epicriidae includes three genera and about 10 species described, while Arctacaridae includes but one genus and three species. Although phoresy is not known for any species in this cohort, we suspect that the deutonymph of the new taxon treated herein may be phoretic, for reasons presented in the discussion.

The hierarchic concepts of Karg (1965, 1993), which included Epicriidae among otherwise podospermous families in Phytoseioidea and Zerconiidae among otherwise podospermous families in Ascoidea, is not accepted here. His classification implies independent derivation of the complexity of structures involved with podospermy, including the male spermatodactyl and the female bilateral sperm access systems, several times. The classification of Krantz (1978), in following Karg and additionally in placing Arctacaridae in yet another group, Parasitoidae, that includes some podospermous families such as Veigaiidae, is unacceptable for the same reason.

The present paper deals with the description of a new family of Zerconioidea for which material representing but one new species and genus has been studied. The recognition of attributes that may be diagnostic at the familial level, as distinct from the generic and in turn specific levels, is clearly problematical for such monobasic taxa. In this case we have been guided to a considerable extent by the attributes used by various other authors to distinguish between families of Gamasida other than Uropodina and Trigynaspida, and by the attributes used by authors to distinguish the many genera of Zerconidae currently recognized. The genus-group characters in Zerconidae include the following adult attributes (Halásková, 1977, 1979): number of setae on peritrematal shield; relative length and shape of “peritrematal” setae r1 and r3 (p1 and p2 in most papers on Zerconidae); shape of posterior margin of peritrematal shield, and its connection with ventrianal shield; length and curvature of peritreme; sternal setae st/ on jugularia or on sternal shield; absence versus presence, number and arrangement of adgenital gland pores, gv2; presence/absence of adgenital platelets; presence/absence of small sclerites between genital and ventrianal shields; shape of ventrianal shield; number of setae on anterior margin of ventrianal shield; arrangement of opisthontonal setae, and number of setae on lateral margins of opisthontonal shield; presence/absence of transverse row of sclerotized fossae near posterior margin of opisthontonal shield; consolidation of opisthontal and podonotal shields; holotrichy versus neotrichy on idiosomal dorsum; shape of anterior margin of tectum. In our view, some of these character states may be trivial, species-level attributes, and they have led to the splitting of generic concepts in Zerconidae, from the three genera that were recognized by Sellnick (1958) to the 37 genera that are recognized currently. Except for the study of Athias-Henriot (1976) on Syskeuzzercon Athias-Henriot, the polarities of many of these character states have not been considered. As a re-evaluation of generic groupings in Zerconidae is outside the scope of this study, however, we have provisionally accepted them as they stand.

**Material and Methods**

Mites were extracted, using Berlese-Tullgren funnels, from samples of feces of a wood rat, Neotoma floridana magister Baird, from a cave (see remarks following description of the new species for details). Specimens were mounted individually in Hoyer’s medium and sealed with GPT insulating varnish on microslides. Morphological observations, measurements, and illustrations were made using compound microscopes equipped with differential interference contrast and phase-contrast optical systems. All measurements, given as micrometers, were made with stage-calibrated eyepiece micrometers. Idiosomal setal notation follows Lindquist & Evans (1965), with modifications for the posterior region as given by Lindquist (1994) and Lindquist & Moraza (1999); leg chaetotaxy follows Evans (1963, 1965), with modifications for tarsi II–IV as given by Evans (1969). Distinctions between porelike structures of the idiosoma as either gland pores (solenostomes) or poroids (lyrifissures), are based on morphological
observations of Athias-Henriot (1969a, 1969b), substantiated subsequently by physiological findings of Krantz & Redmond (1987). Notation for these structures, as adenotaxy and poroidotaxy, respectively, follows Johnston & Moraza (1991); using this notation, the prominent two pairs of opisthonotal gland pores gdZ3 and gdZ4 are homologous with those denoted as Po3 and Po4 by Sellnick (1958) and subsequent authors for zerconid mites.

Measurements of structures, expressed as ranges, were made as follows, unless noted otherwise. Dorsal body length: midline length from anterior margin between setae jJ to the caudal margin between setae JV5; anterior and posterior (when present) dorsal shield lengths: taken at midline from anterior to posterior margins of each shield; ventrianal or anal shield length: midline length from anterior margin to posterior edge of cribrum (which may be folded under); ventrianal or anal shield width: taken at greatest width (usually at level of anterior margin of anal opening). Leg lengths: from base of coxa to apex of tarsus excluding the pretarsus.

**COPROZERCONIDAE** new family

Type genus: *Coprozercon* new genus. Family monotypic, based on adult female and male and deutonymphal material representing one genus and one species.

**Diagnosis.** Adults of this family resemble those of other families of Epicriidae sensu Johnston (1982) (i.e., Epicriidae Berlese 1887, Zerconidae Berlese 1892) as follows. In adults of both sexes: palpi with five free segments, and palp-tarsal claw two-tined; peritremes reduced in length, not extending above bases of legs I; coxa II with anterodorsal spinelike projection; coxa IV retaining alveolar vestige of seta av; and legs I to IV with similar complement of setae on femora, genua and tibiae, including 10 setae on genua III and IV (pv present) and 9 on tibia III (pl-2 present). In the adult female: setae st4 off sternal shield; and epigynial portion of genital shield small, lacking expanded hyaline rim anteriorly. In the adult male: chelicerae formed much as in female, with movable digit lacking spermatodactyl; genital orifice mid-sternal (though relatively anteriorly placed in *Coprozerconidae*) on sternogonal shield; and leg II not modified for mating. They further resemble those of Zerconidae, in distinction to Epicriidae, as follows. In both sexes: dorsal body setation holotrichous; tri-dorsal setation with well-developed laciniae; peritremes well developed in deutonymph, though reduced in adults; and tarsi II to IV with dorsal lyrifissure well removed distad circumsegmental fissure so that together they do not circumscribe a dorsal platelet bearing setae ad3 and pd3. In the adult female: genital shield not enlarged, bearing only genital pair of setae, st-5. In the adult male (and deutonymph of both sexes): idiosoma covered by two well-developed, subequal podonotal and opisthonotal shields; anteriormost pair of marginal setae, r1, present; humeral pair of setae, r3, displaced ventrolaterally and inserted on peritremetal shield; and caudoventral pair of setae, JV5, displaced onto opisthonotal shield so as to appear like an extra pair of dorsal setae, “J6” or “Z6”.

Members of *Coprozerconidae* are distinguished from those of Zerconidae and Epicriidae by the following characters. Idiosomal dorsum of adult female with podonotal shield reduced laterally, such that marginal r-setae inserted on soft cuticle rather than on its margins, and with opisthonotal shield absent (not even pygidial or mesonotal remnants evident); that of male and deutonymph with two fully developed shields which bear most of the marginal setae anteriorly (except r3) and posteriorly; opisthonotal shield of male with lateral margins extended posteroventrally to capture insertions of several ventral setae (JV4, JV5, sometimes ZV4), yet not consolidated caudally with ventrianal shield (in contrast with Zerconidae). Opisthonotum lacking transverse row of four, often sclerotized, depressions (or fossae) near posterior margin, which is characteristic of deutonymphs and adults of most members of Zerconidae. Peritremal shield greatly reduced in adults of both sexes (though well developed in deutonymph), this shield a small fragment alongside coxa IV. Sterngonital region with normal five pairs of setae but lacking sternal poroids (lyrifissures); gland pores gV1 present on posterior margin of sternal shield of female, but not evident on male and deutonymph. Male genital orifice located within sternogonal shield but rela-
tively far forward between setae *st1* and *st2* at midlevel of coxae II, orifice covered by single valve or platelet which lacks eugenital setae. Euanal setae and their alveolar vestiges absent. Tarsi II–IV each with 16 setae in adult, lacking one of two ventral sets *av-1*, *pv-1* and *av-2*, *pv-2*, though both sets present in deutonymph.

