Anales Inst. Biol. Univ. Nac. Autón. México, Ser. Zool. 67(2): 225-237. 1996

TWO NEW SPECIES OF *DACTYLOSCIRUS* (ACARI: PROSTIGMATA: CUNAXIDAE) IN THE HAWAIIAN ISLANDS

SABINA FAJARDO SWIFT*

RESUMEN

Se describen dos especies nuevas , *Dactyloscirus hoffmannae* sp. nov. y *D. smileyi* sp. nov., de las Islas de Hawaii. También se incluye la descripción de una tritoninfa de la especie *D. inermis* colectada en el atolón Kure. Se adopta el sistema modificado de Grandjean para las sedas dorsales del cuerpo, en el género *Dactyloscirus* y en la familia Cunaxidae. Se discute la posición de las cupulas *ih* y de las sedas *ps* en los terguitos H y PS fusionados.

Palabras clave: *Dactyloscirus*, Cunaxidae, Prostigmata, Islas Hawaii.

ABSTRACT

Dactyloscirus hoffmannae sp. nov. and *D. smileyi* sp. nov. are described and illustrated from the Hawaiian Islands. Also described is a tritongmph of *D. inermis* collected on Kure Atoll. Grandjean's modified dorsal setal designations are adopted for the genus *Dactyloscirus* and the family Cunaxidae. Placement of cupules *ih* and *ps* setae on the integrated H and PS tergites is discussed.

Key words: *Dactyloscirus*, Cunaxidae, Prostigmata, Hawaiian Islands.

INTRODUCTION

Berlese (1916) proposed the subgenus *Dactyloscirus* in the genus *Scirus* to accommodate his new species *Scirus* (*Dactyloscirus*) *eupaloides*. Thor & Willmann (1941), elevated the subgenus to generic status, designating *Scirus* (*Dactyloscirus*) *eupaloides*

* J. Linsley Gressitt Center for Research in Entomology, Department of Natural Sciences, Bishop Museum, P. O. Box 19000. USA.

Berlese, 1916 as its type species. Baker & Hoffmann (1948) considered *Dactyloscirus* a senior synonym of *Cunaxa* Von Heyden, 1926. Smiley (1975) revised the family Cunaxidae, retaining *Dactyloscirus* and redescribing *D. eupaloides* (Berlese, 1916) and *D. machairodus* (Oudemans, 1922).

Dactyloscirus is a valid genus in the subfamily Cunaxiinae, characterized by the presence of short and stout tarsi I-IV that terminate in large, conspicuous lateral bilobed flanges, the presence of a special sensilla on tarsus I with an elongate base, and a distinctive reticulate ornamentation on the propodosomal plate. Palps are 5 segmented, extending beyond the apex of the hypostome, and are with or without an apophysis on the papal telofemur and papal genu.

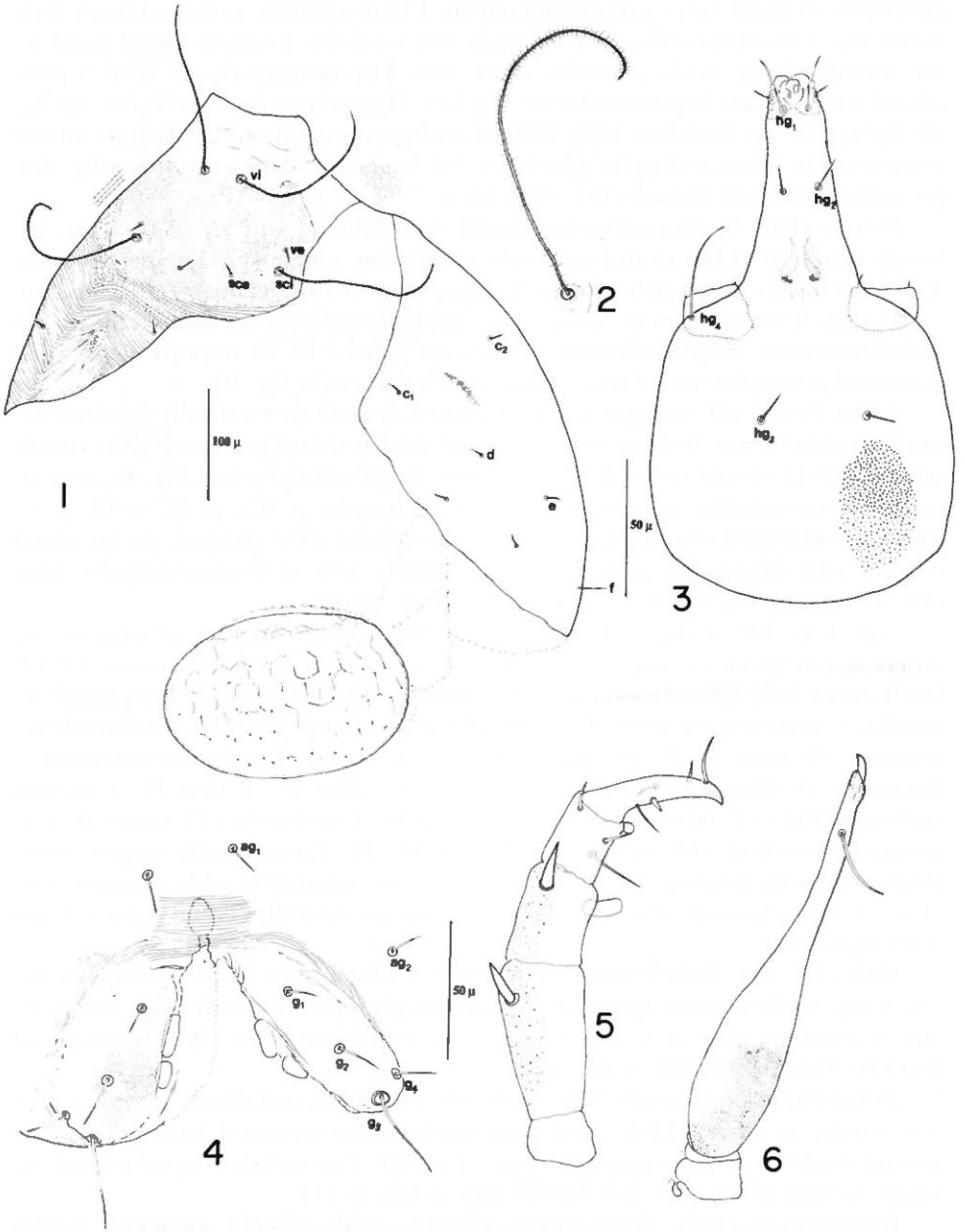
Cunaxoides andrei (Baker & Hoffmann, 1948) and *Dactyloscirus inermis* (Trägårdh, 1905) were the first species of Cunaxidae reported from the Hawaiian Islands (Goff, 1983). *Cunaxoides andrei* was associated with *Metrosideros polymorpha* (Myrtraceae) and collected from soil and litter samples from Oahu and Hawaii Islands. *Dactyloscirus inermis* reported as *C. inermis* (Goff, 1983), was collected from soil and leaf litter from Kure Atoll. The purpose of this paper is to describe *D. hoffmannae* n. sp., collected from moss on a rock wall on Oahu I. and *D. smileyi* n. sp., associated with soil and leaf litter of *Metrosideros* and *Cibotium* on Kauai I. Redescription of the tritonymph of *D. inermis*, first described by Den Heyer (1979), is included in this paper. The two new species from the Hawaiian Islands raise the total number of *Dactyloscirus* to 20 worldwide.

