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A REVISION OF THE GENUS *BLATTISOCIUS* KEEGAN (MESOSTIGMATA: ASCIDAE) WITH ESPECIAL REFERENCE TO *B. TARSALIS* (BERLESE) AND THE DESCRIPTION OF A NEW SPECIES

BY

C. P. HAINES 1

ABSTRACT

A revision of the known species of *Blattisocius* is presented, with summaries of the important characteristics of these species. Seven species are recognized, including a new species which is described. The relationships of these species are discussed, and keys are presented for the identification of females and males of *Blattisocius* spp. The larva, protonymph and deutonymph of *B. tarsalis* are described. The use of cheliceral characters of the nymphs for identification of species is discussed.

RÉSUMÉ

Une révision des espèces connues de *Blattisocius* est présentée, avec le résumé des caractéristiques importantes de ces espèces. Sept espèces sont reconnues, y compris une espèce nouvelle qui est décrite. Les rapports entre ces espèces sont discutés, et des clés sont présentées pour l'identification des femelles et des mâles des espèces de *Blattisocius*. La larve, la protonymph et la deutonymph de *B. tarsalis* sont décrites. L'emploi des caractères chélicériens des nymphes pour l'identification des espèces est discuté.

INTRODUCTION

The features of the genus *Blattisocius* KEEGAN (1944), in the family Ascidae, have been fully described by LINDQUIST & EVANS (1965). Among the few described species in this small genus, the majority have been recorded from situations which indicate predation or phoresy on arthropod hosts (e.g. HUGHES, 1976; TREAT, 1966, 1973). The most commonly recorded species is *B. tarsalis* (Berlese) which is frequently found in association with various pests of stored products, notably moths of the family Phycitidae. In the course of studies at this laboratory on the natural control of *Ephestia cautella* (Walker) by *B. tarsalis*, it became evident that a revision of the known species of *Blattisocius* was necessary for a number of reasons: (i) no published key to species includes more than four of the species, (ii) with one exception, in which only two of the species are distinguished, there are no published keys to males, (iii) the status of two of the three species described in the past twenty years has been questioned in the literature, and (iv) the immature stages of

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most species of *Blattisocius* have not been described. The aim of the studies described in this paper was to revise the genus in the context of these four points, particularly with reference to *B. tarsalis*.

In May 1976, specimens of *Blattisocius* recently collected in Jamaica were sent to this laboratory for identification. Examination revealed that these represented a distinctive, but undescribed, species. This new species is described in this paper and included in the keys to species.

**Materials and methods**

Slide-mounted specimens of all the species under consideration were examined by phase-contrast microscopy. Specimens of all life-stages of *B. tarsalis* were also examined by scanning electron microscopy. Specimens of the common stored-products species were from collections at this laboratory and on loan from colleagues in the U.K. and Canada. Type-specimens of *B. mali* (Oudemans) and *B. daci* (Narayanan & Ghai) were obtained on loan, and specimens of *B. bakeri* (Chant) and *B. patagiorum* Treat were borrowed from their respective authors. All drawings in this paper were prepared (with the aid of projection microscopy) by the author from specimens seen. The setal nomenclature adopted is that of *Lindquist & Evans* (1965) for the idiosoma and of *Evans* (1963) for the legs.

**Species of Blattisocius**

The definition of the genus *Blattisocius* *Keegan* (1944) used in this paper is that of *Lindquist & Evans* (1965) who give a full description of the diagnostic and typical characters of adults.

*Blattisocius tarsalis* *(Berlese, 1918)*

*Lasioseius (Lasioseius) tarsalis* *Berlese, 1918*
*Typhlodromus tineivorus* *Oudemans, 1929*
*Blattisocius triodons* *Keegan, 1944*
*Typhlodromus tineivorans* ; [sic], *Hughes* (1948)
*Lasioseius similis* *Schweizer, 1949*
*Blattisocius tineivorus* (Oudemans) ; *Nesbitt* (1951)
*Melichares (Blattisocius) tarsalis* (Berlese) ; *Evans* (1958)
*Blattisocius tarsalis* (Berlese) ; *Schweizer* (1961)
*Melichares tarsalis* (Berlese) ; *Hirschmann* (1962)
*Lasioseius similis* ; [sic], *McGraw & Farrrier* (1969)

This list is restricted to the first published instances of the various combinations; subsequent uses of these names are listed by *McGraw & Farrrier* (1969).

Adult females and males of this species have been adequately described in recent literature (*Chant, 1963 ; Evans, 1958 ; Hughes, 1961, 1976 ; McGraw & Farrrier, 1969*). The following features combined will serve to distinguish adults of *B. tarsalis* from those of the other known species of *Blattisocius*. Both sexes have a shortened peritreme, extending to the level of the posterior margin of coxa II (Fig. 9a); the dorsal setae are of normal thickness and medium length (in
the j-J and z-Z series, sometimes reaching the base of the next seta in the series); leg IV has no macroseta. In the female, the fixed digit of the chelicera is very short (about one-third the length of the movable digit) and bears the pilus dentilis at its extreme distal end (Fig. 6a); this fixed digit is edentate but the movable digit bears three teeth in its distal half; the third sternal setae are positioned on the postero-lateral angles of the sternal shield, and the fourth sternal setae are on the membrane behind the shield (Fig. 7a); the ventrianal shield is somewhat rectangular and has three pairs (Jv 1-3) of pre-anal setae (Fig. 8a). In the male, the posterior of the sternogenital shield (between coxae IV) is abruptly constricted to form a tongue-shaped area, leaving the genital setae (st 5) free on the membrane lateral to this area (Fig. 10a).

