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The Great Basin Naturalist

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VOLUME 32 March 31, 1972 No. 1

FOSSIL PALM MATERIALS FROM THE TERTIARY DIPPING VAT FORMATION OF CENTRAL UTAH

William D. Tidwell,[1] David A. Medlyn,[1] and Gregory F. Thayn[1]

ABSTRACT.— The *Rhizopalmoxylon* (petrified palm roots) species from the hills west of Redmond, Utah, were originally reported as from the Jurassic Arapien Shale. However, the Utah State Geologic Map upon which this was largely based is erroneous, and the strata containing the palm roots are in the Tertiary Dipping Vat Formation, rather than in the Jurassic Arapien Shale. From the palm roots previously reported, three new species have been identified: *Rhizopalmoxylon behuninii*, *R. blackii*, and *R. scottii*.

Specimens of the new species, *Palmoxylon gustavesonii*, were collected from the Dipping Vat Formation east and south of Redmond. This formation unconformably overlies the Arapien Shale in the vicinity of the previously reported Jurassic palms. At the present time, the palm axes reported from the Arapien Shale cannot be conclusively demonstrated to have come from the Dipping Vat Formation. However, the presence of another species of petrified palm in the Dipping Vat Formation is sufficient to cast doubt on their existence in the Arapien Shale.

The species of fossil palm material (*Rhizopalmoxylon* and *Palmoxylon*) discussed in this paper are from the Dipping Vat Formation of Tertiary age near Redmond, Utah.

The *Rhizopalmoxylon* species from the Redmond Hills west of Redmond (Figs. 1, 2b) were originally reported as from the Jurassic Arapien Shale (Tidwell et al., 1970b, 1971a). This was based largely upon these strata being mapped as Arapien Shale (Utah State Geologic Map). This mapping has since been demonstrated to be erroneous (Scott et al., in press), and the strata containing the palm roots are, without question, in the Dipping Vat Formation.

Specimens of the new *Palmoxylon* species (*Palmoxylon gustavesonii*) were collected from the Dipping Vat Formation approximately four miles east and south of Redmond in central Utah (Fig. 1). These specimens consist of axes which were embedded within a resistant tuffaceous sandstone, as well as eroded, fragmental surface samples.

The specimens in the Dipping Vat Formation, which unconformably overlies the Arapien Shale Formation in the vicinity of where the Jurassic palms were previously reported (Tidwell et al., 1969, 1970a, 1970b), were shown to us by Mr. Jay Gustaveson of

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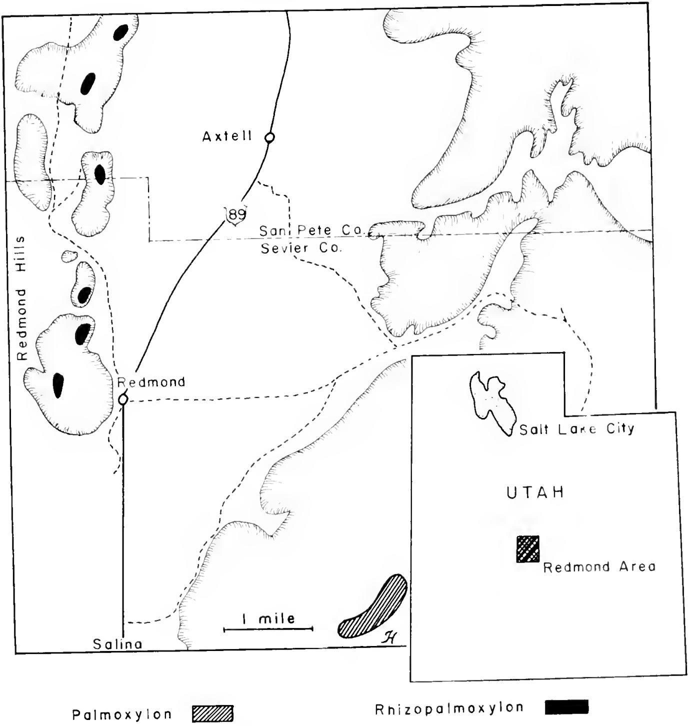

Fig. 1. Index map of sites of palm material in the Tertiary Dipping Vat Formation.

Salt Lake City some time after articles on the Jurassic palms were published. These papers would have been seriously modified had the presence of petrified palms in the Tertiary beds been known. The surrounding hills had been seriously searched previously and no fossil palm materials were encountered at that time, geologically or topographically above the Arapien Shale. The reason for not previously encountering fossil palm materials appears to be the result of (1) not searching far enough into the valley formed in the Dipping Vat Formation to encounter the palm localities from which the amateur collectors had previously collected palm specimens and (2) the collectors removal of float in this area, resulting in a paucity of specimens.

Although *Palmoxylon simperi* and *P. pristina*, described from the Arapien Shale, are distinct species, there is a possibility that they may also have come from the younger Dipping Vat Formation. It is not certain as to how they arrived in the Arapien Shale. But, to have them eroded, roll approximately a mile over a near vertical cliff of about 100 feet, and remain intact as axes three to four feet in length does not seem possible.

STRATIGRAPHY.— The Dipping Vat Formation (McGookey, 1960) is one of a series of formations deposited in association with a large Late Eocene Lake in central Utah. Clastic fragments of the formation were derived largely from volcanic activity to the south or southwest of the central Utah locality. The formation here consists of coarse-grained, gray to white, sometimes gray-blue, locally hydrothermally altered to red, evenly bedded tuffaceous sandstones which contain varying amounts of pyroclastic fragments. Minor white clay and silty limestone are also interbedded.

The Dipping Vat Formation is overlain by the Bullion Canyon Volcanics at the type section and is underlain by the Bald Knoll Formation. In the Redmond Hills, the Dipping Vat Formation is hydrothermally altered to reddish gray. These sediments are strikingly similar in appearance to some horizons in the Arapien Shale.

RHIZOPALMOXYLON Felix, 1883

Rhizopalmoxylon is the form genus for petrified roots referable to the family Palmae. Diagnostic criteria for determination of species and genera have been variously treated. Tomlinson (1961), Drabble (1904), and Cormack (1896) considered them not to be definite enough for differentiation. Mahabale and Udwadia (1959) ". . . suggested that since many of these characteristics [concerning palm roots] are of a stable nature, they can be used for the analysis of the artificial genus of palm roots, *Rhizopalmoxylon*." Palm roots possess some peculiar features such as a so-called polystele due to dissolution of the stelar system into strands of various shapes, changes in their anatomy due to varied habitats, etc. Some of these features are distinctive for certain species and genera which will help in identifying them on the basis of their anatomy (Mahabale and Udwadia, 1959).

Roots of living palms arise generally from the basal portion of a tree trunk where they form a dense, surrounding network. Position on the plant and function of roots of palms can be distinguished. There are large-sized, aerial roots which function as prop or stilt roots. Others are small and grow downward, serving as absorbing roots. Cluster-forming aerial roots arise a little above ground, grow downwards at various angles, and form a thick mat around the tree trunk. In some palms the secondary roots grow vertically upward and form pneumatophores. Each of these vary as to their anatomy, but have distinctive criteria useful in recognizing species of palms (Mahabale and Udwadia, 1959).

The anatomy of *Rhizopalmoxylon* has been discussed in conjunction with *Palmoxylon* species to which they are attached (Stenzel, 1904; Sahni, 1938; Gothan, 1942; Stockmans and Williere, 1943;

Shukla, 1946; Ogura, 1952; Lakhananpal, 1955; Rao and Menon, 1965; Menon, 1968; Tidwell et al., 1971b).

The well-preserved palm roots constituting this report are imbedded in growth position at several horizons within sandstone strata of the Dipping Vat Formation. In some areas, they form an intricate pattern of large and small roots similar to the network developed in living arborescent monocots.

Rhizopalmoxylon behuninii, n. sp.