All measurements are in micrometers. Terminology follows Smiley (1992). Dorsal setal designations follow those of Kethley (1990) (see Table 1 for setal designation equivalents). Eupathidial setae on tarsi are designated with the symbol theta (ζ). Body length is measured from posterior tip of hysterosoma to tip of tibiotarsal claw palps, length of leg segments from trochanter to tip of tarsal claws. Setal distances are expressed as *vi-vi* or *hg*$_1$-*hg*$_2$. Holotypes and paratypes are deposited at the Acarology Collection of the J. Linsley Gressitt Center for Research in Entomology, Bishop Museum.

Dactyloscirus hoffmannae Swift sp. nov.
(Figs. 1-12)

Description of species. Holotype female (split during mounting), with egg. Dimensions approximately 760 long, 451 wide. Color in life pale green.

Gnathosoma. Length 233; width 105. Ventral integument densely covered with punctations, non-reticulate (Fig. 3); dorsolateral surface around palp-coxal area reticulate. Palpal length 133, terminates in a small claw (Fig. 5). Chaetotaxy of palpal segments: trochanter, 0; basifemur, 1 dorsal spinelike seta on apical half; telofemur, 1 dorsal spinelike seta, a short elongate apical truncate apophysis on distal inner surface; genu, 2 dorsal simple setae on apex, 1 medially long aciculate simple seta, above this seta, 1 short simple, shorter seta, a minute, circular, hyaline



Figs. 1-6. *Dactyloscirus hoffmannae* sp. nov. female. (1) Dorsum, split during mounting, with egg; (2) trichobothrial seta *sci*; (3) hypostome; (4) genital plates showing aggenital and genital setae; (5) left palpus; (6) right chelicera.

apophysis on distal inner surface; tibiotarsus, 1 long aciculate proximal inner seta, anteriorly, 1 short spinelike seta, 1 simple seta medially, 2 simple dorsal distal setae, anterior long, thick, posterior short, fine. Hypostome (Fig. 3) with 2 pairs adoral setae, 4 pairs hypostomal setae (*hg* 1-4). Hypostomal setal distances: *hg*1-*hg*2 28, *hg*2-*hg*3 83; *hg*4 aciculate, long, located on hypostomal shoulder. Longer adoral setae seem to be on tunbercle. Chelicera 154 long, reticulate pattern basally, simple subterminal seta behind chela (Fig. 6).

Dorsum (Fig. 1) Propodosomal shield reticulate, *vi* and *sci* setose (Fig. 2), length subequal (144); *ve* and *sce* simple nude setae, subequal (11); *vi-vi* 31, *sce-sce* 45. Hysterosoma with a pair of narrow, elongated, inconspicuously reticulated lateral shields between c_1 an c_2. Six pairs of simple dorsal setae on striated hysterosomal integument, length subequal (9.5) except *f* and *h* 18, 23 respectively. Cupule *ip* located posterolaterad of seta *e*, aligned with seta *f* as in Fig. 10.