*Blattisocius patagiorum* Treat, 1966

The adult female and male of this species have been fully described by its author (Treat, 1966). The combination of characters given below distinguishes adults of *B. patagiorum* from the other known species in the genus. Both sexes have a short peritreme, extending to the level of the middle of coxa III (Fig. 9b); the dorsal setae are of normal thickness and are rather long (in the j-J and z-Z series, often reaching beyond the base of the next seta in the series); leg IV has no macroseta. In the female, the fixed digit of the chelicera is edentate and short (about one-half the length of the movable digit), and bears a long pilus dentilis near its apex (Fig. 6b); the movable digit is also edentate, and has its distal half slender and tapering evenly to a point; the third sternal setae are positioned on the sternal shield at the postero-lateral angles, and the fourth sternal setae are on the membrane behind the shield (Fig. 7b); the ventrianal shield is somewhat rectangular and has three pairs (Jv 1-3) of pre-anal setae (Fig. 8b). In the male, the posterior of the sternogenital shield (between coxae IV) is abruptly constricted to form a tongue-shaped area, leaving the genital setae (st 5) free on the membrane lateral to this area (Fig. 10b).

*Blattisocius keegani* Fox, 1947

*Blattisocius [sic] keegani* Fox, 1947
*Melichares (Blattisocius) keegani* (Fox); Evans (1958)
*Melichares keegani* (Fox); Hirschmann (1962)

A full list of subsequent uses of the three combinations is given by McGraw & Farrier (1969). The adult female has been adequately described in recent literature (Evans, 1958; Hughes, 1976; McGraw & Farrier, 1969). The male is known and is described and figured by McGraw & Farrier (1969). The following features, in combination, distinguish *B. keegani* from the other known species of *Blattisocius*. Both sexes have a very short peritreme, extending just beyond the level of the posterior of coxa III (Fig. 9c); the dorsal setae are rather fine and somewhat short (in the j-J and z-Z series, rarely reaching the base of the next seta in the series); leg IV has no macroseta. In the female, the fixed digit of the chelicera is shortened (about two-thirds the length of the movable digit) and bears the pilus dentilis at about the distal third (Fig. 6c); this fixed digit bears two small teeth in the distal third, immediately distal to the base of the pilus dentilis; the movable digit is distinctly angled at its mid-point and bears one large tooth at about the distal third; the third sternal setae are positioned on the sternal shield at the postero-lateral
angles, and the fourth sternal setae are on the membrane behind the shield (Fig. 7c); the ventrianal
shield is somewhat rectangular and bears three pairs (Jv 1-3) of pre-anal setae (Fig. 8c). In the
male, the posterior of the sternogenital shield (between coxae IV) is abruptly constricted to form
a tongue-shaped area, leaving the genital setae (st 5) free on the membrane lateral to this area
(Fig. 10c).

**Blattisoeius quadridentatus** sp. n.

This species is more closely related to *B. dentriticus* (Berlese) than to the other known species
in this genus; the female differs from *B. dentriticus* in the following characters: the dentition
of the chelicerae, the position of the fourth sternal setae in relation to the sternal shield, the separa-
ation from the sternal shield of the platelets supporting the third sternal setae, and the length
of the peritreme. The specific name proposed here refers to the distinctive array of four teeth
on the fixed digit of the female chelicera.

**Female**: Dorsum of idiosoma as in Fig. 1. Length of dorsal shield 429-452 µ (mean of nine
specimens, 440 µ), width of shield (at widest point of anterior half) 202-229 µ (mean of eight speci-
mens, 215 µ). Twenty-one pairs of setae on anterior region of shield (including r2-4 on extreme
edge), and fifteen pairs of setae on posterior region. Setae r5, r6 and all R and UR setae on lateral
membrane. Vertical and paravertical setae (j1 and z1), and setae J5, short, simple, and smooth.
Setae Z5 long, rather stout in basal half, and with several fine pectinations. All other dorsal
setae of idiosoma smooth, rather stout in basal half, and long (always reaching well beyond base
of next seta in the series). Surface of shield with distinct, dense reticulation in median area of
anterior region, elsewhere faintly reticulate except at extreme anterior and posterior. Shape
of shield rather elliptical, entire, but with a slight concavity on each side between setae r4 and S2.
Anterior of dorsal shield fused to apices of peritrematal shields, forming acutely angled emargi-
nations nearly reaching the bases of setae s1.

Corniculi slender and convergent. Pedipalp with a two-tined apotele. Deutosternum with
seven rows of denticles, anterior five rows and seventh row narrow with few denticles (usually
two or three), sixth row widened beyond lateral lines and with several denticles. Base of trito-
sternum slender, and simple distally. Fixed digit of chelicera equal in length to movable digit,
and bearing a short, setiform pilus dentilis at its distal third (Fig. 2). Fixed digit bidentate at
apex, and bearing a distinctive row of four equal teeth between the mid-point and the distal
fifth. Movable digit evenly curved, and bearing three well-separated teeth in its distal half;
these teeth slightly angled towards the posterior, and with the proximal tooth smaller than
the other two.