**Description of adults. Idiosomal dorsum.** Female idiosoma (Fig. 1) with reduced podonotal shield and unsclerotized opisthonotum (no mesonotal or pygidial plates evident); podonotum holotrichous, with setae idionymic, most of them, except *r*-marginals, on podonotal shield; opisthonotum holotrichous or slightly hypertrichous, with setae idionymic, all on unsclerotized cuticle. Male idiosoma (Fig. 21) with two subequally sized dorsal shields; podonotal shield expanded laterally and posteriorly to include all podonotal setae and porelike structures on soft cuticle in female; opisthonotal shield separate from ventrianal shield, but expanded caudoventrally to include one or more of posterior *JV* and *ZV* setae.

**Idiosomal venter.** Tritosternum with slender, elongate trapezoidal base and well-developed laciniae (Fig. 4). Sternal poroids (lyrifissures *ist1*–*ist3*) absent, genital poroids *iv1* present on soft cuticle, and gland pores *gv1* present but on female only. Female with sternal setae *st1*–*st3* and gland pores *gv1* on sternal shield; genital shield small, lacking expanded hyaline rim anteriorly, with genital setae *st5* on its lateral margins (Fig. 3). Male with sternal setae *st1*–*st5* on sternogenital shield, and with genital orifice located between setae *st1* and *st2* at midlevel of coxae II, this orifice covered by single valve which lacks eugenital setae (Fig. 22). Peritrematal shielding greatly reduced, without associated porelike structures evident; peritremes much reduced in length from those on deutonymph, extending only to level of coxae IV. Anal valves with lateral poroids present and euanal setae absent (Fig. 5), and postanal cribrum present (Figs. 3, 22).

**Gnathosoma.** Anterior margin of tectum with denticulate medial projection (Fig. 10). Subcheliceral plate with a pair of paralabral processes (Fig. 11). Chelicerae three-segmented, with well-developed, dentate fixed and movable chelae; fixed chela with simple pilus dentilis; dorsal cheliceral seta in dorso-lateral position behind dorsal lyrifissure; arthrobal process at base of movable chela simple (Fig. 6); movable chela of male lacking spermatodactyl. Subcapitulum with 4 pairs of setae, pair *h2* inserted lateral to pair *h3* (Fig. 7). Anterior extremity of hypostome with pair of corniculi arising from its dorsolateral walls, and with one pair of internal malae; salivary stylets absent. Palpal segmentation normal, tibia not coalesced with tarsus; palptarsal apotele 2-tined; palpal setation holotrichous, its chaetotactic formula, *sensu* EVANS (1964), 2-5-6-14-15; palp genu with dorsosabal lyrifissure (Fig. 8).

**Legs.** (Figs. 17–20, 26). Tarsus I with paired claws and round-lobed pulvillus; tarsi II to IV with pretarsi bearing paired claws and round-lobed pulvillus. No sexual dimorphism in form of leg segments and their setae. Tarsi II to IV with 16 setae, 3-4/2,3/1-3, including apical dorsal set *ad1*, *pd1* which resemble setalike processes, and lacking ventral set *av-2*, *pv-2*; tarsi II–IV lacking ventral intercalary sclerite and setae *av-4*, *pv-4* in region of circumsegmental fissure; tarsus IV with dorsal lyrifissure well removed distad circumsegmental fissure so that together they do not circumscribe a dorsal platelet bearing setae *adB* and *pdb*.

Setation of coxae of legs I–II–III–IV, respectively, 2-2-2-1, coxa IV with alveolar vestige of second seta, *av*; setation of trochanters, 6-5-5-5. Chaetotactic formulae for femoral, genual, tibial setae of legs I–II–III–IV, respectively: femora I (2-3/2,2/0-0), II (2-3/1,2/2-1), III (1-2/1,2/0-0), IV (1-2/1,1/0-1); genua I (2-3/2,3/1-2), II (2-3/1,2/1-2), III (2-2/1,2/1-2), IV (2-2/1,3/1-1); tibiae I (2-3/2,3/2-2), II (2-2/1,2/1-2), III (2-1/1,2/1-2), IV (2-1/1,3/1-2). Leg I with four ventral setae on femur, three ventral setae on genu, and four ventral setae on tibia; femur II with two setae, *al-2* and *pv-2* (denoted *v-3* in EVANS, 1963), on basifemoral section, and lacking setae *pd-3* and *pl-2* on telofemoral section; femur III with seta *pd-2* but lacking *pl-1* (possibly an instance of homologue *pl-1* displaced to *pd-2* position); tibia IV with seta *pd-3*.

**Deutonymphal characteristics.** (Figs. 23–25). Idiosomal dorsum with two, well-developed dorsal shields; peritrematal shields with setae *r3*, gland pores *gdr4*, and long peritremes extending to anterior region of podonotal shield; opisthonotal shield separate from anal or ventrianal shield caudally. Dorsal chaetotaxy, poridiotaxy and adenotaxy similar to
adult. Idiosomal venter with weakly sclerotized shielding; sternogential pore structures absent, poroids iv5 on soft cuticle. Opisthogastric chaetotaxy and adenotaxy similar to adult. Gnathosoma as described for adult. Legs as described for adult except tarsis II to IV each with 18 setae, including both of ventral sets av-1, pv-1 and av-2, pv-2.

Distribution and habitats: We have examined a total of 30 specimens representing one species of this family from wood rat feces found in Little Beauty Cave, Mammoth Cave National Park, Edmanson County, Kentucky, USA.

Etymology. See under description of genus.

Remarks. The cohort Epicriina has not been the subject of any adequate cladistic analysis, and its component families have generally not been defined apomorphically. Discordant views persist even in placement of the family Zerconidae in the Epicriina, with Karg (1965, 1993), followed by Krantz (1978) and Krantz & Ainscough (1990), classifying Zerconidae in the superfamily Ascoidea in the cohort Gamasina. Arguments against Karg's view are given in our general discussion, below. A cladistic analysis of the Epicriidae sensu Evans & Till (1979), or the Epicriina sensu Johnston (1982), and their constituent families is beyond the scope of our study, though the following remarks and concluding general discussion are presented in a tentatively cladistic context.

Adults and deutonymphs of Coprozerconidae share a variety of characteristics with those of Zerconidae, as follows. (1) The peritrematal length is reduced in the adult from the normal, elongated state in the deutonymph. (2) The humeral pair of setae, r3, is in a lateroventral position, and they are often referred to as “peritrematal” or “peltidial” setae in the literature on Zerconidae (Lindquist & Moraza, 1999). (3) The deutonymph and adult male have separate but well developed podonotal and opisthonotal plates. (4) Setae s6 are inserted on the posterolateral corners of the podonotal shield. (5) Opisthonaotal gland pores gdZ3 and gdZ5 are prominent. (6) A pair of caudo-ventral setae, JV5, is captured on the opisthonaotal shield so as to appear like an extra pair of “dorsal” setae (Lindquist & Moraza, 1999). (7) Sternal gland pore gvl is present in the adult female. (8) The basal pair of subcapitular setae is barbed. (9) The palptar-
apomorphies of Zerconidae. The genus Alekoszercon Petrova is characterized in part by an entire dorsal shield in adults (Petrova, 1978); however, in other respects this appears to be a more recent derivative taxon in Zerconidae, such that we view the entire dorsal shield as a secondarily derived attribute within this family.