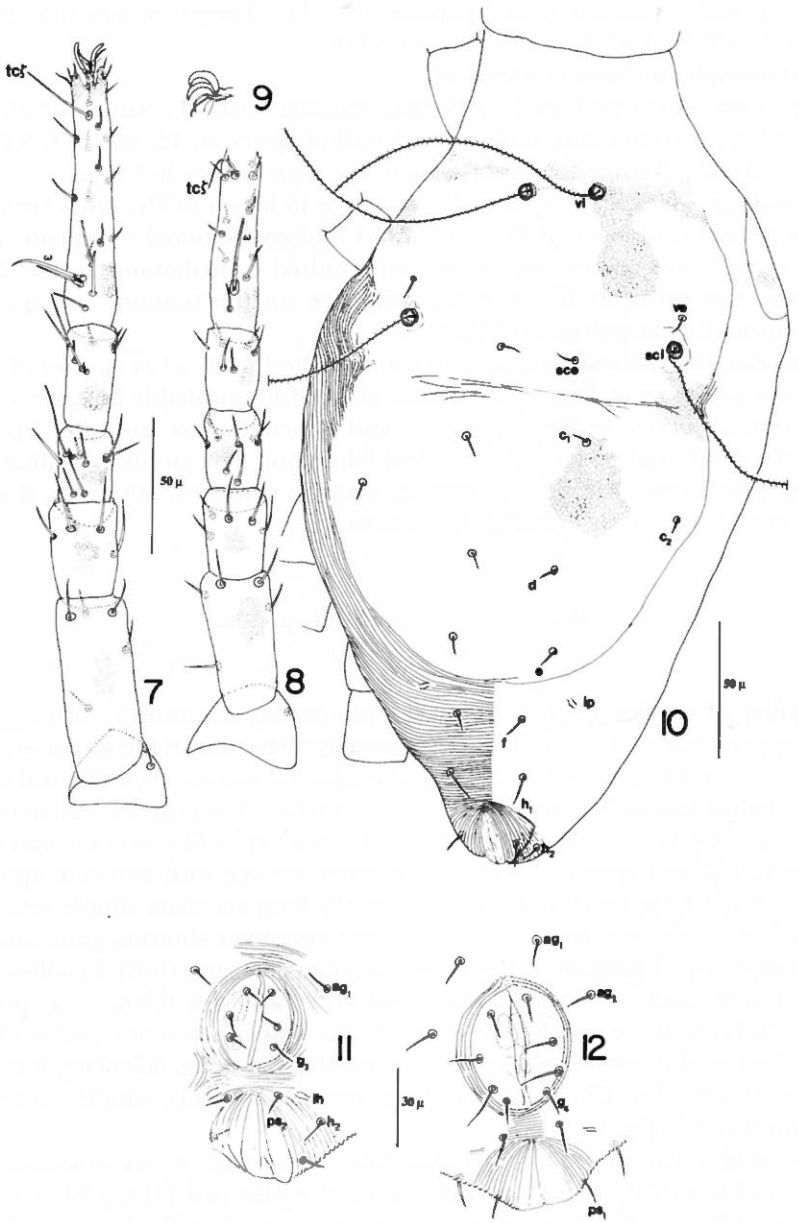
Venter. Coxae I-II contiguous, coxal shields densely covered with punctations, not reticulate; coxae III-IV contiguous, coxal shields reticulate. Three pairs simple setae located between coxae II-IV. Four pairs simple genital setae (Fig. 4), g_1-g_3 arranged longitudinally, g_4 located laterad of g_3, lengths: g_1 9.5, g_2 19, g_3 32, g_4 15. Two pairs aggenital setae (*ag*1-2). Two pairs pseudanal setae (*ps*1-*ps*2), *ps*1 on lateral edge of anal shields, *ps*2 posterior of anal shields. Seta h_2 located ventrally, adjacent to anal shields, cupule *ih* aligned posteriorly nearby.

Legs (Figs. 7-8). Length of legs I-IV: 277-242-275-322. Number of setae on leg segments I-IV (setae on lateral lobed flanges of tarsus not included): coxae 3-3-3-3; trochanters 1-1-2-1; basifemora 5-5-3-1; telofemora 5-5-4-4; genu I, 4 attenuate solenidia, 1 microseta +4; genu II, 2 attenuate solenidia +5; genu III, 1 attenuate solenidion +4; genu IV, 2 attenuate solenidia +4; tibia I, 2 attenuate solenidia, 1 microseta +4; tibia II, 1 attenuate solenidion +5; tibia III, 4; tibia IV, 1 smooth trichobothrium +2; tarsus I, 5 attenuate solenidia, 1 microseta +13; tarsus II, 1 attenuate solenidion +13; tarsus III, 13; tarsus IV, 12. Tarsus I with triplex setae, short microseta abutting lateral base of attenuate solenidion with elongate base (Fig. 7). Leg segments reticulate dorsally, punctate ventrally. Tectal setae *tc* I and *tc* II eupathidial.

Male (Fig. 10). Body length 441, width 237. Identical to female except for the following: smaller, single reticulated shield on idiosoma; solenidion ωI long (39) almost reaching base of *tc*, ωII 35; aedeagus sclerotized as in Fig. 19. Length of legs I-IV: 218-194-209-228; *vi* 102; *sci* 95.

Tritonymph. Body length 555, width 266. Propodosomal shield, dorsal chaetotaxy similar to female adult. Four pairs genital setae arranged longitudinally on genital shields, two pairs aggenital setae (Fig. 12). Two well-developed genital papillae. Length of legs I-IV: 261-220-270-296; *vi* 135, *sci* 112.