Figures 2a, 3

Description.— These consist of silicified roots, 5-10 mm in diameter, interwoven among the sediments. The epidermal layer, epiblema of Mahabale and Udwadia (1959), or limiting layer of Drabble (1904) and the hypodermal layers are generally not preserved.

The three parts of the cortex lie beneath the slight remains of the hypodermis. The outer cortex is about 0.05 mm in thickness and consists of one to four layers of thin-walled, blocky, parenchymatous cells.

The lacunar, middle cortex contains slender, radiating air spaces which are separated by irregular, thin radially extended diaphragms. The short, thick-walled parenchyma cells forming the diaphragms are radially aligned, usually one to three cells in thickness. This zone is approximately 2 mm wide.

Fourteen layers of blocky or oblong-shaped, compact, thin-walled parenchyma cells compose the inner cortex, which has a total thickness of about 0.05 mm. Beautifully preserved brachysclereids are sometimes present in this tissue.

The single cell layer of the endodermis is poorly preserved and resembles the single-layered pericycle. Casparian strips occur, where visible, only on radial walls. Some endodermal cells contain a dark substance.

There are upward of 26 exarch xylem strands present in the stele. Each strand contains two or three metaxylem vessels, wall to wall, or alternating in two to three concentric rings. Areas of phloem occur between the protoxylem elements near the pericycle. The metaxylem elements are surrounded by compact, thin-walled parenchyma cells, in which an occasional fiber can be observed.

The pith is formed of compact, thin-walled parenchyma cells and rarely contains cells with secondary walls. The center portion of the pith breaks down, leaving an irregularly shaped hollow center surrounded by parenchyma.

This species is named for the late Mr. Homer Behunin of Redmond, Utah, who was the original discoverer of these fossil palm localities.

Repository.— Brigham Young University, 920 (Holotype)

Locality.— Redmond Hills, Utah

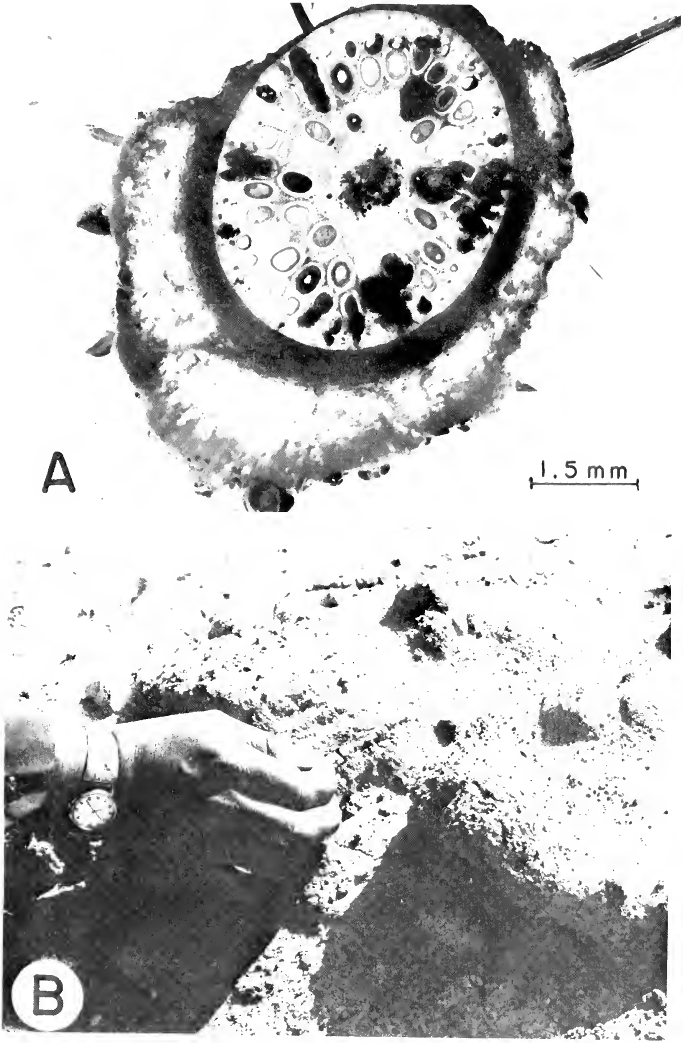

Fig. 2. *A*. Cross section of *Rhizopalmoxylon behuninii*. *B*. A *Rhizopalmoxylon* specimen in place.

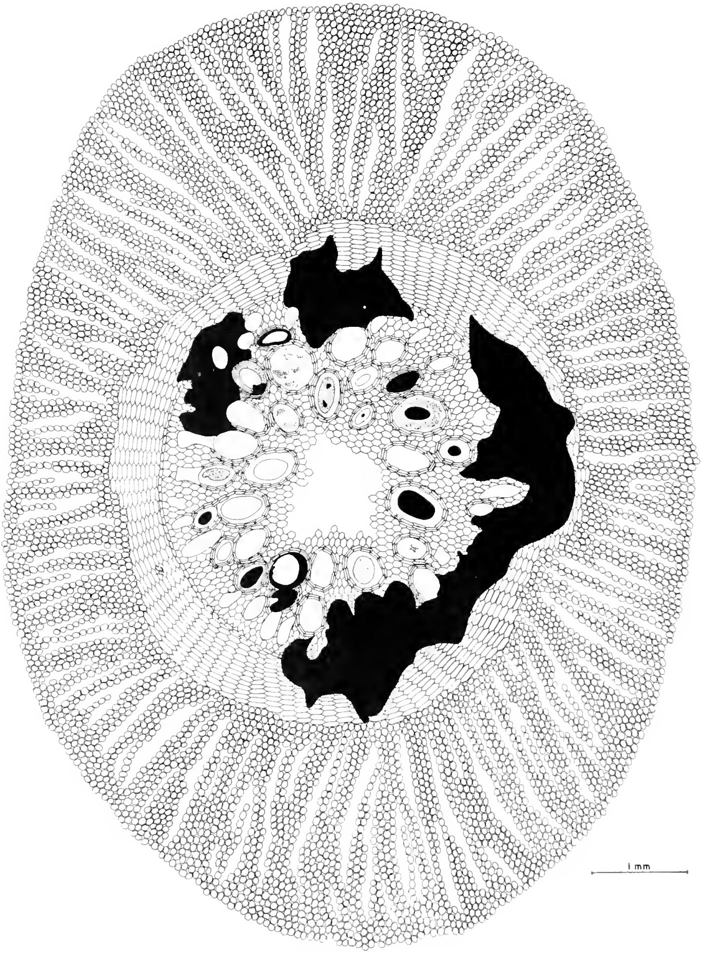

Fig. 3. Cross section of *Rhizopalmaxylon behuninii*. The blackened portions indicate areas of poor preservation. (Cells are slightly enlarged.)

Horizon.— Dipping Vat Formation
Age.— Late Eocene

Rhizopalmoxylon blackii, n. sp.

Figure 4

Description.— Silicified roots are approximately 10 mm in diameter.