Within Zerconidae, there is no subset grouping of genera that shares any of the derivative attributes of the new taxon. Therefore, Coprozercon should not be classified as a subfamily or as some other subset within Zerconidae but, rather, as the sister family of Zerconidae based on the shared apomorphic characteristics noted above. Relationships between Zerconidae + Coprozerconidae and other putative families of the cohort Epicriina are problematical. These are considered under the final discussion of this paper.

Coprozercon new genus

Type species: Coprozercon scopaeus new species. Genus based on adult female, male and deutonymphal material representing one species.

Diagnosis. Opisthonotum with gland pores gdZ3 and gdZ5 (termed Po3 and Po4 in much of literature on Zerconidae) prominent, enclosed by circular platelets on soft cuticle of adult female, and enclosed by somewhat larger, protruding circular areas superimposed on opisthonotal shield of deutonymph and adult male. Lateral margins of sternal shield of female and sternogenital shield of male emarginated between setae st-2 and st-3. Female with pair of metasternal platelets bearing setae st4. Adults lacking endopodal and exopodal sclerites alongside coxae I to III. Adgenital platelets absent; adgenital gland pores gv2 single, on female only.

Description of adults. Adults of small size (idiosomal length 190–270 mm) relative to most Zerconidae (260–750 mm), and with character states of family as described above, but restricted and augmented as follows:

Idiosomal dorsum (Figs. 1, 21). Female podonotum with 23 pairs of setae, including 14 to 16 pairs (j2–j6, z2–z6, sl, s3–s5, sometimes j1, z1) on somewhat reduced podonotial shield proper, and 7 to 9 pairs (r1–r5, s2, s6, sometimes j1, z1) on soft marginal cuticle alongside this shield; podonotum lacking setae r6; opisthonotum with 22 or more pairs of setae (j1–j5, z1–z5, s1–s5, r1–r7 plus sometimes with unpaired jx-setae), all on soft striated cuticle. Dorsal and lateral porelike structures of female include: 7 pairs of poroids (idj1, idj3, idj6, idZ3, idz6, idS4, idS6) and 6 pairs of gland pores (gdj2, gdj4, gdZ5, gdz5, gdS4, gdS6) on podonotum, of which several pairs on soft cuticle due to reduced area of podonotial shield; 11 pairs of poroids (idJ1, idJ2, idJ4, idJ5, idZ3, idS1, idS2, idS3, idS4, idR3, idR5) and 2 pairs of gland pores (gdZ3, gdZ5) on soft cuticle of opisthonotum; gland pores gdZ3 and gdZ5 prominent, each on small circular scutellae; opisthonotal sigillae readily discernible on soft cuticle. Male with all podonotal setae, poroids and gland pores on podonotial shield, including setae r3 and gland pores gdS4 on marginal ventral extensions of this shield, but excepting poroids idS6, idS6 and gland pores gdS6 which are on anterior margin of opisthonotial shield; with all opisthonotal setae, poroids and gland pores on opisthonotial shield, which are expanded lateroventrally so as to also capture several ventral setae (JV4, JV5, sometimes ZV4) and poroids (ivo2, ivo4); gland pores gdZ3 and gdZ5 large, each on circular protuberant area.

Idiosomal venter (Figs. 3, 22). Both sexes with sternal and genital shielding weakly sclerotized; adgenital platelets absent; endopodal strips absent alongside coxae II–IV except for short strip behind coxae IV in male. Female with pair of metasternal platelets bearing setae st4, and with single pair of adgenital gland pores gv2 on soft cuticle immediately behind bases of legs IV; these pores absent in deutonymph and male. Exopodal shielding absent and peritrematal shielding reduced, scarcely larger in area than reduced peritreme and stigma. Female opisthogaster with 9 pairs of setae (Jv1–Jv5, Zv1–Zv4) and 5

1. The genus Halozercon was proposed for a species of mite, H. karacholana Wiśniowski, Karg & Hirschmann, whose females and males lack structures indicative of podosperm. In males, the chelicerae lack a spermatodactyl and the genital aperture is mid-steral. Females apparently lack a pair of solenostomes near the bases of legs III or IV. Therefore, this genus should not be placed in Haloalesalpidae, as proposed by Wiśniowski et al. (1992), or in any other family of podospermous Gamasina. Halozercon is here transferred to the tocospermous family Zerconidae, as a relatively early-derivative genus related to Syskenzercon, based on several of the apomorphies common to these genera that were noted by Wiśniowski et al. (1992).
pairs of poroids (ivo1–ivo4, ivp) inserted on soft cuticle, and with setae JV3 aligned longitudinally with JVI-JV2; male opisthogaster with 3 or 4 pairs of setae (JV1, ZV1, ZV2, sometimes ZV4) and 2 or 3 pairs of poroids (ivo1, ivp, sometimes ivo3) on soft cuticle. Metapodal shielding not captured by ventri­nal shielding in either sex, but formed as a pair of small free platelets near poroids ivo2 on soft cuticle in female and apparently captured along with these poroids by ventral extension of opisthonotal plate in male. Female with opistho­gastric shielding reduced to inversely subtriangular anal shield bearing 3 circumanal setae and gland pores gv3; male with small ventrianal shield bearing several pairs of ventral setae in addition to circumanal setae and gland pores gv3; para-­anal setae in both sexes subequal in size with postanal seta, and inserted at level of pos­terior margin of anal opening.

Gnathosoma (Figs. 6–12). Tectum a single, narrow, denticulate projection. Fixed digit of chelicera with minute pilus dentilis and row of several teeth; movable chela dentate. Corniculi simple, well developed; internal maleae slender, acuminate. Subcapitulum with basalmost pair of setae barbed, other three pairs smooth. Deutosternum with smooth anterior margin and usually 5 transverse rows of denticles, without longitudinal linear cells between rows of denticles. Palpal chaetotaxy as stated for family; palp trochanter with distal anterolateral pointed process.

Legs (Figs. 17–20, 26). Legs I–IV with paired claws well developed, inserted on well developed pretarsi. Tarsus I with lanceolate-tipped sensilla conspicuous but not elongate. Tarsi II–IV with vestige of ventral intercalary sclerite in circumsegmental fissure. Tarsi II–IV with apical setal processes a2d-1, p2d-1 as long as pretarsi. Leg setae of moderate length, none modified as macrosetae; leg chaetotactic formulae as stated for family.

Deutonymphal characteristics. Idiosomal dorsum (Fig. 23). Idiosoma with subequally sized podonotal and opisthonotal shields, these separated by transverse strip of striated soft cuticle; peritremal shield on either side united with podonotal shield anteriorly. Podonotal and opisthonotal chaetotaxy and poroidotaxy as in adult. Podonotal shield well sclerotized as in adult male, with 22 pairs of setae (j1–j6, z1–z6, s1–s6, r1, r2, r4, r5). Opisthonotal shield well sclero­tized as in adult male, with about 20 pairs of setae much as in male except some R-marginal setae and poroids idR3, idR5 on soft marginal cuticle; gland pores gdZ3 and gdZ5 large, on prominent circular protuberant areas as in male.

Idiosomal venter (Fig. 24). Tritosternum and podo­sonal chaetotaxy and poroidotaxy as in adult; gland pores gv1 absent as in male. Sterngenetial shielding with 4 pairs of sternal setae (st1–st4) and genital setae (st5). Endopodal and exopodal strips absent. Peritremes long, extending anteriorly to level above bases of legs I. Opisthogastric chaetotaxy, poroidotaxy and adenotaxy as in adult, except poroids ivp not discernible; opisthogaster with separate ventral shield bearing several pairs of ventral setae and anal shield bearing 3 circumanal setae and gland pores gv3; anal valves as in adult. Several ventral setae and poroids on soft cuticle around ventral and anal shields. One pair of metapodal platelets free on soft cuticle behind legs IV.