Sternal shield with first and second pairs of sternal setae and sternal pores. Shape of shield
as in Fig. 3, anterior margin indistinct, lateral projections (to between bases of coxae I and II)
at level of first sternal pores, postero-lateral angles obliquely truncate. Shield faintly reticulate,
and with second sternal pores at posterior angles. Third sternal setae on sternal platelets com-
pletely separated from sternal shield. Fourth sternal setae free on membrane posterior to sternal
platelets. All sternal setae long, smooth, and rather stout in their basal half.

Genital shield truncate posteriorly (Fig. 4), narrowing anteriorly, and bearing a pair of genital
setae slightly posterior to the mid-points of its lateral margins, these setae long, smooth, and rather
stout in their basal half. Shield very faintly reticulate, but with impressed lines in the form of
an inverted-Y becoming obsolete in the anterior half and just before the posterior angles. Inter-
scutal membrane sometimes forming a transverse fold immediately posterior to the genital shield.
Fig. 1. — Dorsum of idiosoma of ♀ B. quadridentatus
(from holotype, with minor details from paratype) : sculpturing of shield shown on right side only.
FIGS. 2-3. — 2) Chelicera of ♀ *B. quadridentatus* (from holotype) ; 3) Sternal shield of ♀ *B. quadridentatus* (from paratype).

Ventrianal shield (Fig. 4) rather triangular but with lateral margins of posterior half sub-parallel, thus producing a rather angular concavity in the middle of each side, occasionally (two out of eleven specimens seen) with an emargination in anterior edge near seta **Jv1**. Four pairs of pre-anal setae (**Jv1-3, Zv2**) on the shield. Setae Zv1 on the membrane in front of the anterior angles of the shield. Setae Zv3 and Jv4-5 on the membrane lateral to the shield. Para-anal setae flanking the posterior of the anal plates; postanal seta posterior to the anal opening. All pre-anal setae long, smooth, and rather stout in their basal half; para-anal and postanal setae shorter. Surface of shield reticulate, with transverse lines on anterior half and arched lines around the anus more distinct.

Peritrematal shield connected posteriorly to exopodal plate curving behind coxa IV (Fig. 5), and fused anteriorly-to dorsal shield (Fig. 1).

Peritreme very long, extending from stigma to level of paravertical seta (z1) and anterior to coxa I (Figs. 1 and 5).

Chaetotaxy of legs as follows : tibia I : (2-6/3-2); genu I : (2-6/3-2); femur I : (2-5/3-2); tibia II : (2-4/2-2); genu II : (2-5/2-2); femur II : (1-5/3-1); tibia III : (2-3/2-1); genu III : (2-4/2-1); tibia IV : (2-4/2-2); genu IV : (2-5/1-1).

Leg IV with a long macroseta on the basitarsus in the proximal pl position.
Male: Unknown.

Type material: The description above is based on eleven adult female specimens from one location; two deutonymphs were found in the same sample. The holotype female and paratype females will be deposited at the British Museum (Natural History), London.

Collection data: The type-specimens were collected by Mr. D. B. Jayasingh from a chocolate factory about 30 km north of Kingston, in Jamaica. The mites were found inside the aluminium-foil wrapping of a sample bar of confectionery chocolate. The chocolate sample had been imported to Jamaica about two years previously (country of origin not recorded) and was infested with the stored-product beetle Ahasverus advena Waltl (Silvanidae). It seems probable, by comparison with the feeding habits of other Blattisocius species, that the mites were preying on the beetle eggs and young larvae.
Blattisocius dentriticus (BERLESE, 1918)

Lasioseius (Lasioseius) dentriticus BERLESE, 1918
Lasioseius fimbriatus HALBERT, 1923
Seiulus amboinensis OUDEMANS, 1925
Typhlodromus amboinensis (Oudemans) ; OUDEMANS (1930)
Garmania (Paragarmania) amboinensis (Oudemans) ; NESBITT (1951)
Melichares (Blattisocius) dentriticus (Berlese) ; EVANS (1958)
Melichares dentriticus (Berlese) ; BURNETT (1960)
Blattisocius dentriticus (Berlese) ; CHANT (1963)
Paragarmania dentriticus (Berlese) ; WESTERBOER (1963)
Paragarmania amboinensis (Oudemans) ; WESTERBOER & BERNHARD (1963)
Melichares dentriticus ; [sic], COSTA (1966)
Laelaps fimbriatus ; [sic], MCGRAW & FARRIER (1969)
Seiulus amboinensis ; [sic], MCGRAW & FARRIER (1969)

Subsequent uses of these names are listed in full by MCGRAW & FARRIER (1969).