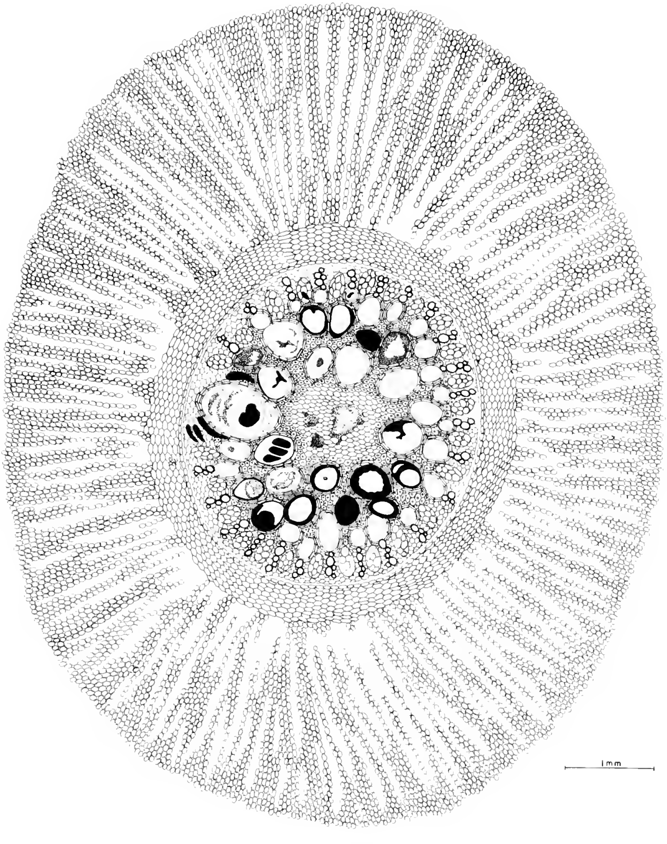

Fig. 4. Cross section of *Rhizopalmoxylon blackii*. Note the thick-walled conjunctive tissue. (Cells are slightly enlarged.)

Epidermis and hypodermis are not preserved and the outer cortex is nearly obliterated. The outer and middle cortex is 2.5 mm wide with the composition of the outer being compact, thin-walled parenchyma. The middle cortex is not well preserved. Where present it consists of radiating diaphragms separating air cavities. The diaphragms are made of thin-walled, isodiametric parenchyma cells.

The inner cortex is 0.05 mm in width, and, although poorly preserved, relatively thick-walled, isodiametric cells are observable. This relatively uniform cortical tissue is approximately eleven cells in thickness.

The endodermis is one cell thick with some darkened areas on its radial cell walls which may be the remains of casparian strips. The pericycle is not preserved but appears to have been about one cell in thickness.

The stele is well preserved. Patches of phloem with approximately eight sieve tubes per area occur between strands of protoxylem. Thirty protoxylem points are observable with twenty metaxylem elements in each of two concentric rings. The protoxylem and first formed metaxylem elements are wall to wall with later developing metaxylem elements alternating.

Compact, small, thick-walled cells make up the conjunctive tissue with some thin-walled parenchyma ensheathing some of the vessel elements. Pith contains large, thin-walled cells. A lacuna occurs in the pith, but this appears to be due to preservation rather than a breakdown of parenchyma cells.

Rhyzopalmoxylon blackii was named for Mr. Robert Black of Redmond, Utah, for his contribution to this study.

Repository.— Brigham Young University, 921 (Holotype)

Locality.— Redmond Hills, Utah

Horizon.— Dipping Vat Formation

Age.— Late Eocene

Rhizopalmoxylon scottii, n. sp.

Figure 5

Description.— Petrified roots, 7-9 mm in diameter, embedded within sandstone layers.

The epidermis and hypodermis are not preserved. The outer cortex, comprised of layers of compactly arranged parenchyma cells, is 0.05 mm wide. The 2 mm middle cortex in some specimens is composed of compact, thick-walled, round to hexagonal, isodiametric parenchyma cells. In other specimens, the middle cortex consists of diaphragms of these isodiametric cells separated by air cavities. Some isolated fibers are present in the middle cortex.

The thin-walled, isodiametric-celled, inner cortex is four cells and 0.05 mm in thickness. The cells become smaller toward the endodermis. The endodermis and pericycle are uniseriate, and the pericycle is poorly preserved. Casparian strips may be observed on the lateral and inner walls of the endodermal cells.

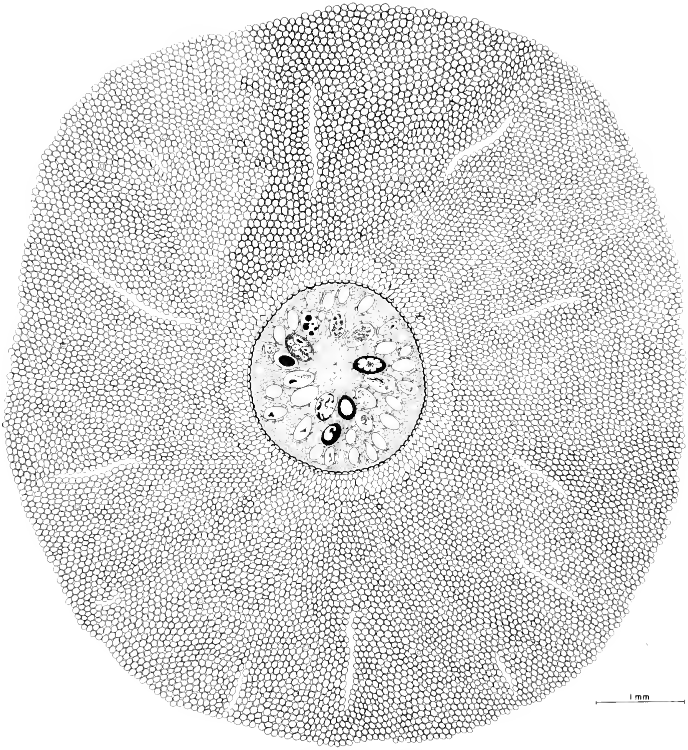

Fig. 5. Cross section of *Rhizopalmoxylon scottii*. Note the compact middle cortex, the smaller stele size, and the *C*-shaped casparian strips on the endodermis. (Cells slightly enlarged.)

In the stele, which is 2 mm in diameter, patches of phloem occur between the protoxylem strands. There are fourteen exarch xylem strands arranged in two concentric rings surrounded by thin-walled conjunctive tissue. Xylem elements are wall to wall or alternating. Parenchyma, ensheathing the vessel elements, contains some type of dark substance.

The thin-walled parenchyma cells of the pith are larger than the cells composing the conjunctive tissue. A lacuna occurs but appears to be due to preservation.

Rhizopalmoxylon scottii was named for Dr. Richard Scott of the U.S. Geological Survey for his interest and contribution to this study.

REPOSITORY.— Brigham Young University, 922 (Holotype)
LOCALITY.— Redmond Hills, Utah
HORIZON.— Dipping Vat Formation
AGE.— Late Eocene

DISCUSSION OF THE RHIZOPALMOXYLON SPECIES.— The palm roots of this study are found in growth position within the sediments of the Dipping Vat Formation. The roots appear to be subterranean and probably do not represent aerial roots or pneumataphores, which would be more inclined to be destroyed because of exposure. They appear to be absorbing roots, all serving the same function, and possessing a different anatomical structure than the other root types.

In comparing the species discussed here with other described forms, they were found to be dissimilar in their stelar configuration. *Rhizopalmoxylon behuninii*, *R. blackii*, and *R. scottii* have two or three concentric rings of metaxylem elements, whereas those to which they were compared had only one.

The stelar configuration and conjunctive tissue of *Rhizopalmoxylon behuninii* and *R. scottii* are similar, with the exception of the much smaller stele size of the latter. The overall root size is the same in both species, and therefore *R. scottii* does not appear to represent a small secondary root of *R. behuninii*. Smaller secondary roots possess a compact middle cortex as in *R. scottii*; however, the middle cortex of some specimens of *R. scottii* also contain air cavities, indicating that they are distinctly different from *R. behuninii*.

These species differ from *Rhizopalmoxylon blackii* in their stelar pattern and conjunctive tissue. Mahabale and Udwadia (1959, p. 93) states, "The different patterns of the stele in palm roots with its conjunctive parenchyma form a very characteristic feature of each species. . . ."

The endodermal cells of *R. scottii* have the typical C-shaped casparian strips of Russow, whereas those on *R. blackii* and *R. behuninii* appear to be only on the radial walls.

The conjunctive tissue of *Rhizopalmoxylon behuninii* and *R. scottii* is composed of thin-walled parenchyma, contrasting with the thick-walled conjunctive tissue of *R. blackii*. The conjunctive tissue of *R. behuninii* varies little from its pith, while the pith of *R. scottii* is composed of thin-walled cells which are larger than the cells of its conjunctive tissue. The pith of *R. blackii* is composed of thin-walled cells which differ from its thick-walled, smaller-celled conjunctive tissue. *R. blackii* also has more metaxylem elements, and the inner cortex consists of isodiametric cells, rather than the elongated hexagonal cells of *R. behuninii*.