Deutonymph (n=2). Body length 475-518, width 223-242. Generally weakly sclerotized. Propodosomal shield, dorsal chaetotaxy identical to female adult. Three pairs of genital setae arranged longitudinally on shields, one pair aggenital



Figs. 7-12. *Dactyloscirus hoffmannae* sp. nov. (7) Leg I, female; (8) leg II, female; (9) tarsal claws and empodium; (10) dorsum, male; (11) deutonymph showing genital and pseudanal plates and corresponding setae; (12) tritonymph showing genital and pseudanal plates and corresponding setae.

setae. Two well-developed genital papillae (Fig. 11). Length of legs I-IV: 199-218; 168-194; 206-235; 216-249; *vi* 105-124, *sci* 95-116.

Protonymph and larva (Unknown).

Type data. Holotype female. HAWAIIAN ISLANDS: Oahu I., Nuuanu-Pali, Board of Water Supply compound, moss on rock wall of reservoir, 12. XI. 1988, S.F. Swift, collector; 2 male, 3 nymphal paratypes with the same data as holotype.

Etymology. The species epithet *hoffmannae* is in honor of Dr. Anita Hoffmann, Professor, Faculty of Science, Department of Biology, National University of Mexico, in recognition of her numerous distinguished contributions to the field of acarology. She probably had a major influence on the training and success of many outstanding acarologists of Mexico.

Remarks. *Dactyloscirus hoffmannae* is distinguished from other species of the genus by the presence of a minute, circular and indistinguishable apophysis on the distal internal surface of the papal genu and a medium size truncated apophysis on the distal internal surface of the palpal telofemur. The circular, hyaline palpal genu apophysis has a whitish dot that indicates its presence, otherwise, it is easily missed in unsatisfactorily mounted specimens.

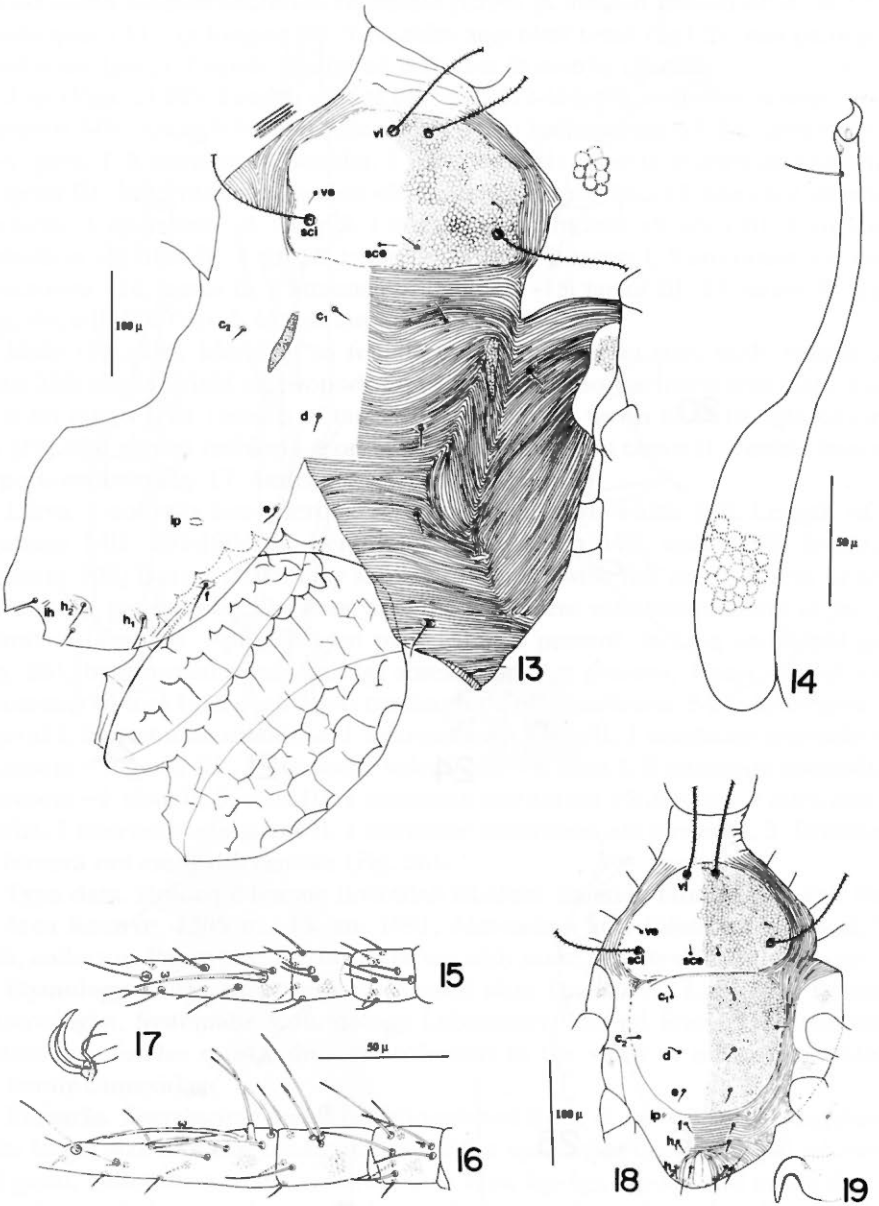
Dactyloscirus smileyi Swift sp. nov.
(Figs. 13-26)

Description of species. Holotype female (split during mounting), with egg. Body lenght approximately 1026, width approximately 484; color in life unknown.