The adult female of this species has been described adequately in recent literature (CHANT, 1963 ; EVANS, 1958 ; HUGHES, 1976 ; MCGRAW & FARRIER, 1969) and the male is described briefly by HUGHES (1976). B. dentriticus is a distinctive species which is easily distinguished from all previously-described species of Blattisocius. However, B. quadridentatus sp. n. (described above) is obviously closely-related to B. dentriticus. The following characters in combination distinguish B. dentriticus adults from those of the otherwise-previous descripted Blattisocius species, but (in the absence of known males of B. quadridentatus sp. n.) only the females can at present be distinguished from the new species. Both sexes have a long peritreme, extending to the level of the posterior half of coxa I (Fig. 9d) ; the dorsal setae are stout in their basal half, and long (in the j-J and z-Z series, usually reaching well beyond the base of the next seta in the series) ; leg IV has a long macroseta on the basitarsus. In the female, the fixed digit of the chelicera is equal in length to the movable digit, and bears the pilus dentilis at its distal third, a large tooth also at its distal third, and one or two small teeth sub-apically (Fig. 6d) ; the movable digit is distinctly curved (particularly near its apex) and bears one large tooth at its distal quarter ; both the third and fourth pairs of sternal setae are positioned on platelets which are narrowly connected to the extreme postero-lateral angles of the sternal shield (Fig. 7d) ; the ventrianal shield is somewhat triangular (but with lateral margins posteriorly sub-parallel) and has four pairs (Jv1-3, Zv2) of pre-anal setae (Fig. 8d). In the male, the posterior of the sternogenital shield (between coxae IV) is not abruptly constricted, and bears the genital setae (st 5) on its posterior margin (Fig. 10d).

Blattisocius mali (OUDEMANS, 1929)

Typhlodromus mali OUDEMANS, 1929
Garmania (Paragarmania) mali (Oudemans) ; NESBITT (1951)
Melichares (Blattisocius) mali (Oudemans) ; EVANS (1958)
Lasioseius (Paragarmania) bakeri CHANT, 1958 ; syn. rev.
Blattisocius bakeri (Chant) ; CHANT (1963) ; syn. n.
Blattisocius mali (Oudemans) ; CHANT (1963)
Paragarmania mali (Oudemans) ; WESTERBOER & BERNHARD (1963)
The status of Blattisocius bakeri (Chant) has been disputed in the literature. Chant (1958), in the original description of B. bakeri, indicated that it differed from B. mali "in the length of the setae on the dorsal shield, the shape of the sternal shield, the number of setae on the membrane surrounding the ventrianal shield, the number of metapodal plates, and the shape of the peritreme". Subsequently, Athias-Henriot (1959) listed B. bakeri as a junior synonym of B. mali, but did not give reasons for the new synonymy. However, Chant (1963) disputed this synonymy, and pointed out that B. bakeri has three pairs of setae around the ventrianal shield and has a uniformly sculptured dorsal shield, whereas Oudemans' illustrations of B. mali (in Nesbitt, 1951) clearly show only two pairs of setae around the ventrianal shield and sculpturing only in the anterior median area of the dorsal shield. Furthermore, the descriptions and figures of B. mali given by Hughes (1976) and Athias-Henriot (1959) correspond more closely to the description of B. bakeri than to Oudemans' illustrations of B. mali. In order to resolve these differences, the following material was compared: specimens of B. bakeri identified as such by Prof. Chant, the type-specimens of B. mali (Oudemans), and photocopies of Oudemans' original drawings of B. mali.

Examination and comparison of this material has revealed that most of the confusion is due to inconsistencies between Oudemans' type-specimens and original drawings. In particular, Oudemans (i) omitted one pair of opisthogastric setae (Zv3) from the original drawing which are clearly present on the type-specimens, (ii) omitted to portray the two pairs of lateral extensions of the sternal shield, (iii) did not indicate clearly that the reticulation observed on the anterior median region of the dorsal shield is also present (though less distinctly and densely) over the rest of the shield, (iv) failed to illustrate the smaller pair of metapodal plates, and (v) inaccurately portrayed the shape of the peritrematal shield. The correct characters have all been described or illustrated by other authors (e.g. Athias-Henriot, 1959; Hughes, 1976) but the inconsistencies have not been formally noted. With reference to the remaining distinction between the two species indicated by Chant (1958), namely a difference in lengths of the dorsal setae, comparisons of specimens of B. bakeri with type-specimens of B. mali, and of drawings of B. bakeri by Chant (1958, 1963) with original drawings of B. mali by Oudemans, have not revealed any differences of note. The specimens of B. bakeri agree with the type-specimens of B. mali and the synonymy proposed by Athias-Henriot (1959) is here re-established.

As indicated above, the original description of B. mali (and its reproduction in Nesbitt (1951)) is inadequate, but the adults have been redescribed correctly by other authors. The following features, in combination, distinguish adults of B. mali from the other known species of Blattisocius. Both sexes have a very long peritreme, extending to the level of the paravertical seta (z1), beyond coxa I (Fig. 9e); the dorsal setae are of normal thickness and are short (in the j- and z-Z series, usually reaching about two-thirds of the distance to the base of the next seta in the series); leg IV has no macroseta. In the female, the fixed digit of the chelicera is equal in length to the movable digit, has the pilus dentilis and a large tooth at about its proximal third, and is minutely dentate at its apex (Fig. 6e); the movable digit is rather strongly curved near its apex and bears two teeth, one at its distal quarter and the other (larger) one at about its midpoint; the chelicerae are relatively stout and large; the third sternal setae are positioned on the posterior margin of the sternal shield, and the fourth sternal setae are on the membrane behind the shield (Fig. 7e); the ventrianal shield is rather triangular (but with the lateral margins sub-parallel posteriorly) and typically bears four pairs (Jvl-3, Zv2) of pre-anal setae (Fig. 8e); occasionally, specimens have been found in which the anterior margin and angles of this shield have emarginations and protrusions, and in which either a seta Zv1 may be on the shield or a seta Zv2 may be off the shield (Athias-Henriot, 1959; Hughes, 1976) — however, there appear to be no
recorded instances in which both setae of a pair are abnormally located. In the male, the posterior of the sternogenital shield (between coxae IV) is not abruptly constricted, and bears the genital setae (st 5) on its posterior margin (Fig. 10e).