The *Palmoxylon* species to which these roots may be related is uncertain at the present time. Although all *Palmoxylon* specimens collected by the authors from the Dipping Vat Formation are assignable to *P. gustavesonii*, other species of this genus may have also been present. Eventually, the basal portion of *P. gustavesonii* and other possible species may be uncovered and collected, and the affinities of these *Rhizopalmoxylon* species may then become known.

Roots of the living palm genus *Latania* are similar to these *Rhizopalmoxylon* species in stelar configuration. They vary, however, by the roots of *Latania* having lysigenous air cavities in the middle cortex, whereas the middle cortex of the *Rhizopalmoxylon* species described in this paper appears to be formed schizogenously. This is similar to those found in some palms growing in swampy situations, such as *Raphia* and *Nypa* (Tomlinson, 1961).

PALMOXYLON Schenk, 1882

Palmoxylon gustavesonii, n. sp.

Figures 6a, 6c

DESCRIPTION.— All that is anatomically preserved of these specimens are the central and subdermal zones of the petrified axes which vary from 25 to 30 cm in diameter. The central zone is characterized by irregularly oriented vascular bundles. These bundles are 750μ at their widest, and vary from 800 to 950μ in height. There are approximately 67 bundles per cm^2. The f/v ratio is commonly 1:1 but can differ slightly (1.5:1, 1:1.2). The bundle shape is blocky, oblong to infrequently ovate. The bundle cap is reniform in shape with a shallow median sinus. *Auricular sinuses are markedly absent*, with auricular lobes being rounded.

Vascularization consists of two metaxylem elements per bundle, occasionally three. The elements vary from 155 ta 200μ in diameter. In longitudinal section, the vessels are 500 to 600μ in length with simple perforation plates and scalariform thickenings on the wall. Protoxylem elements were not observed in the central region of our specimens. The phloem is usually not preserved, but in some bundles the outline of elements can be determined, and they range from 40 to 65μ in diameter. Both the vascular portion and the fibrous bundle cap are encased by tabular parenchyma. The ground tissue consists of thin-walled, compact, isodiametric cells, lacking lacunae. Numerous fibrous bundles 150 to 259μ in diameter are present, but lack stegmata.

The bundles of the subdermal zone, although poorly preserved, tend to be more or less regularly aligned near the dermal zone, and irregularly oriented near the central zone. The bundles tend to be larger in the subdermal zone (1 mm x 1.25 mm). There are approximately 84 bundles per cm^2 with a f/v ratio of 1:2, rarely 1:1.

The vascularization and size of the metaxylem elements are similar to those of the central zone.

This species was named in honor of Mr. Jay Gustaveson of Salt Lake City, Utah, for his aid in this study.

REPOSITORY.— Brigham Young University, 923 (Holotype)

LOCALITY.— Four miles east and south of Redmond, Utah

HORIZON.— Dipping Vat Formation

AGE.— Late Eocene

DISCUSSION AND CONCLUSIONS.— Some collected or observed axes of *Palmoxylon gustavesonii* were eight to nine feet long and

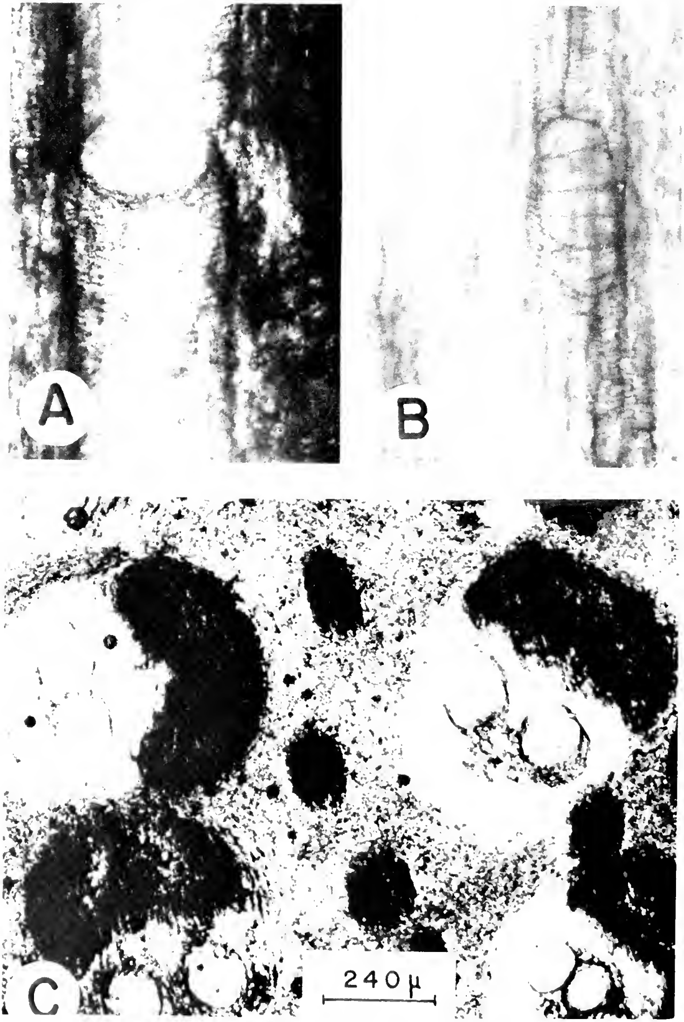

Fig. 6. *A.* Longitudinal view of simple perforation plate on vessel of *Palmoxylon gustavesoni*. *B.* Longitudinal section of scalariform perforation plate on vessel of *Palmoxylon simperi*. *C.* Cross section of bundles of *Palmoxylon gustavesoni* (enlarged) illustrating typical oblong bundle shape.

were embedded within a resistant tuffaceous sandstone. Samples were studied from various points along these axes. There does not appear to be any appreciable anatomical differences between them.

Palmoxylon gustavesonii and *P. simperi* Tidwell are not similar, but, because their collection sites are within the same general area, a detailed comparison of these two species is necessary.

Palmoxylon gustavesonii is distinct from *P. simperi* in that the vascular bundles of *P. simperi* tend to be larger (1.25 mm to 2 mm), less numerous, and more widely spaced with 53 bundles per cm^2. The bundle caps of both species are reniform, although *P. simperi* has prominent auricular sinuses and a rounded to somewhat angular median sinus. The f/v ratio in the central zone of *P. simperi* is 2.5:1 compared to 1:1 in *P. gustavesonii*. Vessels of *P. simperi* have both simple and scalariform perforation plates (Fig. 6b) and its vessels tend to be longer (about 1 mm in length) in longitudinal section.

Palmoxylon pristina Tidwell is also found in the same general area as both *P. simperi* and *P. gustavesonii*, but, due to the poorly preserved specimens of *P. pristina*, a more detailed comparison is not possible. The bundles of *P. pristina* are smaller and more rounded with the bundle height being the same as the width. The bundles of *P. gustavesonii* are mostly oblong, whereas those of *P. pristina* are pear-shaped to triangular. The f/v ratio of *P. pristina* is 1.7:1 to 2.7:1 as compared to 1:1 to 1.5:1 for *P. gustavesonii*.

Based on the comparison of the central zones, *Palmoxylon gustavesonii*, *P. pristina*, and *P. simperi* are distinct species. Although the statement was originally made that *P. pristina* and *P. simperi* may have been from different parts of the same plant and may represent the same biological species (Tidwell et al., 1970a), they are distinct and appear to represent separate biological as well as form species.