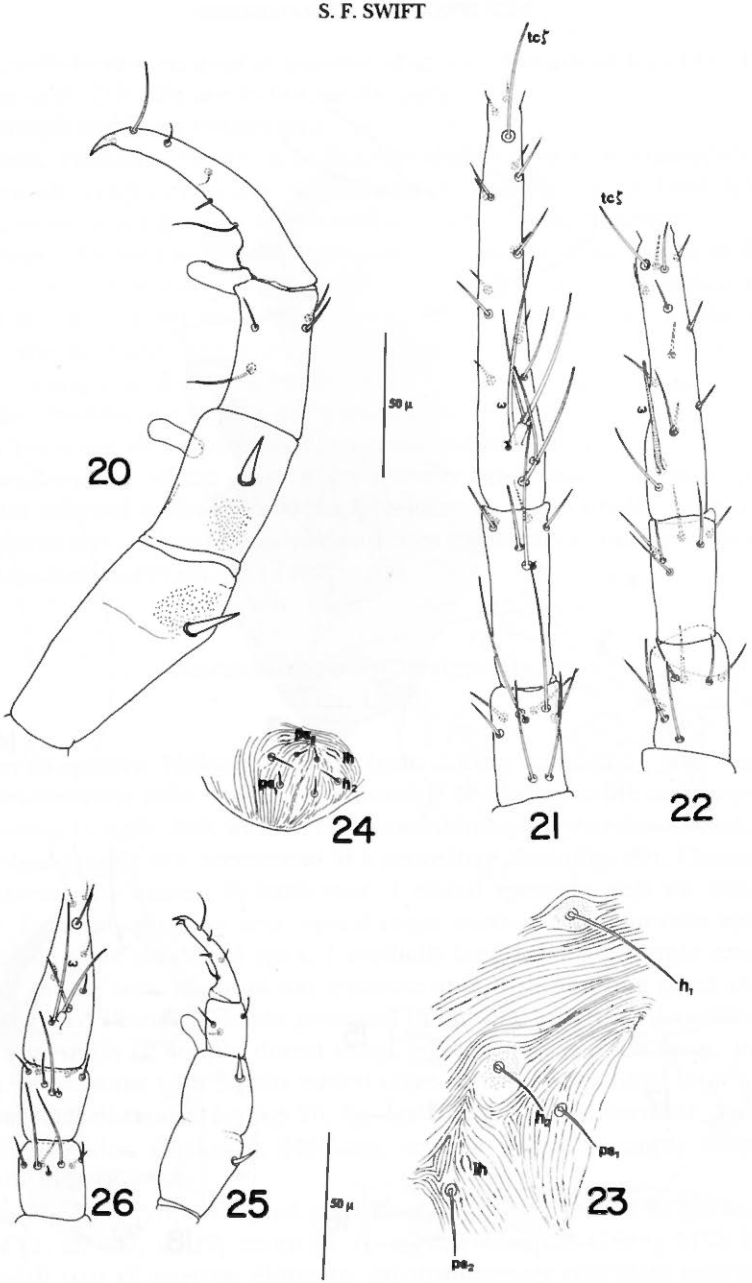
Gnathosoma. Length, 469; width 178. Dorsolateral surface around coxal area reticulate. Palpal length 313, terminates in a distinctive claw (Fig. 20). Chaetotaxy of palpal segmens: trochanter, 0; basifemur, 1 dorsal spinelike seta on apical half; telofemur, 1 dorsal spinelike seta, apical inner surface with truncate apophysis; genu, 2 simple setae on dorsal apex, 1 medially long aciculate simple seta, above it, 1 shorter simple seta, medium size truncate apophysis abutting genu and tibiotarsus; tibiotarsus, 1 long, aciculate proximal inner seta, anteriorly 1 rodlike seta, 1 simple seta medially, 2 simple dorsal distal setae, anterior thick, long, posterior fine, short. Hypostome with 2 pairs adoral setae, 4 pairs hypostomal setae (*hg* 1-4). Hypostomal setal distances: hg_1-hg_2 26, hg_2-hg_3 162; hg_4 long, aciculate, located on hypostomal shoulder. Chelicera, 249 long, reticulate basally, simple subterminal seta behind chela (Fig. 14).

Dorsum (Fig. 13). Propodosomal plate finely reticulate, *vi* and *sci* setose, *vi* 244, *vi-vi* 36, *ve* 11, *sci* 237, *sce* 17, *sce-sce* 36, c_1, c_2, *d*, *e* subequal (19), *f* 34, *h* 40. Hysterosoma with pair of narrow, elongate, inconspicuously reticulate lateral plates. One pair of cupules present, *ip* anterolaterad of *f*.

Venter. Coxae I-II contiguous; III-IV contiguous separated by narrow striated integument. Coxal plates finely reticulate, longitudinal striations in between plates. Three pairs simple setae anterior of genital plates. Four pairs simple genital setae,



Figs. 13-19. *Dactyloscirus smileyi* sp. nov.(13) Dorsum, female, split during mounting, with egg; (14) left chelicera, female; (15) genus, tibia and tarsus of leg II, male; (16) genu, tibia and tarsus of leg I, male; (17) tarsal claws and empodium, male; (18) dorsum, male; (19) male aedeagus.



Figs. 20-26. *Dactyloscirus smileyi* sp. nov. (20) Right palpus, female; (21) genu, tibia and tarsus of leg I, female; (22) genu, tibia and tarsus of leg II, female; (23) integrated H and PS tergites showing $h_{1\text{-}2}$ and $ps_{1\text{-}2}$ setae, cupule *ih*, female; (24) pseudanal plate with h_2, $ps_{1\text{-}2}$ setae and cupule *ih*, larva; (25) right palpus, larva; (26) leg I, larva.