**Blattisocius daci** (Narayanan & Ghai, 1961), sp. rev., comb. n.

*Melichares (Blattisocius) daci* Narayanan & Ghai, 1961; sp. rev.

This species has been recently referred to (Hughes, 1976) as a junior synonym of *B. mali* (Oudemans). This decision was based (Dr. A. M. Hughes, personal communication) on the unpublished opinion of Dr. E. E. Lindquist (unpublished thesis). The original description and figures were not sufficiently detailed for an assessment of the status of this species, and a paratype female was therefore obtained on loan from Dr. S. Ghai, particularly for comparison with the type-spectimens of *B. mali*.

Examination of the paratype revealed some inaccuracies in the original description by Narayanan & Ghai (1961), namely: (i) the fourth sternal setae, which are present on the paratype
Fig. 7. — Sternal shields of ♀ Blattisocius spp.: a) B. tarsalis; b) B. patagiorum; c) B. heegani; d) B. dentriticus; e) B. mali (from type); f) B. daci (from paratype).

(Fig. 7f), are not shown in the original figures; (ii) the sternal shield and ventrianal shield (Figs. 7f and 8f, drawn from the paratype) are not portrayed in fine detail in the original; (iii) the lengths of the dorsal setae are given in the original as 1, 7 and 3 μ for J5, Z5, and other setae, respectively, whereas on the paratype these setae measured 17, 60, and 30 μ, respectively; and (iv) the corniculi are referred to in the original description as 'robust', but the paratype had corniculi which were rather slender and convergent. The form of the paratype is consistent with the definition of the genus Blattisocius.
Comparison of the paratype of *B. daci* with the type-specimens of *B. mali* showed that, although these two species are very closely related, they differ in the shape and chaetotaxy of the ventrianal shield, in the relative size and stoutness of the chelicerae, and in minor details of the dentition of the fixed and movable digits.

Males of *B. daci* are not known, but female adults may be distinguished from females of other species of *Blattisocius* by the following characters combined. The peritreme is very long, extending to the level of the paravertical seta (z1), beyond coxa I (Fig. 9f); the dorsal setae are of normal thickness and are short (in the j-J and z-Z series, usually reaching about two-thirds of the distance to the base of the next seta in the series); leg IV has no macroseta; the fixed digit of the chelicera is equal in length to the movable digit, bears the pilus dentilis and a tooth at about its mid-point and is minutely dentate apically (Fig. 6f); the movable digit is evenly curved near the apex and bears two teeth of similar size, one at its distal fifth and the other at its mid-point; the chelicerae are rather large but not stout; the third sternal setae are positioned on the sternal shield slightly in front of its posterior margin, and the fourth sternal setae are on the membrane behind the shield (Fig. 7f); the ventrianal shield is triangular (with its lateral edges slightly arcuately concave but still distinctly convergent at the level of the para-anal setae) and bears three pairs (Jv1-3) of pre-anal setae (Fig. 8f).
Relationships between species

In a genus containing only seven known species, the creation of formal species-groups is inappropriate and undesirable, and the notes which follow (on obvious relationships appropriate for inclusion in this revision) are not intended to constitute formal definitions of the 'groups' referred to. The known species fall clearly into three 'groups': (i) tarsalis, patagiorum, heegani; (ii) dentriticus, quadridentatus; (iii) mali, daci. The 'tarsalis-group' is characterized by shortened fixed digits in the female, reduced peritremes, a rectangular ventrianal shield in the female, and free genital setae in the male. The 'dentriticus-group' and 'mali-group' share the features of normal fixed digits in the female, long peritremes, and a sub-triangular ventrianal shield in the female. The 'dentriticus-group' is distinguished by long stout dorsal setae, macrosetae on legs IV, and distinctive sternal platelets in the female, from the 'mali-group' which does not possess these features. Within each of these three small 'groups', the species are very closely related. An appraisal of the characteristics of the 'groups' shows that the 'tarsalis-' and 'mali-groups' have certain affinities, as do the 'mali-' and 'dentriticus-groups', whereas the 'tarsalis-group' and the 'dentriticus-group' share very few sub-generic features. These relative affinities, and comparisons of 'group' characters with characters of related genera, seem to indicate that the 'tarsalis-' and 'dentriticus-groups' may represent two separate lines of specialization.