The bundle shape in the central zone of *Palmoxylon pondicherriense* Sahni is similar to *P. gustavesonii*, but it differs mainly in the occurrence of stegmata on the fibrous bundles and the presence of large lacunae in the ground tissue of the central zone. The vascular bundles of *P. pondicherriense* decrease in size from the dermal to the central zone, a character which is the reverse of most *Palmoxylons*.

Palmoxylon edwardsi Sahni looks very similar, but only the dermal and subdermal zones were present and described. This makes a comparison with *P. gustavesonii* difficult because of the poorness of preservation in the subdermal zone and the lack of the dermal zone in the latter. Some of the observable differences are the lack of tabular parenchyma, the occurrence of small air spaces in the ground tissue, and the tendency for some of the bundles in the subdermal zone of *P. edwardsi* to show a radiating pattern.

Because of the interest shown for the possibility or impossibility of palms occurring in the Jurassic, this paper on petrified palm axes and roots from the Tertiary Dipping Vat Formation, which in some areas overlies the Jurassic Arapien Shale, has an added significance.

The responsibility of any errors in the prior publications relating to Jurassic palms (Tidwell et al., 1969, 1970a, 1970b, 1971a) remains with the senior author. Although these publications appear to be due to hasty conclusions, this was not the case. Much time and effort was spent in trying to arrive at the truth. Several expeditions with as many as twenty students were made into the hills surrounding the collecting localities of *Palmoxylon simperi* and *P. pristina* looking for any petrified material above the Arapien Shale and, as previously stated, none was found. Many persons were questioned concerning the possibility of fossil palm materials above the Arapien Shale, and in most cases their answers were later proven to be either false or evasive for whatever reason each one had. However, no one admitted to the petrified materials being present in the younger beds until Mr. Gustaveson came forward and conducted us to their location after our earlier papers were published.

The palm roots are definitely from the Dipping Vat Formation, whereas the palm axes previously reported from the Arapien Shale cannot be conclusively demonstrated, at the present time, to have come from this younger formation. However, the possibility of their derivation from the younger strata, as suggested by petrified palm axes from the Dipping Vat, is sufficient to cast doubt on their existence in the Arapien Shale.

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The authors wish to thank the following individuals for their time and efforts during the study. Naomi Hebbert for aid in the illustrations, A. Daniel Simper of the University of California at Davis, Dr. J. Keith Rigby and Dr. James L. Baer of the Department of Geology at Brigham Young University, and Dr. S. R. Rushforth of the Botany Department, Brigham Young University, as well as those previously cited.

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A NEW SUBSPECIES OF *CROTALUS LEPIDUS* FROM WESTERN MEXICO

Wilmer W. Tanner,[1] James R. Dixon,[2] and Herbert S. Harris, Jr.[3]

Abstract.— An examination of additional specimens of *Crotalus lepidus* from western Durango and the adjacent parts of Sinaloa and Nayarit have demonstrated the validity of Klauber's (1956) suggestion that a new subspecies may occur. The new subspecies (*C. l. maculosus*) is described and compared to other subspecies.

Klauber (1956:37) recognized the uniqueness of three specimens of *Crotalus lepidus* from areas near the junction of the Mexican States of Durango, Sinaloa, and Nayarit. Although *lepidus* from that area were considered to belong to the subspecies *klauberi*, or were at least in the designated range for that subspecies, Klauber keyed such specimens to the subspecies *lepidus* or *morulus* and suggested that an adequate series from this rough and inaccessible area might justify the recognition of a new subspecies.

The area northwest, west, and southwest of El Salto, Durango, is some of the most rugged terrain in Mexico. In this area with its deep canyons, high ranges, plateaus, and its diverse climate ranging from wet to dry, there has been produced a variable and challenging environment which has seemingly been responsible for the development through adaptation of a number of subspecies. Perhaps of equal importance in this study is the fact that within this general area at the higher elevations are found some of the more primitive members of the genus *Crotalus*. It is not, therefore, surprising to find a population of *C. lepidus* which has, in its adaptation to this area, developed a series of unique characteristics.

We now have available a series of 19 specimens from these states and consider them to be sufficiently distinct to warrant a description of a new subspecies. Because of the distinctive character of the series of small dorsal spots we choose to name it

Crotalus lepidus maculosus, subsp. nov.

Type.— BYU No. 33328, 15 miles (24 km) west of La Ciudad, near Highway 40, Durango, Mexico. An adult male collected on 31 July 1970 by Richard T. Basey.

Paratypes.— BYU 40188, 1 km W Los Bancos, HSH 71-24 and HSH 71-133, near La Ciudad, MVZ 59310, 16 miles (22 km) SW La Ciudad and UCM 46011, 11 miles W La Ciudad, Durango; TCWC 33358, 2 days by mule E from Huajicori, Nayarit; BYU 40189, Puerto El Alazan, BYU 40190-91, 3 miles E Puerto El Alazan, HSH 71-23, 10 miles W Durango-Sinaloa line (Hwy 40), KU 78973, 19.2 km NE Santa Lucia, KU 79232, 5 km SW Palmito,

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LACM 50960, 4.8 miles E Santa Rita (Hwy 40), TCWC 33354-6 Rancho Carrizo 12.5 miles (20 km) W Palmito, TCWC 33357, 2 miles (3 km) W Palmito and TCWC 33359, near El Maguey (Eastward from Huajicori), Sinaloa, Mexico.

Diagnosis.—A medium to small subspecies of *lepidus* differing from other subspecies in having a dorsal series of small spots often longer than wide and in a primary series averaging 29-31 spots. It also differs from other subspecies in that the dorsal spots do not extend laterally on each side of the body to form cross bars, except near the tail where the spots may form moderate cross bars (Fig. 1). *C. l. maculosus* differs from *klauberi* and *lepidus* in having an increase in the average number of ventrals and caudals, and from *klauberi* in that the ground color is heavily pigmented between the spots, a character shared with *lepidus* and *morulus*. It is further distinguished from *klauberi* by the heavy flecking on the ventrals, reduced number of scales between the supraoccipitals, presence of a postocular stripe, reduction in number of scales in internasal-prefrontal area, and by its smaller size.

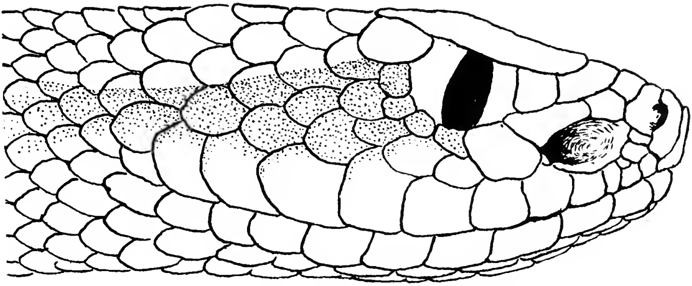

Fig. 1. Lateral view of the head of the type (BYU 33328) showing loreals, anterior subocular and postocular stripe.

Crotalus l. maculosus shares with *lepidus* and *morulus* the dark ground color, postocular stripe and with *morulus* an increase in body spots, ventrals and caudals and paired occipital blotches. It is most distinct from *morulus* in that the upper preocular is divided and the anterior subocular is usually in contact with the upper labials.

Description of Type.— An adult male, total length (snout to first rattle) 591 mm, tail (vent to first rattle) 56 mm, head length 26.2, head width 15.5, fang length 4.1, rattle small, lateral width of proximal rattle 2.5, dorsoventral depth 5.4; ratio of tail into total length 10.55 percent, head into body length 20.42, head into total length 22.56, fang into head length 6.39, and proximal rattle into head length, 4.76.

Scale rows on body 23-23-17, on tail at tenth caudal 12 rows, fringe scales around first rattle 10; ventrals 169, caudals 30, anal complete; supralabials 12-13, infralabials 10-11; preoculars 2-2 elongate, upper one divided horizontally, postoculars 3-3, suboculars 2-2, anterior subocular round, enlarged and in contact with the orbit and the fourth and fifth supralabials; one row of interoculabials between postsubocular and supralabials; anterior nasal largest and in broad contact with first supralabial and internasal; loreal angular; three small prefoveals between loreal and first two supralabials; three small postfoveals along lower margin of pit and above third and fourth supralabials.