*g*1-3 arranged longitudinally on reticulate plates, *g*4 located laterad of *g*3, *g*1 17, *g*2, *g*4 subequal (33), *g*3 longest 50. Two pairs aggenital setae (ag1-2), two pairs pseudanal setae (*ps*1-2). Cupule *ih* aligned with seta *h*2 nearby (Fig.23).

Legs (Figs. 21-22). Length of legs I-IV: 462-412-415-498. Number of setae on leg segments I-IV: coxae 3-3-3-3; trochanters 1-1-2-1; basifermora 5-5-3-2; telofemora 5-5-4-4; genu I, 5 attenuate solenidia, 1 microseta +4; genu II, 2 attenuate solenidia +5; genu III, 1 attenuate solenidon +5; 2 attenuate solenidia +5; tibia I, 2 attenuate solenidia, 1 microseta +4; tibia II, 1 attenuate solenidion +5; tibia III, 1 attenuate solenidion +5; tibia IV, 1 simple trichobothrium +4; tarsus I, 5 attenuate solenidia, 1 microseta +14; tarsus II, 1 attenuate solenidion +13; tarsus III, 13; tarsus IV, 12.ωI long, 66, ωII, 50. Tectals *tc*I, *tc*II eupathidial.

Male (Fig. 18). Identical to female except smaller in size, body length 556, width 238; single shield on propodosoma and hysterosoma, finely reticulate. Longest ω on tarsus I, 61 (length of tarsus 104) (Fig. 16), tarsus II 48 (length of tarsus 80) (Fig.15), almost reaching *tc* on tarsus I, beyond *tc* on tarsus II. Tarsal claws and empodium as in Fig. 17. Aedeagus sclerotized (Fig. 19).

Larva. Generally less sclerotized, body length 461, width 195. Length of leg segments I-III: 201-190-218. Length of gnathosoma 178, width 108; length of chelicera 108. Dorsal chaetotaxy similar to female with full complement of setae and cupule, genital plates lacking, anal plates present with complement of *ps*1, *ps*2, *h*2 and *ih* (Fig. 24). Apophysis on palpal femur present, lacking on palpal genu (Fig. 25); hypostomal setae *hg*3, *hg*4 absent, *hg*1, *hg*2 present; 1 pair adoral setae; chaetotaxy of legs I-III: coxa 3-1-1; trochanter 0-0-1; basifemur 2-2-1; telofemur 5-5-4; genu I, 2 attenuate solenidia, 1 microseta +4; genu II, 1 attenuate solenidion, 1 microseta +4; genu III , 1 attenuate solenidion +4; tibia I, 2 attenuate solenidia, 1 microseta +4; tibia II, 5; tibia III, 1 attenuate solenidion +5; tarsus I, 3 attenuate solenidia, 1 microseta +6; tarsus II, 1 attenuate solenidion +5; tarsus III, 5. Division of leg femora not easily discernible (Fig. 26).

Type data. Holotype female HAWAIIAN ISLANDS: Kauai I., Hono O Na Pali Natural Area Reserve, 1305 m., 13. VII. 1991, *Metrosideros* and *Cibotium* litter/soil, S.F. Swift, collector. Paratypes: 2 males, 3 larvae with same locality data as holotype.

Etymology. *Dactyloscirus smileyi* is named after Dr. Robert L. Smiley, Research Entomologist, Systematic Entomology Laboratory, United States Department of Agriculture, for his outstanding contribution to the study of mites, especially of the family Cunaxidae.

Remarks. *Dactyloscirus smileyi* is distinguished from *D. inermis* and *D. hoffmannae* by its larger size and the configuration of the apophyses on the palpal telofemur and genu. Differences in distances of setae *vi-vi*, *hg*1-*hg*2, *hg*2-*hg*3 and in the fine details of reticulation on the propodosomal plate and on the palps distinguish *D. smileyi* from other species in the genus.

Dactyloscirus inermis (Trägårdh)

Scirus inermis Trägårdh, 1905: 5; Halbert, 1923:388.
Cunaxa inermis (Trägårdh), Sellnick, 1926: 1973; Baker & Hoffmann, 1948: 235.
Cunaxia (sic) *inermis* (Trägårdh), Goff, 1983: 173; Goff, 1987: 28.
Dactyloscirus inermis (Trägårdh) Thor & Willmann, 1941: 173; Willmann, 1950: 188; Den Heyer, 1979:92; Sepasgosarian, 1984: 142; Michoka, 1987:92; Smiley, 1992:234.

Type species: *Scirus* (*Dactyloscirus*) *inermis* Trägårdh, 1905, Holotype female, Egypt: Giseh, Cairo, 27 December 1900, collected on the surface of a small pool of water.Type deposition unknown.

Description of tritonymph. Body length (approximate) 745, width (approximate) 308; length of gnathosoma 183, width 105; length of palps 183, palpal telofemur and genu with bulbous apophyses; propodosomal shield finely reticulated, *vi* and *sci* setose, 152 and 173 respectively; *vi-vi* 23, *sce-sce* 47; hg_1-hg_2 23, hg_2-hg_3 79. Hysterosoma with a pair of narrow, elongate, inconspicuously reticulated lateral shields. Six pairs of simple dorsal setae on striated hysterosomal integument, c_1, c_2, *d*, *e* subequal (13), *f*, h_1 subequal (20). Cupules *ip* and *ih* present. Length of legs I-IV: 261-233-284-318.