Gnathosoma and Legs (Fig. 25). As described for adult, except tarsi II–IV with both sets of ventral setae, av-1, pv-1, and av-2, pv-2, present.

Etymology. The name for this genus is a combina­tion of the word “copro”, meaning dung or fecal, and “zercon”, a proper name, according to BERLESE (1892), used by many authors to form names for genera of mesostigmatic mites. The name is masculine in gender, and is intended to refer to the habitat in which these mites are found.

Coprozercon scopaeus sp. nov.

Diagnosis. Dorsal setae of idiosoma nearly all of similarly moderate length (about 20–25 μm, except for shorter j1 and z1) and somewhat thick form, with small basal spur. Opisthonotum with two unpaired, adelonymic (sensu HAMMEN, 1975) J-setae on soft cuticle in adult female, and on opisthonotal shield in deutonymph and adult male. Dorsal shielding lightly reticulated in adult female, but more strongly reticulated in adult male and deutonymph. Peritremes abbreviated in adults, about as long as diameter of
FIGS. 1-5: Coprozercon scopaeus n. gen. et sp., adult female.

1. — Body dorsum, with complete notation for setae and porelike structures; notation follows that of LINDQUIST & MORAZA (1999) for Zerconidae.
2. — Enlarged view of a posterodorsal body seta, showing detail of basal spurlike process and barbs along shaft.
3. — Body venter, with notation for opisthogastric setae and porelike structures; notation follows that of LINDQUIST & MORAZA (1999) for Zerconidae.
4. — Tritosternum.
5. — Enlarged view of anal opening.
stigma; peritremes elongate, extending to level of setae st1, in deutonymph.

Description. With character states of genus as described above, but restricted and augmented as follows:

ADULT FEMALE. Idiosomal dorsum (Fig. 1). Idiosomal length 260–270 μm (3 specimens); idiosomal width at level of posterior margin of podonotal shield including soft marginal cuticle in undistorted specimens 145–170 μm; podonotal shield length 130–135 μm, width 127–130 μm at level of setae s5; opisthosomal length from bases of setae J1 to bases of setae Z5, 114–122 μm. Podonotum with 23 pairs of setae, including 14 to 16 pairs (j2–j6, z2–z6, s1, s3–s5), sometimes j1, z1) on podonotal shield, and 7–9 pairs (s2, s6, r1–r5, sometimes j1, z1) on soft marginal cuticle, r3 in lateroventral position; setae j1 (12–14 μm) and z1 (10–11 μm) shorter than other setae, these of similarly moderate length (18–24 μm, nearly as long as longitudinal intervals between their bases) and thick, slightly curved form, with small basal spur (Fig. 2). Podonotal shield lightly reticulated, with fine striae and puncta within some reticula (ornamentation not shown in Fig. 1), and with irregularly sinuous lateral margins. Opisthonotum covered with striated soft cuticle, lacking any remnant of opisthonotal shield; with 22 pairs of setae (J1–J5, Z1–Z5, SI–S5, RI–R7) plus 2 unpaired extra setae (Jx), all of similar length (20–27 μm), thickness, and curved, basally spurred form to podonotal setae; Jx setae located along midline, one between bases of J1, one between bases of Z3 and J4. Dorsal and lateral idiosomal porelike structures, positioned as in Fig. 1, include: 4 pairs of poroids (idj1, idj3, idz3, ids4) and 4 pairs of gland pores (gdj2, gdj4, gdz5, gds4) on podonotal shield, 3 pairs of poroids (idj6, idz6, ids6) and 2 pairs of gland pores (gdj4, gdz6) on soft podonotal cuticle, and 11 pairs of poroids (idj1–idj5, ids1–ids4, idr3, ids5) and 2 pairs of gland pores (gdz3, gdz5) on soft opisthonotal cuticle; pores gdz3 and gdz5 each on small, subcircular, sclerotized platelets about 6–7 μm in diameter.

Idiosomal venter (Fig. 3). Tritosternum with elongate trapezoidal base (length 12 μm), and paired laciniae which are free from each other along entire length (16–17 μm), each ending in arista (Fig. 4). Presternal region lacking platelets or ornamented cuticle. Sternal shield weakly sclerotized, unornamented, length 59–67 μm, width 37–39 μm, with lateral margins indented at level between setae st1 and st2, and more deeply so between setae st2 and st3; length setae st1–st3 12 μm; gland pores gvl on slightly convex posterior margin of shield. Metasternal platelets weakly sclerotized; setae st4 slightly shorter (10 μm) than other sternal setae. Genital shield subpentagonal, unornamented, small, its length (35–36 μm) slightly greater than its width (32–33 μm); anterior margin of shield narrowed, convex; posterior margin truncated; genital setae (length 10–12 μm) on lateral edges of this shield; genital poroids iv5 on soft cuticle laterad genital shield. Peritreme length 15 μm including stigmata, peritreme itself subequally as long as diameter of stigma; abbreviated peritrematal plates with posterior margins pointed, and lacking porelike structures. Metapodal platelets slender, length 21 μm. Opisthogastrer with 10 pairs of setae and 5 pairs of poroids (ivo1–ivo4, ivp) on soft striated cuticle; area between genital and anal shields with 6 pairs of simple, slender setae, of which JV1, JV2, ZV1, ZV2 slightly shorter (10–12 μm) than JV3, ZV3 (13–15 μm); area laterad anal shield with 3 pairs of longer (18–23 μm), thicker setae (ZV4, JV4, JV5), these similar in form to dorsal setae; poroids ivo2 near ivo3 laterad setae ZV2, ivo4 posterolaterad setae ZV4, and ivp lateral setae JV5. Anal shield inversely subtriangular, unornamented, subequally as wide (56–61 μm) as long (56–58 μm), its anterior margin flat or slightly concave; para-anal setae (15 μm) nearly as long as postanal seta (16–17 μm); gland pores gvl on lateral edges of shield at level of anterior margin of anal opening; anal valve length 17 μm; cribrum restricted to triangular area of shield behind postanal seta.

Gnathosoma (Figs. 6–11). Tectum with broad, smooth, nearly flat anterolateral margins and slender, coarsely denticate medial projection (Fig. 10). Subcheliceral plate with pair of deeply fringed paralabral processes arising from its dorsoproximal surface (Fig. 11). Fixed digit of chelicera with minute pilus dentilis proximad 2 well spaced, subdistal teeth; movable chela with 2 teeth similar in size and position to those of fixed digit, plus a smaller, offset third tooth between them; dorsal cheliceral seta prominent...
FIGS. 6-12: *Coprozercon scopaenus* n. gen. et sp., adult.


(length 10 μm), inserted well proximad dorsal lyrifissure; antiaxial lyrifissure well developed; margin of hyaline envelope at base of movable chela smooth (Fig. 6). Corniculi well spaced, parallel; internal malae with lateral margins smooth, with broadly acute apices extending beyond tips of corniculi. Deutosternal groove of subcapitulum with smooth anterior margin hardly discernible between bases of anterior pair of subcapitular setae, and with 5 moderately broad rows of denticles, each with 3–5 denticles but anterior 2 rows sometimes edentate; rows gradually narrowing posteriorly (Fig. 7). Posteriormost pair of subcapitular setae barbed, similar in length to smooth second and third pairs of setae; anteriormost pair of setae smooth, nearly twice as long as other pairs. Palpal length 68–70 μm; palpal chaetotaxy as described for family; palptrochanter with apical spinelike process paraxially, and with seta *v-2* barbed, longer (15–16 μm) than seta *v-1*; palpfemur with seta *al* slightly barbed, and pointed apically; palpgenu with seta *al-1* smooth, stouter than other genual setae, and with *al-2* slightly barbed (Fig. 8).