![Fig. 9. — Peritremes of ♀ Blattisocius spp.: a) B. tarsalis; b) B. patagiorum; c) B. heegani; d) B. dentriticus; e) B. mali (from type); f) B. daci (from paratype).](image-url)
from an ancestral origin represented by the ‘*mali*-group’. This view is supported by habitat associations, since four out of the five known species in the ‘*tarsalis* — ’ and ‘*dentriticus*-groups’ (but neither of the species in the ‘*mali*-group’) are usually found in stored-products situations, which are man-made and considered to be relatively recent habitats in evolutionary terms.

**KEY TO FEMALES**

The key to adult females given below will distinguish the seven known species of *Blattisocius*. This key can be more easily used if the specimen is mounted ventral side uppermost, and with a chelicera extruded and twisted for lateral viewing.

1) Peritreme reduced, not extending beyond coxa II (Fig. 9abc); ventrianal shield sub-rectangular (anteriorly between 3/4 and 1 1/4 times width at level of anal plates), always with 3 pairs of pre-anal setae (Fig. 8abc); fixed digit of chelicera reduced (between 1/3 and 2/3 as long as movable digit) (Fig. 6abc) .......................................................... (2)

Peritreme normal, extending at least to coxa I (Figs. 5 & 9def); ventrianal shield sub-triangular (anteriorly between 1 1/2 and 2 times width at level of anal plates), usually with 4 pairs (rarely 3) of pre-anal setae (Figs. 4 & 8def); fixed digit of chelicera equal in length to movable digit (Figs. 2 & 6def) .......................................................... (4)

2) Peritreme longer, extending to level of posterior margin of coxa II (Fig. 9a); fixed digit very short (about 1/3 length of movable digit) with no teeth, and with pilus dentilis at extreme distal end (Fig. 6a); movable digit with 3 teeth. ...................... B. *tarsalis* (Berlese)

Peritreme shorter, not extending anterior to coxa III (Fig. 9bc); fixed digit not so short (about 1/2 or 2/3 length of movable digit) with no teeth or with 2 or 3 small teeth, and with pilus dentilis in distal third (Fig. 6bc); movable digit of chelicera with one large tooth or with no teeth. .... (3)

3) Peritreme short (about 30 μ from stigma to anterior), reaching to level of middle of coxa III (Fig. 9b); dorsal setae rather long (often reaching beyond base of next seta in same series); movable digit with distal half slender and tapering smoothly to a point, with no teeth (Fig. 6b); fixed digit shorter (about 1/2 as long as movable digit) with no teeth. ........ B. *patagiorum* Treat

Peritreme very short (about 20 μ from stigma to anterior) reaching to level of posterior third of coxa III (Fig. 9c); dorsal setae rather short (rarely reaching base of next seta in same series); movable digit with distal half not so slender and tapering rather abruptly to its apex, with one large tooth at distal third (Fig. 6c); fixed digit longer (about 2/3 as long as movable digit) with 2 or 3 small teeth in distal third .......................................................... B. *keegani* Fox

4) Sternal shield distinctly transverse (Figs. 3 & 7d); 3rd sternal setae on sternal platelets isolated from, or only narrowly connected to, the sternal shield; dorsal setae long (usually reaching well beyond base of next seta in same series) and rather stout; leg IV with long macroseta on basitarsus; movable digit with 1 or 3 teeth; fixed digit with pilus dentilis at about distal third (Figs. 2 & 6d) .......................................................... (5)

Sternal shield quadrate or elongate (Fig. 7ef); 3rd sternal setae on postero-lateral angles of sternal shield (no sternal platelets present); dorsal setae short (reaching about 2/3 of distance to base of next seta in same series) and rather slender; leg IV without macroseta on basitarsus; movable digit with 2 teeth; fixed digit with pilus dentilis at, or posterior to, mid-point (Fig. 6ef). . (6)

5) Sternal platelets smaller, separated from sternal shield, and only bearing 3rd sternal setae (4th sternal setae free on membrane) (Fig. 3); peritreme long, extending to level of paravertical seta, beyond coxa I (Fig. 5); movable digit with 3 teeth; fixed digit with row of 4 teeth in distal half and with 1 sub-apical tooth (Fig. 2) .......................................................... B. *quadridentatus* sp. n.

Sternal platelets larger, narrowly connected to sternal shield, and bearing both 3rd and 4th sternal setae (Fig. 7d); peritreme not so long, extending to level of posterior of coxa I (Fig. 9d); movable digit with 1 tooth; fixed digit with 1 large tooth at distal third and with 2 small sub-apical teeth (Fig. 6d) .......................................................... B. *dentriticus* (Berlese)
6) Ventrianal shield sub-triangular with rather angular concavity on each side (lateral margins at level of para-anal setae only slightly convergent) and bearing 4 pairs of pre-anal setae (occasionally 3 or 5 setae may be present on one side) (Fig. 8e); chelicerae very large and rather stout (Fig. 6c); fixed digit with large tooth and pilus dentilis at about distal third; movable digit with distal tooth much smaller than proximal one..........................  B. mali (Oudemans)

Ventrianal shield triangular with slight arcuate concavity on each side (lateral margins at level of para-anal setae distinctly convergent) and bearing only 3 pairs of pre-anal setae (Fig. 8f); chelicerae not so large, and of normal proportions (Fig. 6f); fixed digit with tooth and pilus dentilis at about mid-point; movable digit with distal and proximal teeth of similar size.................. B. daci (Narayanan & Ghai)

**KEY TO MALES**

Although the males of *B. quadridentatus* and *B. daci* are not yet known, many of their features can be predicted: namely, those characters which are not affected by sexual dimorphism in the other five species, and general sexual characters constantly associated with a particular female form in these other species. In this way, the form of the male of *B. quadridentatus* can be predicted to a level which allows specific identification, and that of *B. daci* can be predicted as very similar to the male of *B. mali* (the known specific differences between the latter two species are ones affecting female secondary sexual characters only). The predicted males of these two species have thus been included in the following key in parentheses. This key can be more easily used if the specimen is viewed ventrally; cheliceral characters have not been included.