Specimen examined. HAWAIIAN ISLANDS: Kure Atoll, 6.5 m, 31.VII.1980, litter by pier, C. Sengbusch, collector, MLG 800804-4.

Remarks. This tritonymph from Kure Atoll with bulbous apophyses on the palpal femur and palpal genu agrees well with Smiley's (1992) redescription of *D. inermis*. Smiley indicated that the inconspicuously short elongate lateral plates on the hysterosoma distinguish *D. inermis* from similar species in the genus. Den Heyer's (1979) illustration agrees with Smiley's in the presence of short lateral plates. The Hawaiian specimen however, varies slightly from *D. inermis* in that the lateral plates are longer rather than shorter compared to the two times length of c_1, c_2. It should be noted that the dorsal drawings of Thor & Willmann (1941) and Michoka (1987) of *D. inermis* showed elongated lateral plates. This specimen is temporarily placed under *D. inermis* until more material from Kure Atoll and the Hawaiian Islands are collected and studied.

DISCUSSION

Dorsal setal notations used by workers for various mite groups differ tremendously (e.g., Atyeo, 1960; Summers, 1962; Lindquist & Evans, 1965; Smiley, 1992). As setal homologies for various families are reconciled with increasing inclusion of studies of immature stages and ultrastructures (Lindquist, 1986; Baker, 1990), the chaetotaxic system of Grandjean (1939, 1947) has been adopted for many families in the Prostigmata (van der Hammen, 1970; Lindquist, 1976, 1977; Kethley, 1990) and is appropriately applied in the family Cunaxidae in this paper. The setal nota-

tions of Atyeo (1960) for Bdellidae and Den Heyer (1979) and Smiley (1992) for Cunaxidae are basically similar, and are equated with the setal designations used in the present paper in Table 1.

Table 1. Dorsal setal designations used by various authors for Bdellidae and Cunaxidae

Atyeo, 1960	Smiley, 1992	Den Heyer, 1979	Present Study
Anterior sensillum	Anterior sensillum	PS1	*vi*
Lateral propodosomal	P1	d11	*ve*
Posterior sensillum	Posterior sensillum	PS2	*sci*
Median propodosomal	P2	dc1	*sce*
Internal humeral	D1	dc2	c_1
External humeral	L1	dl2	c_2
Internal dorsal	D2	dc3	*d*
Internal lumbral	D3	dc4	*e*
Internal sacral	D4	dc5	*f*
Internal clunal	D5	dc6	h_1
External sacral	*	dl6	h_2
Posterior anal	*	*	ps_1
Anal seta	*	*	ps_2

* No designation

The genus *Dactyloscirus* has a complement of 6 pairs of dorsal hysterosomal setae, *c*1, *c*2, *d*, *e*, *f*, and *h*1. Cupule *ip* is aligned laterad of seta *f*. On the ventrocaudal area, the anal plates have 1 pair of simple setae located medially or at the periphery of the striated anal plates. Adjacent to these plates are two pairs of simple setae arranged anterior-posterior along the plates, the anterior seta is almost on the same level as the anal seta and the posterior seta is situated laterad or posterior of the anal plates depending on the immature stage of the specimen. In between these adjoining setae is a cupule (Figs. 11, 23, 24). Due to proximity of these three pairs of setae, they are easily misinterpreted to be PS setae (*ps*1-3).

In the Tarsonemoidea, Lindquist (1977) reported modification of structure and setation in segment H, including integration with segment PS on the larva and male. I believe that, in *Dactyloscirus*, similar modification and integration has occurred, as shown by the ventral location of presumably seta *h*2 and cupule *ih*, in the vicinity of the anal plates. The dorsal setae of *D. smileyi* are on small platelets

(Fig. 13). The small platelet of presumed *h*2, which is similar to the platelet of *h*1 (Fig. 23) and to the other dorsal setae, distinguished it from the pseudanal setae. The alignment of cupule *ih* with *h*2 is convincing evidence of integration of tergites H and PS. Therefore, the anal seta on the plate is interpreted as *ps*1, and the seta posterior of the plate as *ps*2. *Dactyloscirus* and probably other genera in the family Cunaxidae have only 2 pairs of pseudanal setae in all instars.

The nymphal stages of *Dactyloscirus* are distinguished by the number of genital setae and by the arrangement of these setae on the anal plate. The deutonymph has 3 pairs of genital setae, arranged longitudinally along the genital plate while the tritonymph has the full complement of 4 pairs, also arranged longitudinally. Other than by the presence of an egg, the female adult is distinguished from the tritonymph in having *g*4 placed laterad of *g*3. The setal sockets are also deeper and more pronounced. The protonymph was not observed in this study; however, Den Heyer (1979) reported that in the genus *Pulaeus* the protonymph has 1 pair genital setae, 1 pair genital papillae, and two pairs of hypostomal setae, which could possibly characterize the *Dactyloscirus* protonymph.

Enlargement and elongation of solenidion ω on tarsi I and II of *Dactyloscirus* males parallel similar sexual morphological characteristic of males of the families Caligonellidae and Raphignathidae (Swift, 1996).

Dactyloscirus species are known from the islands of Oahu, Kauai and Kure Atoll of the Northwestern Hawaiian Islands. A larva from Hawaii I., not included in this study, indicates the possible wide distribution of this genus in the Hawaiian Islands.