Legs (Figs. 13–20, 26). Excluding ambulacra, lengths of leg I 178–200 μm, leg II 103–137 μm, leg III 91–117 μm, leg IV 122–156 μm. Coxa I with 1 gland pore ventroproximally and ridge of serrated processes on anterolateral distal margin; coxa II with pointed spinelike process distally on anterodorsal margin, and with distal margin serrated behind condyle (Fig. 18); coxae III and IV with dorsodistal
Figs. 13–16: Coprozercon scopaeus n. gen. et sp., tarsus of leg I, adult.

13. — Ventral aspect. 14. — Dorsal aspect, excluding pretarsus; sensilla with porose walls shown in black. 15. — Separate detail of lanceolate-tipped seta and adjacent setae. 16. — Diagrammatic view, circles indicating position of bases of setae and sensilla; ventral setae indicated by black, dorsal and lateral setae by open, circles.

Margins smooth; coxa IV with alveolar vestige of second seta, av, minute (Fig. 20). Pretarsi of legs I–IV with well-developed, evenly curved claws (Figs. 13, 18). Tarsus I with 49 setae, including (as denoted in Figs. 13, 14) 6 anterolaterals, 5 posterolaterals, 5 anteroventrals, 4 posteroventrals and 29 other setae and sensilla dorsally and apically; configuration of dorsodistal cluster of sensilla as shown in Fig. 14; lanceolate-tipped sensilla s of moderate length (15 μm), moderately expanded distally (Fig. 15). Tarsi II–IV each with apical setal processes ad-1 and pd-1 moderately long (10–12 μm), smooth, slender, and with pretarsi moderately short (5–7 μm), their paired claws short (5–7 μm). Setation of trochanters of legs I–IV, respectively, 6-5-5-5; that of femora, 13-11-6-6; that of genua, 13-11-10-10; that of tibiae, 14-10-9-10 (Figs. 17–20); leg chaetotactic formulae normal for family Coprozerconidae as presented above. Most leg setae slightly thickened and barbed on segments distad trochanters; none of leg setae elongated or enlarged as macrosetae.

Adult male. Idiosomal dorsum (Fig. 21). Dorsal shields together 192–227 μm long (7 specimens), moderately sclerotized, entire surface of both shields reticulated, with fine striae and puncta within reti-
cula. Podonotal shield 110–120 μm long, 128–142 μm wide at level of setae J5, with straight posterior margin; this shield more expansive laterally than in female and deutonymph, bearing all 23 pairs of setae, 7 pairs of poroids and 6 pairs of gland pores of podonotum, though excluding poroids idz6, ids6 and gland pores gdz6 which are on anterior margin of opisthonotal shield. Opisthonotal shield 98–110 μm long, 125–132 μm wide at level of setae J2, more expansive laterally than in deutonymph, bearing 25 pairs of setae including all 22 pairs (plus 2 unpaired Jx) of opisthonotal setae, 11 pairs of poroids and 3
pairs of gland pores, plus 2 or 3 pairs of ventral setae (JV4, JV5, sometimes ZV4) and 2 or 3 pairs of ventral poroids (ivo2, ivo4, sometimes ivo3) on its lateroventral extensions (Fig. 22). Size and form of dorsal setae, position of Jx setae, and position of porelike structures as in adult female; podonotal gland pores gdZ5 on small, rounded or conical protuberances behind setae z5; opisthonotal gland pores gdZ3, gdZ5 prominent, on circular areas of about 13–15 μm diameter which protrude about 7 μm above surrounding surface of shield.

**Idiosomal venter** (Fig. 22). Tritosternum and preentral area as in adult female. Sterrogenital shield weakly sclerotized, narrow, length 90–95 μm, greatest width between setae st2 and st3 35–37 μm; anterior edge of genital opening only 3 μm behind level of setae st1; lateral margins of shield deeply emarginated at level of genital opening and more shallowly emarginated at level between setae st2 and st3; setae st1–st4 length 10–11 μm, genital setae st5 shorter (7–8 μm); genital poroids iv5 on soft cuticle flanking narrow marginal rim of sternogenital shield. Narrow strip of endopodal plating present behind legs IV. Peritrematal structures abbreviated as in adult female. Opisthogaster with 3 pairs of setae (JV1, ZV1, ZV2) and 1 or 2 pairs of poroids (ivo1, sometimes ivo3) on soft cuticle flanking anterolateral margins of ventrianal shield (ivo3 sometimes asymmetrically captured on ventral margin of podonotal shield). Ventrianal shield moderately well sclerotized, lightly ornamented with transverse lines and fine puncta, subpentagonal with rounded anterolateral angles, length (76–79 μm) about 1.4 times greatest width (54–55 μm) at level of gland pores gdv3; this shield with 3 pairs of ventral setae (JV2, JV3, ZV3) in addition to circumanal setae and pores gdv3. Opisthogastric setae similar in form and size (or slightly smaller) to their homologues on adult female. Anal valves and cribrum as in adult female.

**Gnathosoma.** Tectum, subcapitulum and palpi as in adult female, except a basalmost sixth row of deutosternal denticles present in some individuals. Cheliceral structures as in adult female except fixed chela with apex more slender, nearly straight (rather than hooked), extending slightly beyond tip of movable chela, and with apical tooth so as to appear bifid; movable chela with two teeth, lacking small third tooth of female (Fig. 12).

**Legs.** Excluding ambulacra, lengths of leg I 172–185 μm, leg II 122–128 μm, leg III 112–120 μm, leg IV 154–157 μm. Form, setation and other structures of legs, including alveolar vestige of second seta, av, on coxae IV, as in adult female.

**DEUTONYMPH. Idiosomal dorsum** (Fig. 23). Idiosoma elliptical, covered by two subequally sized shields which are as well sclerotized, though not as expansive, and similarly ornamented as in adult male; idiosomal length, measured from bases of setae j1 to those of JV5, 211–248 μm (12 specimens). Podonotal shield length 112–122 μm, width at level of setae r4 121–134 μm, with straight posterior margin; shield bearing all 23 pairs of podonotal setae including setae r3 which, with gland pores gdr4, on lateral peritrematal extensions of shield; setae r4, r5, s6 on well delineated, narrow marginal rim of shield. Opisthonaotal shield length 98–120 μm, width at level of setae R1 107–122 μm, with rounded posterior margin; shield reticulated over most of surface, and with delineated narrow marginal rim, in contrast to adult male; setae S1, R1, R3, R5, R7 inserted on this rim; podonotal shield bearing 20 pairs of setae plus 2 unpaired Jx setae, 10 pairs of poroids, and 3 pairs of gland pores. Setae R2, R4, R6 and poroids idR3, idR5 on soft lateral cuticle. Size and form of dorsal setae, position of Jx setae, and position of porelike structures as in adult male; gland pores gdZ3, gdZ5 on conspicuous circular areas of similar size and protrusion as in male.