1) Peritreme reduced, not extending beyond coxa II (as in Fig. 9 abc) ; posterior of sternogenital shield (between coxae IV) abruptly constricted to form a tongue-shaped area, genital setae free on membrane (Fig. 10 abc) .................................................. (2)

Peritreme normal, extending at least to coxa I (as in Figs. 5 & 9 def) ; posterior of sternogenital shield (between coxae IV) not abruptly constricted, genital setae on posterior edge of shield (Fig. 10 de) ................................................................. (4)

2) Peritreme longer, extending to level of posterior margin of coxa II (as in Fig. 9a)..........................  B. tarsalis (Berlese)

Peritreme shorter, not extending anterior to coxa III (as in Fig. 9 bd).......................... (3)

3) Peritreme short (about 25 μ from stigma to anterior), reaching to level of middle of coxa III (as in Fig. 9b) ; dorsal setae rather long (often reaching beyond base of next seta in same series)....

B. patagorum Treat

Peritreme very short (about 18 μ from stigma to anterior), reaching to level of posterior third of coxa III (as in Fig. 9c) ; dorsal setae rather short (rarely reaching base of next seta in same series) ............ B. keegani Fox

4) Dorsal setae long (usually reaching well beyond base of next seta in same series) and rather stout; leg IV with long macroseta on basitarsus........................................ (5)

Dorsal setae short (reaching about 2/3 of distance to base of next seta in same series) and rather slender; leg IV without macroseta on basitarsus........................................ (and *B. daci* (Narayanan & Ghai) *)

5) Peritreme long, extending to level of paravertical seta, beyond coxa I (as in Fig. 5) .................. (B. quadridentatus sp. n.*)

Peritreme not so long, extending to level of posterior of coxa I (as in Fig 9d) .................. B. dentriticus (Berlese)

[* Males not yet known : predicted characters only.]

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Immature stages of *B. Tarsalis*

The larval and nymphal stages of *B. tarsalis* have not been previously described in detail. The descriptions and figures presented below were prepared from immature specimens collected from living cultures of *B. tarsalis* maintained at this laboratory. Observations on normal microscopic preparations by phase-contrast microscopy were supplemented by examination of specimens using a scanning electron microscope.

**Larva**: Idiosomal length about 315 μ. Dorsum of idiosoma as in Fig. 12a. Podonotal shield large (but indistinctly defined), bearing nine pairs of setae (j1, j3-6, z2, z4-5, s4), and with median area faintly but densely reticulate: this area bounded laterally by bi-arcuate impressions. All dorsal setae long (40 to 90 μ), Z3 and Z4 very long (about 130 μ). Chelicera as in Fig. 11a. Fixed digit shorter than movable digit. Ventrum of idiosoma as in Fig. 12d. Three pairs of sternal setae (st 1-3) present in sternal region. Anal shield sub-quadrate and bearing para-anal setae and postanal seta. Four pairs of pre-anal setae (Jv1-2, Jv5, Zv2) situated on membrane. Sternal and pre-anal setae of normal length (30 to 35 μ), para-anal setae (50 μ) longer than postanal seta (35 μ). Stigmata and peritremes absent.

**Protonymph**: Idiosomal length about 400 μ. Dorsum of idiosoma as in Fig. 12b. Podonotal shield distinct and large, bearing eleven pairs of setae (j1-6, z2, z4-5, s4-5), faintly and rather evenly reticulate, and with an L-shaped impression on each side (not visible in slide-mounted specimens) running transversely from seta s5 towards the mid-line and turning anteriorly in front of seta j6 to become obsolete posterior to seta j5. Pygidial shield distinct, covering most of posterior fifth of dorsum, bearing eight pairs of setae (J3-5, Z3-5, S4-5), and faintly reticulate. Membrane between podonotal and pygidial shields with four pairs of setae (J1-2, Z1-2) and with mesonotal scutella: four pairs (of which the posterior pair very small) between the J and Z series of setae, and one pair of very small scutella anterior to seta Z1. All dorsal setae of normal length (25 to 50 μ) except J5 short (about 13 μ) and Z5 long (about 75 μ). Chelicera (Fig. 11b) similar to that of adult female (cf. Fig. 6a). Fixed digit short, about one-third length of movable digit, and bearing long pilus dentilis sub-apically. Movable digit with three teeth in distal half. Ventrum of idiosoma as in Fig. 12e. The lightly sclerotized sternal shield bears three pairs of sternal setae (st 1-3) and two pairs of pores. The fourth sternal setae are absent, but the genital setae (st 5) are present on the membrane between coxae IV. The anal shield is sub-quadrate (but with the anterior margin convex) and bears the para-anal setae and postanal seta. Four pairs of opisthogastric setae (Jv1-2, Jv5, Zv2) are present on the membrane anterior and lateral to the anal shield. All sternal and opisthogastric setae of normal length (22 to 35 μ) except st5 short (about 12 μ). Peritreme short (about 17 μ from anterior to stigma).