ACKNOWLEDGMENTS

I sincerely thanks Ms. Karin Kami, Bishop Museum, for her help at the laboratory. Partial funding for field work was provided by the Department of Land and Natural Resources, through a Natural Area Reserves Commissions Grant.

LITERATURE CITED

ATYEO, W.T. 1960. A revision of the mite family Bdellidae in North and Central America (Acarina, Prostigmata). *Univ. Kans. Sci. Bull. 40*: 345-499.

BAKER, A. S. 1990. A survey of external morphology of mites of the superfamily Eupodoidea Banks, 1894 (Acari: Acariformes). *J. Nat. Hist. 24*: 1227-1261.

BAKER, E.W. & A. HOFFMANN. 1948. Acaros de la familia Cunaxidae. *An. Esc. Nac. Cienc. Biol. Mex 5*(3-4): 229-273.

BERLESE, A. 1916. Centuria seconda di Acari nouvi. *Redia 12*(1): 127-177.

DEN HEYER, J. 1979. Notes on the cunaxid genus *Dactyloscirus* (Actinedida: Acarida) with description of two new species from the Ethiopian Region. *Phytophylactica 11*(2): 87-98.

GOFF, M. L. 1983. Notes and exhibitions. *Proc. Hawaii. Entomol. Soc. 24* (2-3): 173.

GOFF, M. L. 1987. A catalog of Acari of the Hawaiian Islands. *Research Extension Series*, 075, Hawaii Institute of Tropical Agriculture and Human Resources, 75 p.

GRANDJEAN, F. 1939. Les segments post-larvaire de l'hysterosoma chez les Oribates (Acariens). *Bull. Soc. Zool. Fr. 64*: 273-284.

GRANDJEAN, F. 1947. Les Enarthronota (Acariens). Premiere Serie. *Ann. Sci. Nat. Zool., Ser. II, 8*:213-248.

HALBERT, 1923. Notes on Acari, with descriptions of new species. *J. Linn. Soc. 35*:363-393.

KETHLEY, J. B. 1990. Acarina: Prostigmata (Actinedida), pp. 667-756. *In*: D. L. Dindal (ed.) *Soil biology guide.* John Wiley and Sons, New York.

LINDQUIST, E. E. 1976. Transfer of the Tarsocheylidae to the Heterostigmata, and reassingnment of the Tarsonemina and Heterostigmata to lower heirarchic status in the Prostigmata (Acari). *Can. Entomol. 108*: 23-48.

LINDQUIST, E. E. 1977. Homology of dorsal opisthosomal plates, setae, and cupules of heterostigmatic mites with those of other eleutherengone Prostigmata (Acari). *Acarologia 19*(1): 97-104.

LINDQUIST, E. E. 1986. The world genera of the Tarsonemidae (Acari: Heterostigmata): a morphological, phylogenetic , and systematic revision, with a reclassification of family-group taxa in the Heterostigmata. *Mem. Entomol. Soc. Can. 136*: 1-517.

LINDQUIST, E. E. & G. O. EVANS. 1965. taxonomic concepts in the Ascidae, with a modified setal nomenclature for the idiosoma of the Gamasina (Acarina: Mesostigmata). *Mem. Entomol. Soc. Can. 47*: 1-64.

MICHOKA, S. 1987. Mites (Acari) of the Bdellidae and Cunaxidae families in Poland. *Monogr. Fauny Pol. 14*:1-130.

SEPASGOSARIAN, 1984. The world genera and species of the family Cunaxidae (Actinedida: Acarida). *Z. Angew. Zool.71*: 135-150.

SELLNICK, M. 1926. Eine parasitische milben aus dem Balatonsee. *Arch. Balaton. 2*: 173-177.

SMILEY, R.L. 1975. A generic revision of the mites of family Cunaxidae (Acarina). *Ann. Entomol. Soc. Am. 68*(2): 227-244.

SMILEY, R.L. 1992. *The predatory mite family Cunaxidae (Acari) of the world with a new classification.* Indira Publishing House, Michigan. 356 p.

SUMMERS, F. 1962. The genus *Stigmaeus* (Acarina: Stigmaeidae). *Hilgardia 33*:491-537.

SWIFT, S. F. 1987a. The family Bdellidae (Acari: Prostigmata) in the Hawaiian Islands. *Int. J. Acarol. 13*(1): 29-49.

SWIFT, S. F. 1987b. A new species of *Stigmaeus* (Acari: Prostigmata: Stigmaeidae) parasitic on phlebotomine flies (Diptera: Psychodidae). *Int. J. Acarol. 13*(4): 239-243.

SWIFT, S. F. 1996. Hawaiian Raphignathoidea: Family Caligonellidae (Acari: Prostigmata), with descriptions of five new taxa and a key to genera and species. *Ann. Entomol. Soc. Am. 89*(3): 313-327.

THOR, S. & WILLMANN. 1941. Acarina Prostigmata 6-11 (Eupodidae, Penthalodidae, Penthaleidae, Pachygnathidae, Cunaxidae). *Das Tierreich 71a*: 1-186.

TRAGARDH, I. 1905. Acarieded aus Agrypten und dem Sudan. *Results of the Swedish Zoological Expedition of Egypt and the White Nile, 1901.* Part II. 124 p.

VAN DER HAMMEN, L. 1970. *Tarsonemoides limbatus* nov. spec., and the systematic position of the Tarsonemida (Acarida). *Zool. Verh., Leiden 108*: 1-35.

WILLMANN, C. 1950. Milben aus mineralquellen. *Zool. Anz. 145*(7-8): 188-190.