**Idiosomal venter** (Fig. 24). Sterrogenital shield weakly sclerotized, unornamented, with irregularly sinuated lateral margins, interrupted behind setae st4, such that genital region a separate plate; setae st1–st4 on sternal portion, st5 on genital portion of that shielding; genital poroids iv5 on soft cuticle flanking posterior margin of genital plate. Peritrematal shields well developed, with elongate peritremes reaching onto dorsolateral surface at level between setae r1 and s1. Metapodal plates comma-shaped, positioned anterad poroids ivo2. Opisthogaster with lightly sclerotized, subtrapezoidal ventral shield, nearly smooth or faintly transversely lineate, bearing 3 pairs of setae, JV2, JV3, ZV3, and sometimes asymmetrically one
Figs. 21-22: Coprozoon scopaeus n. gen. et sp., adult male, body dorsum (21) and venter (22).
FIGS. 23-24: *Coprozercon scopaeus* n. gen. et sp., deutonymph, body dorsum (23) and venter (24), with notation for setae and porelike structures; notation follows that of Lindquist & Moraza (1999) for Zerconidae.
of setae ZV2; with separate, inversely subtriangular, unornamented anal shield bearing circumanal setae and gland pores gv3; these shields nearly contiguous, and of similar width; ventral shield length at midlevel (28–33 μm) about 0.6 its width (51–61 μm) at level of setae ZV3; anal shield length 34–36 μm, anterior width 47–48 μm; anal valves and cribrum as in adult. Soft cuticle with 5 pairs of ventral setae (JV1, ZV1, ZV2, ZV4, JV4) and 4 pairs of poroids (ivo1–ivo4) flanking ventral and anal shields. Opisthogastric setae similar in form and size (though slightly smaller) to their homologues on adult.

Gnathosoma. Tectum formed as in adult. Chelicerae as in adult female. Other structures of gnathosoma, including setation of subcapitulum and palpi, as in adult.

Legs. Excluding ambulacra, lengths of leg I 177–195 μm, leg II 124–139 μm, leg III 115–129 μm, leg IV 150–161 μm. Form, setation, and other structures of legs, including presence of alveolar vestige of second seta, av, on coxa IV, as in adult except tarsi II–IV with 18 setae, including both sets of ventral setae, av-1, pv-1 and av-2, pv-2 (Fig. 25).

Protonymph and Larva. Unknown.

Types. Holotype, adult female, U.S.A., Kentucky, Edmanson County, Mammoth Caves National Park, Little Beauty Cave, 31 August 1987, W.C. WELBOURN & M.E. CASANUEVA, ex fecal dump of wood rat, Neotoma floridana magister Baird; deposited in the Florida State Collection of Arthropods, Division of Plant Industry, Gainesville. Paratypes: 2 adult females, 8 adult males, 19 deutonymphs, with data same as for holotype; of these, 2 females, 4 males, 9 deutonymphs deposited in the Canadian National Collection of Insects and Arachnids, type No. 22,268, maintained by Biological Resources Program, Agriculture Canada, Ottawa, Ontario; remainder deposited in Florida State Collection of Arthropods, as above.

Etymology. The specific epithet, scopaeus, is a latinized version of the Greek word "skopaios", meaning dwarf and referring to the diminutive size of these mites.

Remarks. All known mites of the families Zerconidae and Epicriidae have a free-living way of life in a variety of terrestrial and, to a limited extent, arboreal habitats. This new taxon is the first known example of an extant epicrine species that may be restricted to a cavernicolous habitat. Other than having perhaps less heavily sclerotized idiosomal shields than most zerconids, adults and deutonymphs of Coprozercon scopaeus do not exhibit any apparent troglomorphisms, as distinct from edaphomorphisms, sensu ZACHARDA (1980). Paleozzercon cavernicolus Blaszak et al. is known only from fossil specimens found embedded in calcium deposits of a stalagmite near a cave entrance (BLASZAK et al., 1995), but its restriction to cave systems is problematical. Zercon triangulatis Koch is recorded from caves in Europe (WOLF, 1938), but this widespread species is not restricted to caves.

The subspecies of wood rat with which Coprozercon scopaeus is associated nests in caves and rock slide...
crevasses in Appalachian areas of Pennsylvania south to Tennessee (Hall & Kelso, 1959). The rats are active all year, primarily within cave systems, and they frequently defecate in the same places, or dumps, some distance from their nests. An individual rat may have several fecal dumps up to a meter or more apart, and these are actively used for extended periods of time, until the rat dies or moves out of a cave. The dumps thus provide a relatively stable organic resource for colonization by a variety of small arthropods, including various mites, collembolans, and a few insects such as staphylinid beetles, silphid beetles and sciarid flies (W. C. Welbourn, personal communications, June 1993 and May 1997), and probably also by nematodes. The mites in this case were collected from a fecal dump in a moist area about 20 meters from the cave entrance and about 7 meters from the wood rat's nest. The fecal pile was about 20–25 cm high, with fecal pellets of various ages. Due to sampling restrictions, it could not be determined whether C. scopaeus occurred in the wood rat's nest.

Associations, including phoresy, with insects or other arthropods have not been recorded for epicriine mites. Where phoresy has been documented among tocospermous families of Gamasina, it is restricted to the deutonymph, much as it is among the families of Uropodina. Phoretic deutonymphs are generally well sclerotized, for protection against mechanical damage from their carriers and against desiccation while exposed on their carrier (Athias-Binche, 1991). Also, they often have structural modifications, such as the circular, adhesive design of the anal shield among families of Sejina and Uropodina, for affixing themselves to their carriers. One might anticipate that Coprozercon scopaeus would benefit from a phoretic association with the wood rats or vagile insects to move from one patchy, temporary organic resource to another in cave systems, but we have no documentation for this. Perhaps significantly, the dorsal shields of its deutonymph are as well ornamented and sclerotized as in the adult male, and more strongly so than in the adult female, whereas in zerconids these shields are generally less ornamented and sclerotized in deutonymphs than in adults. But otherwise, there are no anal, setal or other structural modifications indicative of phoresy evident in the deutonymph of C. scopaeus.

The sexually dimorphic loss of the opisthonal shield in the adult female of Coprozercon is otherwise not known among genera of Zerconidae and Epicriiidae. Adults of C. scopaeus are small mites (idiosomal lengths of females 260–270 μm, of males 192–227 μm) compared to many other taxa of Gamasida. Perhaps a reduced opisthonal shield in the female allows for more expansion of the soft opisthosomal cuticle when containing a relatively large egg. The greatest linear dimension, 132 μm, of an apparently fully formed egg in one specimen of C. scopaeus is about one half of that female's idiosomal length, and about equal to her opisthosomal length. However, adult females of a considerable variety of Zerconidae are similarly small, with their idiosomal length in the range of 265–365 μm, e.g., Eurozercon pacificus Halášková 267–280 μm, and Aquilonozzercon desuetus Halašková 284–288 μm (Halašková, 1979); yet these mites do not show any reduction of their opisthosomal shield (the egg sizes in such small zerconids has not been recorded). A somewhat comparable, sexually dimorphic reduction in opisthosomal shielding is found among species of Arctacarus Evans, though in this case a single holonotal shield is involved. The need, or function, of reduced opisthosomal shielding in Arctacarus does not seem to relate to the size of the egg in proportion to that of the maternal female. The females are large mites, with idiosomal lengths of 820–1000 μm (Evans, 1955; Bregtova, 1977) and of 1030–1125 μm among specimens at hand in the Canadian National Collection. The greatest linear dimension of a fully formed egg in gravid females of Arctacarus at hand is only from 0.39 to 0.42 of the idiosomal length of the females.

In Coprozercon scopaeus, tarsi II to IV lack one of the two pseudosymmetric pairs of ventral setae, av-1, pv-1 and av-2, pv-2 in adults, even though both pairs are present in the deutonymph. This regressive deficiency is an adult deficiency of what most probably are larval setae on tarsi II and III, and protonymphal setae on tarsus IV, based on the general ontogenetic patterns of setation of tarsi II to IV throughout the Mesostigmata (Evans, 1963, 1965, 1969, 1972). We are not aware of this condition having been reported for any other taxon in the Mesostigmata, and we have not observed it among any taxa of Zerconidae, Epicriiidae and Arctacaridae. However, the number of
setae on tarsi II–IV is often examined cursorily, and such a deficiency, whether larval or postlarval, could be easily overlooked.