**Deutonymph**: Idiosomal length about 485 μ. Dorsum of idiosoma as in Fig. 12c. Dorsal shield entire, rather narrowly elliptical but with posterior slightly truncated, and with a distinct lateral incision at the mid-point of each side (representing the line of fusion of podonotal and opisthonotal elements). Shield faintly reticulate except for a crescent-shaped area of dense reticulation on each side, running antero-medially from seta z6 and turning anteriorly in front of j6 to end at a point posterior to j5 (these areas coinciding with impressed lines visible on specimens viewed on the scanning electron microscope). Anterior region of shield with fourteen pairs of setae (j1-6, z2-6, s4-6) and posterior region with fifteen pairs (J 1-5, Z 1-5, S 1-5). Other setae (z1, s1-3, r2-6, R 1-7, and UR series) all on membrane lateral to shield. All setae on dorsal
Fig. 10. — Sternogenital shields of \( \delta \) Blattisocius spp.: a) B. tarsalis; b) B. patagiorum; c) B. heegani; d) B. dentriticus; e) B. mali.

Fig. 11. — Chelicerae of pre-adult stages of B. tarsalis: a) larva; b) protonymph; c) deutonymph.
shield of normal length (25 to 60 μ) except j2 rather short (about 20 μ) and Z5 long (about 90 μ). Chelicera (Fig. 11c) very similar to that of adult female (cf. Fig. 6a). Fixed digit short, about one-third length of movable digit, and bearing long pilus dentilis apically. Movable digit with three teeth in distal half. Ventrum of idiosoma as in Fig. 12f. Sternal shield distinct, constricted posteriorly to form a rather narrow tongue-shaped area between coxae IV, bearing four pairs of setae (st 1-4) and three pairs of pores, and faintly reticulate except for posterior region which is distinctly and longitudinally reticulate. Genital setae (st 5) on membrane lateral to posterior apex of shield. Anal shield rather rounded, with faint concentric reticulation, and bearing para-anal setae and postanal seta. The Jv and Zv setae are on the membrane anterior and lateral to the anal shield. All sternal and opisthogastric setae of normal length (25 to 50 μ). Peritreme short (about 24 μ from anterior to stigma).

**Pre-adult specific characters**

The relative constancy of the ontogenetic development of structure and chaetotaxy of the idiosoma in different genera of the Ascidae (see Lindquist & Evans, 1965), and the great extent of differences between the developmental stages, make it very unlikely that idiosomal characters

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**Fig. 12.** — Dorsal and ventral views of idiosomae of pre-adult stages of *B. tarsalis*: a) larval dorsum; b) proto-nymphal dorsum; c) deutonymphal dorsum; d) larval ventrum; e) protonymphal ventrum; f) deutonymphal ventrum.
of pre-adult stages can be used for separation of species in Blattisocius. A comparison of the idiosomal characters of immature stages of B. tarsalis with those given by Treat (1966) for B. patagiorum reveals no significant differences. However, these descriptions for B. tarsalis and B. patagiorum show distinct similarities between the cheliceral form of protonymphs, deutonymphs and adult females in each species. The cheliceral form of the larvae in both species shows only rudimentary development of the characters found in the respective adults.

In addition to the immature stages of B. tarsalis, the chelicerae of the following pre-adult specimens of other species of Blattisocius were compared with the female adult chelicerae: larva, protonymph and deutonymph of B. patagiorum; protonymph of B. keegani; deutonymph of B. quadridentatus; protonymph and deutonymph of B. tali.

In all these cases it was found that the chelicerae of the nymphs corresponded with the female adult chelicerae in the following respects: (i) shape of movable digit, (ii) ratio of length of fixed digit to that of movable digit, (iii) number of teeth on movable digit, (iv) number of large teeth on fixed digit, and (v) form of apex of fixed digit (smooth, or dentate, or denticulate).

It is therefore suggested that (apart from distinguishing between B. tali and B. daci, in which the adult female chelicerae differ only slightly) the specific identity of protonymphs and deutonymphs of Blattisocius species can be ascertained by the use of the cheliceral characters in the key to females presented earlier in this paper. In view of the remaining difficulties of generic determination of ascid nymphs, this suggestion will be mainly useful in checking the conspecificity of nymphs found in association with adults of Blattisocius species.

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Footnote: Dr. E. E. Lindquist, in his unpublished thesis (1963. — A revision of mites of the sub-family Blattisocinae (Acarina: Blattisocidae) in America north of Mexico. — Univ. of California, Berkeley), described two "forms" of B. mali, and tentatively proposed that B. bakeri agreed with the "second form". Dr. Lindquist (personal communication) has since examined the type-specimens of B. mali and has found that his "second form" agrees in all respects with these type-specimens. The status of the "first form" of B. mali described by Dr Lindquist remains in doubt. Dr Lindquist's thesis also contains much useful information on the synonymy, pre-adult morphology and habits of some of the species discussed in this paper.

References