Rostral wider (3.8) than high (3.0), clearly visible from dorsal view, not deeply wedging between internasals; two internasals, not in contact with loreals and nearly twice as wide (2.7) as long (1.7), no canthal ridge on edge of internasals from snout to canthal; canthal large, approximately round and in contact with internasal, nasal, loreal, upper preocular, supraocular, and three intercanthals; four small scales (two rows) between canthals and posterior to internasals; supraoculars large and oblong, three rows of small scales between supraoculars near their middle, head scales posterior to interocular area smaller than those on anterior dorsal surface.

First pair of infralabials in broad contact on the midventral line, completely surrounding triangular mental and wedging posteriorly between genials; genials large, elongate, and in broad contact posteriorly, in contact with first three infralabials anteriorly, and wedging between gulars posteriorly; five gulars between genials and first ventral.

Dorsal pattern a series of 31 dark brown spots extending from head to tail; first spot (post temporal) divided and last four extended laterally to form broken or continuous transverse bars; spots often longer than wide and margined with a fine edging of light yellowish or golden brown; spots 2-3 scales long and 4-5 scale rows wide, becoming smaller posteriorly, until fusion with lateral spots forms bars. One row of lateral spots which becomes more obvious posteriorly and fuses with dorsal spots; no intermediate spots between primaries.

Ground color a dark brown, nearly uniform, but with some dark flecking particularly between the dorsal and lateral spots; venter heavily marbled with dark markings and flecks; head without marks on dorsum; a dark stripe from eye to temporal area; labials marbled, with less light markings on supralabials; snout a uniform dark brown.

Tail with one complete bar and four lateral spots on each side, dorsal area posterior to first bar light brown, noticeably lighter than dorsum of body; proximal rattle rust red.

VARIATIONS.— We have used freely the scale counts given by Gloyd (1940) and Klauber (1952 and 1956) in our analysis of the characters used in this study. Obviously, we have not deemed it necessary to recount specimens previously studied. We have, therefore, examined in detail only those specimens not previously examined with the exception of a few specimens from critical areas.

Twenty additional specimens of *klauberi* have been examined from Mexico—six from Chihuahua, seven from Durango, one from Jalisco, one from Nayarit, and five from Zacatecas. Variations from these fit well into the range of variations as established by Klauber (1956). In a few specimens there are variations worthy of note, such as the light color and color pattern of two specimens from 4 miles (6 km) N of La Campana (MSU 2831) and 3 miles (5 km) E of Conjos (MSU 3613), Durango. In both, the dorsal bars are faint or obsolete anteriorly and the ground color is a light cream or grey. We conclude that these specimens are western representatives of the *palmeri* population, which seemingly occurs in the desert basin between eastern Durango and east central Coahuila near the type locality of Monclova as established by Garman (1887). Specimens from central Chihuahua do not show this faded color indicating that the *palmeri* phase occurs only in the central desert region

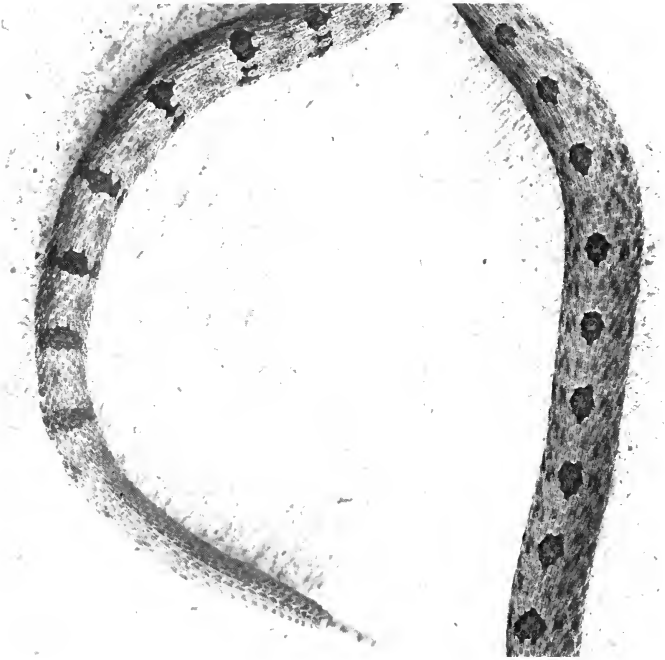

Fig. 2. Dorsal view of type specimen showing the dorsal spots at mid-body (left) and posterior of body and tail (right).

of these Mexican states. There are no unusual variations in the scale patterns of these specimens.

Taylor (1944) in an attempt to understand variations in this species applied the name *semicornutus* to a population of *lepidus* occuring in southwestern Chihuahua. We have seen additional specimens of this population and recognize it as a variant of *klauberi* but with the distinct possibility of having retained some of the *lepidus* characteristics such as a greater diffusion of spotting between the bars and with the accompanying reduction of the greenish ground color so evident in most *klauberi*.

A specimen (BYU 14244) taken 1.5 km W of Cerocouhui, Chihuahua, has the greenish color above and a shade of pink laterally which becomes more intense on the first two rows of dorsals and the tips of the ventrals. This pinkish color also occurred on the supraoculars and across the canthals to the rostral. The supraoculars are raised and extended giving them a very noticeable hornlike appearance and producing a concavity to the dorsum of the head. Both the color pattern and shape of the head plates were described by Klauber (1956) for populations of *klauberi* in southern Arizona. The influence of the Arizona populations apparently extends southward along the western slope of the Sierra Madre Occidental, but we have found no evidence of this influence occurring in *klauberi* on the eastern slope in Chihuahua and northern Durango.

We have seen no specimens between west central Chihuahua and west central Durango, a distance of approximately 350 km. In this area of the western slope, the ruggedness of the area does not change; however, there is a warming and an increase in precipitation from north to south. It is not surprising, therefore, for populations on the Pacific slopes of these mountains in western Durango, eastern Sinaloa, and northern Nayarit to show noticeable variations when compared to *lepidus* found on the drier eastern slope.

A summary of the comparative variations is listed in Tables 1 and 2.

Klauber (1956) recognized the variations in three specimens of *C. lepidus* taken near the Sinaloa-Durango-Nayarit border but was not able to differentiate them from other subspecies. We have seen one of these three specimens (SDSNH 45145) taken approximately 70 miles (112 km) W of El Salto by Darling. Although this specimen was collected in the area of *maculosus*, it is one of a few we have seen in which the anterior subocular does not contact a supralabial and has laterally extending dorsal spots. In other characters, it shows an increase in dorsal spots—28, the dark color on the venter and between the dorsal spots, and an increase in caudals.

A specimen from Santa Teresa, Nayarit (USNM 46333) also has many intergrading characteristics. There are only 21 body spots which form short bars and the ventrals (159) and caudals (21) are low. The color is dark, quite in contrast to *klauberi* and the fringe scales are reduced to 10 around a small rattle (5.5x2.5). Two specimens from near Coyotes, Durango, show indications of intergradation with *maculosus*. Their location near the continental

TABLE 1. Variations in the scale counts and numbers of body blotches in the subspecies of *Crotalus lepidus*.

Subspecies	Dorsal Scale Rows	Fringe Scales	Body Blotches	Ventral Scutes Males	Ventral Scutes Females	Subcaudal Scutes Males	Subcaudal Scutes Females
lepidus[1]	21-25 (23)		13-24 (18.6)	150-168 (161.7)	149-168 (161.1)	21-29 (24.6)	17-23 (19.6)
klauberi[1]	21-25 (23)	10-13 (11.4)	13-21 (17.3)	152-172 (161.7)	155-170 (162.1)	20-29 (24.6)	16-24 (19.9)
			14-21 (16.8)[2]	160-170 (163.6)[2]	157-161 (159.3)[2]	24-27 (25.3)[2]	19-22 (20.5)[2]
morulus[1]	23-25 (23)		24-34 (29.2)	156-167 (159.9)	160-171 (163.8)	25-30 (28.1)	20-25 (22.1)
maculosus	23-25 (23)	8-12 (9.9)	♂ 26-38 (31.5) ♀ 23-36 (30.7)	159-169 (163.7)	157-173 (165.3)	26-33 (29.6)	20-25 (22.5)

[1] Data taken from Klauber's report, 1956.
[2] Data from specimens not seen by Klauber (Chihuahua and Durango, Mexico).