**DISCUSSION**

As noted at the outset of this paper, the Epicriina, variously treated as a cohort, “division”, or suborder, is a problematical grouping, and current classifications are discordant about the content of families in the group, as well as the relationships of the group to others of the same level. In our introduction, we summarily dismissed the most discordant classification view maintained for nearly thirty years by Karg (1965, 1971, 1993) and followed by Krantz (1978) and Krantz & Ainscough (1990). We review that classification further here. To classify the Epicriidae in the otherwise podospermous superfamily Phytoseioidea, the Zerconidae in the otherwise podospermous superfamily Ascoidea, and the Arctacaridae in the otherwise podospermous or at least “neospermous” (sensu Alberti, 1988) Parasitoidae, as the above authors do, is to view the lack of a cheliceral spermatodactyl and the mid-sternal position of the genital aperture in the males of these tocospermous gamasine mites as “coincident occurrences of these unusual characters” amidst these superfamilies (Krantz & Ainscough, 1990). These classifications imply that the morphological and behavioral attributes of podospermy have arisen independently at least four times within the Gamasina: once in each of the superfamilies Phytoseioidea, Ascoidea and Parasitoidae, and at least once among the other superfamilies Eviphidoidea, Rhodacaroidea and Dermanyssoidae.

The mechanisms of podospermy are complex and include transfer of spermatophores by males from their presternally located genital orifice by means of a spermatodactyl on their modified movable cheliceral digits for injection into one of the pair of copulatory pores (solenostomes) of females, which is located usually between the bases of coxae III–IV (Evans, 1992). It is both highly improbable and unparsimonious that such a complex of attributes for direct sperm transfer would arise independently several times among superfamilies in the same major lineage, Dermanyssina. Instead, we are in accord with the interpretation of Alberti (1988) that tocospermy, in particular “archispermy”—the transfer of spermatophores containing vacuolate spermatozoa by males from their midsternally located genital orifice by means of their cheliceral digits for injection into the primary genital orifice of females—is a plesiomorphic complex of attributes. Therefore, it is more parsimonious to exclude the families Zerconidae, Epicriidae and Arctacaridae from the otherwise podospermous superfamilies noted above. In this way, “neospermous” tocospermy may be hypothesized to have arisen once, in a more narrowly circumscribed group Parasitina sensu Johnston (1982) and Evans (1992), which includes but one superfamily Parasitoidae and family Parasitidae, and excludes Veigaiidae and Rhodacaridae. Similarly, as a next step, podospermy may be hypothesized to have arisen but once, in the group Dermanyssina, which includes five superfamilies, sensu Johnston (1982) and tentatively accepted by Evans (1992). The sister linkage of Parasitina and Dermanyssina as a group characterized synapomorphically by “neospermy” is supported by the males of this grouping having ribbon spermatozoa, both in Parasitina whose chelicerae are equipped with a spermatotreme, and in Dermanyssina whose chelicerae have a spermatodactyl, for transfer of spermatophores (Alberti, 1988).

The position of the male genital orifice, and the difference in form and dentition of the male chelicera in comparison with that of the female and deutonymph, in Coprozerconidae are noteworthy in this context of tocospermy versus podospermy. The genital orifice is hardly mid-sternal, in that it is located closely behind the level of sternal setae st1, rather than between the levels of setae st2 and st3 as in Zerconidae, Epicriidae and Arctacaridae. This position is nearly as anterior as that found in the relatively early derivative podospermous family Rhodacaridae of Gamasina. In contrast to the latter, however, the anterior margin of the genital aperture in Coprozerconidae is slightly posterior to the level of setae st1, rather than between these setae, and it is clearly posterior the anterior margin of the sternogenital shield, rather than on that margin. The more slender, straight, pointed form of the fixed chela in the male, than in the female and deutonymph, of Coprozerconidae may be an adaptation for transfer of spermato-
phores, in absence of a spermatodactyl. We have observed a similar difference in form of the male fixed chela from that of the female among species of Zerconidae and Epicriidae, though this does not seem to have been noted in the literature. In Arctacaridae, the male fixed chela remains hooked apically, much as in the female, but it is thicker and less dentate than in the female and deutonymph (EVANS, 1955, and our personal observations). Such subtle modifications of the male chelicerae in tocospermous families may be more prevalent than is currently recognized, and more careful descriptive attention should be given to this form of sexual dimorphism.

Exclusion of Coprozerconidae, Zerconidae, Epicriidae and Arctacaridae from the Parasitina and Dermanyssina leaves the relationships and classification of these families at a still unresolved, albeit earlier derivative, level. A sister-group relationship between Coprozerconidae and Zerconidae is hypothesized in the remarks following the description of the new family above. Based on definitive and diagnostic criteria available in widely accepted general literature (e.g., JOHNSTON, 1982; EVANS, 1992), these two families, along with Epicriidae and Arctacaridae, are excluded from the following, apparently sister-pairs of major groups: the more early derivative Sejina and Microgyniina, the Cercomegistina and Antennophorina of Trigynaspida, and the Uropodina and Diarthrophallina. As a result, this leaves Zerconidae + Coprozerconidae, Epicriidae, and Arctacaridae more or less together by default, though not necessarily by definition.

At the generic level, taxa of Zerconidae and Epicriidae were grouped together over a century ago by BERLESE (1892), and this grouping has persisted in some classifications as recently as EVANS & TILL (1979), who also included the more recently described family Arctacaridae (EVANS, 1955) in their “Division Epicriidae”. The diagnosis for this grouping, however, has been based solely on plesiomorphic attributes, as follow: chelicerae with no or little sexual dimorphism (i.e., the male movable chela lacking an elaborated structure for transfer of spermatophores); male genital orifice mid-sternal in position, located at a level usually between coxae II; male insemination of females by way of the female genital orifice; and tibia I with 4 ventral setae. Earlier, EVANS (1955) noted some other shared attributes between Epicriidae, Zerconidae, and the then new family Arctacaridae: female genital shield with hyaline epignyal portion reduced to a narrow sclerotized rim (such that egg is not extruded along a “chute” as in Dermanyssina); male genital opening covered by two plates, the anterior of which bears a pair of setae (eugenital setae); and palpi with five free segments, with specialized seta on palptarsus two — or three-tined. To these, we add: the at least somewhat shortened peritremes in adults; the lack of metasternal platelets (setae st4 inserted on soft cuticle) in adult females; gland pores g2 usually multiple and together on a pair of ad genital platelets (secondarily single and on soft cuticle, or absent in some genera); and three leg chaetotactic attributes of deutonymphs and adults, namely, genua III and IV each with 10 setae, including a second ventral seta, pr; tibia III with 9 setae, including a second posterolateral seta, pl-2. However, all but two of these attributes are evidently plesiomorphies, and most of them are not exclusive to these families. Of the other two attributes, the narrow, sclerotized anterior rim of the genital shield may be viewed as readily as a primitive absence of a hyaline epignyal extension rather than as a secondarily reduced structure. Based on out-group comparisons, the lack of metasternal platelets is probably a secondary loss, but also a homoplastic one, as these platelets are retained in Coprozercon. At present, therefore, there are no synapomorphic attributes that define an exclusive natural grouping for Epicriidae, Zerconidae (+ Coprozerconidae) and Arctacaridae.