TABLE 2. Dimension and Pattern Variables in *lepidus* subspecies.

Subspecies	% tail to T.L. Male	% tail to T.L. Female	% of 1st Rattle to T.L.	Size of Adults	Occipital Spots Paired	Occipital Spots Joined	Ventral Pattern Dark	Ventral Pattern Light
1. *lepidus*[1]	8.6	7.1		440-770	X		X	
1. *klauberi*[1]	8.1	6.6	.014-.016 (.0145)[2]	400-828		X		X
1. *morulus*[1]	9.0	7.2		400-720	X		X	
1. *maculosus*	9.4	7.4	0.0092-.0120 (.0103)	400-591	X		X	

[1] Some data taken from Klauber (1956).
[2] Based on 10 specimens from Chihuahua, Durango, and Zacatecas.

divide east of El Salto is in the proximity of a probable area for intergradation. In these specimens, as in USNM 46333, the spots are large and fewer as in *klauberi*, although they do not involve as many lateral rows as in most *klauberi*. A suffusion of pigment between the dorsal spots and on the ventrals also reflects the approach to *maculosus*.

We concur with Klauber (1956) that this population appears to be more closely related to the more eastern subspecies than to the western subspecies *klauberi*. We recognize the subspecies *lepidus* as the most primitive group in the species and suspect that its earlier distribution extended south to include not only areas now occupied by *lepidus* but also areas in Zacatecas and adjacent Durango, Sinaloa, and Nayarit, which are now occupied by *klauberi*.

Present distributions indicate that *klauberi* has recently expanded its range by moving southward along the eastern slopes of the Sierra Madre Occidental. In so doing, it is possible that the range of *lepidus* was not only invaded but actually divided, leaving a small population on the western flank of the mountains. From this isolated population the new subspecies *maculosus* has been derived, perhaps in much the same way as *morulus* on the eastern edge of *lepidus*.

We consider *klauberi* to be of a more recent origin than *lepidus*. If this is not the case, then we must assume that *lepidus* moved south and then west at a much earlier date than *klauberi*. At any rate, we believe that it would be very difficult to understand the relationships of *maculosus* in its present distribution if *lepidus* did not precede *klauberi* in its distribution to the south and then have the more vigorous *klauberi* proceed to replace it, at the same time dividing its range, leaving a small pocket isolated on the Pacific slopes. Specimens seen from southern Chihuahua, central Durango, and Zacatecas show no indication that they have been strongly influenced by a *lepidus* gene flow and suggest that the southward thrust of *klauberi*

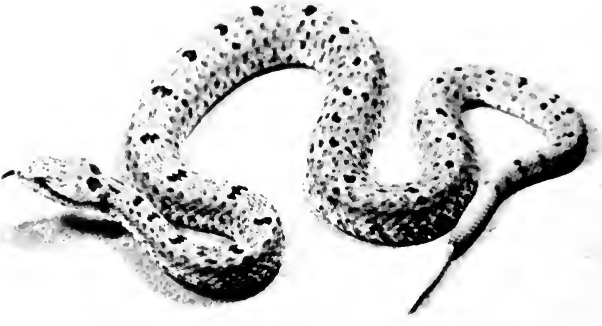

Fig. 3. A dorsolateral view of BYU 40188 (paratype) taken 1 km W Los Bancos, Durango, Mexico, by Mr. and Mrs. Thomas Walker, Sr., 28 Aug. 1968.

quite thoroughly replaced any previous *lepidus stock*. Only in the edges of the distribution do we find noticeable variations suggesting hybridization with other populations. It should also be noted that any intergradation occurring is toward the southern limits of distribution and therefore fits well our suggestion that the distribution of *lepidus* has in reality been divided by *klauberi*, thus isolating the population on the Pacific slopes and producing a biotic situation which permitted the adaptive development of *maculosus*.

At present the subspecies *maculosus* is confined to a rather narrow area extending along the high mountain slopes west of the continental divide in Durango-Sinaloa-Nayarit and perhaps as far south as adjacent northern Jalisco. Its habitat is one of rocky slopes high in the mountains and perhaps descending to the moderately low foothills of the Pacific slopes. Such a habitat is located in an area of greater rainfall than generally occurs in the areas occupied by the subspecies *lepidus* and *klauberi*. We suggest that such climatic conditions have contributed to the darker ground color in *maculosus* and perhaps also in *morulus*.

Materials

Crotalus l. klauberi, BYU 13416, 2 miles W Colonia Juarez, BYU 14247, 15281-2, 5.5 miles NE Colonia Juarez, BYU 14244, 2 miles E Cerocouhui, BYU 16866, 25 miles SE Creel, Chihuahua; FMNH 1494 and HSH 71-261, Coyotes, USNM 46349, Guanacevi, HSH 71-231, 70-90 miles SW Torreon (Hwy 40), Durango; USNM 46472, Bolanos, Jalisco; USNM 46333, Santa Teresa, Nayarit; USNM 46354, Berriozabal, USNM 46470-1, Plateado, HSH 71-25 (alive) and HSH R-784 Southern Zacatecas, Zacatecas, Mexico.

Acknowledgments

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History Society of Maryland (HSH), and Texas A and M University (TCWC) for their continued courtesies. We also appreciate the data provided by Dr. Robert S. Simmons.

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TWO NEW SUBSPECIES OF *CROTAPHYTUS* (SAURIA: IGUANIDAE)

Nathan M. Smith[1] and Wilmer W. Tanner[1]

Abstract.— Analysis of the *Crotaphytus collaris* complex reveals at least eight subspecies in two distinct groupings. The *collaris*-complex containing *C. c. auriceps*, *C. c. baileyi*, *C. c. fuscus*, and *C. c. collaris* lies essentially to the east of the Colorado River. The greatest portion of the western-complex containing *C. c. bicinctores*, *C. i. vestigium*, *C. c. dickersonae* and *C. i. insularis* lies to the west of the Colorado River except through western Arizona and northern Mexico. Two previously undescribed subspecies, *C. c. bicinctores* and *C. i. vestigium*, are described and named.

This paper presents a brief portion of an extensive study of the western collared lizards from the Great Basin and the Baja California Peninsula. The complete report will soon appear in the Biological Series of the Brigham Young University Science Bulletin.

The range of the western collared lizard, *Crotaphytus collaris baileyi*, includes a vast area of the western United States and Mexico. One of us (Tanner, in Fitch and Tanner, 1951; Ingram and Tanner, 1971) has suspected for a number of years that the lizards occurring in this vast area represent a heterogenous population. Stejneger (1890) described *Crotaphytus baileyi* as a species; however, as data became available it was recognized to be a western subspecies of *Crotaphytus collaris* Say (1823), the form found east of the Continental Divide. Two insular forms, *Crotaphytus dickersonae* Schmidt (1922) from Tiburon Island, and *Crotaphytus insularis* Van Denburgh and Slevin (1921) from Angel de la Guardia Island, Mexico, although given species rank, have long been recognized as closely related to *C. c. baileyi*. Allen (1933) referred to the collared lizards from Tiburon Island as *C. c. dickersonae*. Burt (1928) considered all collared lizards to be closely related.