Based on sharing the attributes of the presence of peritrematal plates with clearly developed (though somewhat shortened) peritremes, dorsal shielding without a specially characteristic ornamentation, and jugular plates absent in adults, EVANS (1955) grouped the Arctacaridae together with Zerconidae in a superfamily Zeronioidea, distinct from the Epicrioida which contained but one family. However, the first two of these shared attributes are clearly plesiomorphies, in contrast to each of the alternative character states typical in both sexes of Epicrioidae, namely, peritrematal plates and peritremes absent, and stigma enclosed in dorsal shield, the latter with a characteristic, coarsely tuberculcate ornamentation. The third attribute, absence of jugular plates, does not
hold for all genera of Zerconidae, particularly the early derivative ones (see below). To these attributes we add the shared presence of gland pores grvl on the posterior margin of the sternal shield in adult females and sometimes on the sternogenital shield of deutonymphs and adult males (absent in Coprozercon). Based on out-group comparisons, however, the presence of these pores is plesiomorphic.

It is perhaps because of this lack of synapomorphic evidence to link the families Epicriidae, Zerconidae and Arctacaridae as a natural group that EVANS (1992) subsequently opted to treat each one in its own superfamily and, in turn, suborder! This alternative, however, leaves not only the relationships between these families unresolved, but those of other major groups of Mesostigmata unresolved as well.

A sister relationship between Epicriidae and Zerconidae in a cohort Epicrinia that excluded Arctacaridae, was recognized by JOHNSTON (1982). The basis for this arrangement was not apparent from the diagnosis given by him for the cohort, as it was not made clear whether any of the given characteristics were thought to be exclusive to this cohort, and none of them evidently is. Here, we list and consider character states that may be used to argue for a sister relationship between Epicriidae and Zerconidae (+ Coprozerconidae).

1. Protonymph with pygidial shield expansive, as wide as podonotal shield, and bearing 10 to 15 pairs of setae, including S2, S3 (if present) laterally. Protonymphs of Arctacaridae at hand lack any vestige of a pygidial shield, and in this respect resemble the condition described by KARG (1965) for Veigaiidae.

2. Protonymph with setae J4 widely separated from each other relative to interval between setae J1.

3. Adults with sternal setae st1 on jugular plates. Though typical of epicrid mites, this state is found also in a few zerconids, e.g., Syskenozerceron (ATHIAS-HENRIOT, 1976), Rafaz Blaszak (BLASZAK, 1979), and Halozercon (WISNIEWSKI et al., 1992). As Syskenozerceron and Halozercon are evidently among the earliest derivative known genera of Zerconidae, this attribute may be a possible characteristic of the stem group of Zerconidae, in which the jugular plates subsequently became consolidated into one sternal shield.

4. Adults with expansive peritrematal, or “lateropel-tidial”, shields. These shields are largely coalesced with dorsal shielding in the podonotal region, so as to apparently capture the bases of some r-marginal setae. Arctacarid adults have normally developed, but not expansive, peritrematal shields that do not bear any marginal setae.

5. Adults with peritremes shortened from the length expressed in deutonymphs. This condition is not found in Arctacaridae.

6. Coxa II with acute spur on its distal anterodorsal margin. This spur is absent in Arctacaridae.

On the basis of these attributes, a reasonable case can be made for grouping Epicriidae together with Zerconidae and Coprozerconidae in Epicrinia, and excluding Arctacaridae from that group. Apart from the third attribute, which may be a synapomorphy, the others are synapomorphic for these families among the non-uropodine, non-trigynaspidean and non-podospermous gamasine families of Mesostigmata. None of the five attributes is autapomorphic, however. A similarly expansive opisthonnatal shield in the protonymph occurs among some members of Eviphididae (KARG, 1965), but this clearly is an independently derived, within-group attribute of that family within the podospermous superfamily Macrocheloidea. A relatively wide interval between setae J4 in protonymphs occurs in a variety of podospermous families, in which this seems to have arisen several times. Whether the condition of the peritrematal shielding in adults is an expansion of the peritrematal shields or a reduction of previously larger marginal shields (as prevalent among families of Uropodina and Trigynaspida) is problematical. Enlarged peritrematal shields are derived independently in such podospermous families as Pachylaelapidae and Varroidae. Shortening of the peritremes from the deutonymph to the adult, though homoplastic, has been rarely noted in other groups of Gamasida. A similar reversal in ontogenetic lengthening of the peritreme is found among some species in the podospermous family Digamasellidae (LINDQUIST, 1975), and this may not have yet been noted in other families having species with abbreviated peritremes in adults, as their
deutonymphs have not been studied carefully. The presence of an anterodorsal spur on coxae II appears to be more commonly homoplastic; without undertaking a comprehensive search for this structure in a wide array of Gamasida, we have observed it, for example, in some genera of tocospemrous Sejoidea (e.g., Microsejus, Asternolaelaps) though not others (Microgynium, Sejus), and in some genera of podospemrous Rhodacoaroida (e.g., Rhodacarus, Rhodacarellus) though not others (Panteniphis, Gamasellus, Digamasellus).

Although we are persuaded by the case already presented above, that Coprozerconidae is the sister family of Zerconidae, an alternative argument could be made that the new family is, instead, the sister group of Epicriidae. This could be based on two synapomorphies, reduction of peritremes in the adult to little, if any, more than the stigmata, and ventrolateral extension of opisthontoal shielding in the male, to capture two or three pairs of the ventral ZV or JV setae. However, reduction in peritrematal length is not as extreme in Coprozercon as in genera of Epicriidae, and it is matched in Zerconidae by the condition found among species of Metazercon Błaszk (Halašková, 1979), and nearly so among species of Skeironzercon (Halašková, 1977) and Monozzercon (Błaszk, 1984). Also, the ventrolateral extension of opisthontoal shielding is not a sexually dimorphic character in Epicriidae, and so is probably independently derived in that family.

In view of the above discussion, we conclude the following:

1. A sister group relationship between Zerconidae and Coprozercon, the latter in its own family, is phylogenetically justifiable.

2. These two families constitute the superfamily Zerconoidea in exclusion to any other families.

3. The Zerconoidea is the sister group of the family Epicriidae, the latter in its own superfamily in exclusion to any other families.

4. The Epicrioida and Zerconoidea together constitute the Epiciriina, in the sense of a “cohort” as used by Krantz (1978), or the Epiciriidae, in the sense of a “division” as used by Evans & Till (1979).

5. The Arctacaridae is excluded from the Epiciriina, and its relationship with other superfamilies of tocospemrous Gamasida remains uncertain, other than its not being a member of Uropodina or Trigynaspida. We anticipate that its most likely relationship is as the sister group of the superfamily Parasitoidea, or “Division Parasitides” sensu Evans & Till (1979), or Parasitina sensu Evans (1992). In this respect it will be interesting to determine whether spermatocysts of Arctacaridae are of a more derived spindle or ribbon form, as found by Alberti (1984, 1988, 1991) for Parasitina and Dermanyssina, or of a more plesiomorphic vacuolated form, as found by him for Epicriina (including Epicriidae and Zerconidae), Sejina, Uropodina, Ixodida, Holothyrida and Opilioacarida.

6. The relationship of Epiciriina with other major groupings of Gamasida is similarly problematical, apart from its not being a member of Uropodina or Trigynaspida. We anticipate that its most likely relationships are either as a sister group to the Sejina, or as a sister group to the grouping {Arctacaridae + Parasitidae + Dermanyssina families}.

Acknowledgements

Special thanks are extended to Dr W. Calvin Welbourn, Division of Plant Industry, Florida State Department of Agriculture, Gainesville, for making available the material upon which this most interesting taxon is based. We are grateful to Dr Valerie Behan-Pelletier, Research Branch, Agriculture and Agri-Food Canada, Ottawa, Prof. G. O. Evans, Storrington, England, and Dr D. E. Walter, University of Queensland, Brisbane, Australia, for their useful commentary in reviewing the manuscript.

References