Fitch and Tanner (1951) established *C. c. auriceps* from the upper Colorado River Basin. Ingram and Tanner (1971) reaffirmed *C. c. auriceps* as a subspecies and, upon redefinition of the characteristics of *C. c. baileyi*, established *C. c. fuscus* as a subspecies found in the Chihuahuan Desert south of the range of *baileyi*. The type locality for that subspecies being 6.5 miles N and 1.5 miles W of Chihuahua City, Chihuahua, Mexico. The techniques described by Ingram and Tanner (1971) were used to compare four subspecies of the western-complex with four subspecies of the *collaris*-complex. This technique permitted both an intercomplex and an intracomplex comparison.

Relationships

To determine relationships, Ward's Minimum Variance Cluster Analysis (Wishart, 1968) was used to group lizards in clusters of highest morphological similarity. Lizards were chosen to represent

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the range of the geographic locations available, and 150 lizards were used as input. A random sample was taken from each area and included: Great Basin (N=20); Baja California Peninsula (N=20); Angel de la Guardia Island (N=17); Tiburon Island (N=13); Upper Colorado River Basin (N=20); Central Arizona (N=20); Chihuahuan Desert (N=20); and the Great Plains (N=20). A contingency table was prepared comparing these groupings with the eight groupings formed by the cluster analysis (Table 1). The null hypothesis (the two classifications, one by closest morphological resemblance and the other by geographical location, are completely independent of each other) was tested by a chi-square of 49 degrees of freedom. The test is significant at the 0.001 level.

$$X^2(1-\alpha,49) = \sum_{i=1}^{m} \sum_{j=1}^{n} (O_{ij}-E_{ij})^2/E_{ij}$$

$$X^2(1-\alpha,49) = 485.7$$

$$X^2(0.999,49) = 85.4$$

Therefore $X^2(1-\alpha,49) \geq X^2(0.999,49)$ and the null hypothesis is rejected, and the morphological relationships of the lizards examined form essentially the same groups as those proposed in Table 1.[2]

TABLE 1. A contingency table testing the independence of Ward's clustering method and the proposed groups as follows: A = Great Basin, B = Baja Calif., C = Angel Is., D = Tiburon Is., E = Upper Colo., F = Central Ariz., G = Chih. Desert, H = Great Plains.

	PROPOSED GROUPS							
	Western-Complex				*Collaris*-Complex			
Clusters	A	B	C	D	E*	F	G	H
1	4	6	0	6	0	0	0	0
2	0	12	0	7	0	0	0	0
3	16	0	0	0	0	0	0	0
4	0	2	17	0	0	0	0	0
5	0	0	0	0	9	9	2	4
6	0	0	0	0	9	5	4	4
7	0	0	0	0	2	2	12	0
8	0	0	0	0	1	3	3	11

*The data for the Upper Colorado Rive rBasin and central Arizona does not contain the key characters which distinguish *C. c. auriceps* and *C. c. Baileyi.*

It is noted that none of the western-complex clustered with those of the *collaris*-complex; however *C. dickersonae* which had been given species rank was not as distinctly clustered. This lends additional support to the suggestion (Burt, 1928; Allen, 1933) for revision of this group. We propose that it is a subspecies of *C. collaris* and should be called *Crotaphytus collaris dickersonae*. We have collected on Tiburon Island and also on the Sonoran Coast opposite the island and have found specimens from these two areas to be indis-

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[2] We have done little with the populations occurring on the Great Plains. Our data does, however, suggest that a careful study may reveal additional collared lizard populations worthy of subspecific recognition. We have deferred the study of these populations to R. Montanucci.

tinguishable. Schmidt (1922:639) stated this possibility when he said of *C. dickersonae* "it is possible that this species will be found to extend on the Mexican mainland and that it will ultimately be referred to a subspecific rank under *C. collaris*. . . ."

The other insular form, *C. insularis*, remains a very distinct population closely related to the collared lizards occurring on the Baja California Peninsula. These two populations are very similar in pattern and external morphology. The Angel Island form has the second collar much reduced or absent, and with 39-45 subdigital lamellae on the fourth toe. Individuals on the Baja California Peninsula extend their range north to Palm Springs, California, and form a narrow zone of sympatry with the Great Basin subspecies at the most northern part of their range. Because of these morphological and biological relationships, the population from Angel Island is designated *Crotaphytus insularis insularis* and those from Baja California as *Crotaphytus insularis vestigium*.

There are several characters which distinguish the western-complex from the *collaris*-complex. In the western-complex, the second collar does not extend onto the arm, there is a prominent black groin patch in the males, spots are absent in the dorsum of the first collar, and there are more scales between the interparietal and the anterior edge of the first collar. Diagnostic characters within the western-complex are discussed in the diagnoses of the new subspecies.

Crotaphytus collaris bicinctores, subsp. nov.

HOLOTYPE.— Adult male Brigham Young University no. 23883, collected at Mercury Pass, Nevada Test Site, Nye Co., Nevada, 14 June 1966, by W. W. Tanner.

PARATYPES.— BYU nos. 22191, 23629-30, 30587 (all topotypes) from the Nevada Test Site, Nye Co., Nevada; BYU 12715, Western Beaver Co., Utah; BYU 12696, 12701, N Wash, W side Colorado River, Garfield Co., Utah; BYU 18921, Crossing of the Fathers, Kane Co., Utah; BYU 21000-02, Black Rock Mountain, Millard Co., Utah; BYU 32097, 52 miles N Yuma, route 95, Yuma Co., Arizona; CAS 37055, Caliente, Lincoln Co., Nevada; CAS 22705, Dayton, Lyon Co., Nevada; LACM 63187, Big Rock Creek at Dorr Creek, Los Angeles Co., Calif.; LACM 63182, Sweetwater Spring, Ord Mts., San Bernardino Co., Calif.; SDSNH, 1444, Hot Springs, Owyhee Co., Idaho; CSCLB 2736, 4 miles N Yermo, San Bernardino Co., Calif.; CSCLB 2735, Mule Canyon, Calico Mts., San Bernardino Co., Calif.

DESCRIPTION OF TYPE.— Snout-vent length 95 mm, tail length 177 mm, width of head at angle of jaw 20.5 mm, hindleg length from midline to tip of fourth toe 88 mm, femoral pores 17-19, supralabials 16-15, infralabials 14-15, fused interorbitals 0, frontoparietals 3, loreal-lorilabial series 9, postmentals not in contact with infralabials, gular scale rows from angle to angle of jaw 61, scales from rostral to interparietal 16, scales from interparietal to anterior edge of first collar 32, scales from anterior edge of first collar to posterior edge of second collar 32, total dorsals 161, total ventrals 195, scales within dorsal separation of first collar 1, scales within dorsal separation of second collar 0, number of spots within dorsal separation of first collar 0, subdigital lamellae of second toe of right hind foot 19, subdigital lamellae of fourth toe 39, subdigital lamellae of fifth toe 18 (Fig. 1 and 2).

Type a preserved specimen in which coloration closely resembles living organisms. Reticulation of the chin and parietal area resembles freckles with this pattern extending to posterior dorsum of

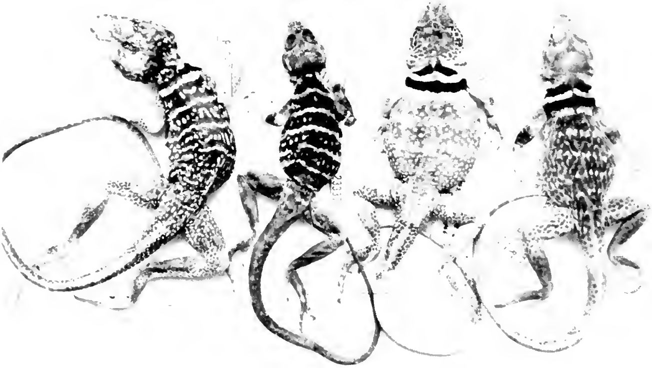

Fig. 1. A dorsal view from left to right of *Crotaphytus insularis vestigium*, male BYU 23338, female BYU 23337 and *Crotaphytus collaris bicinctores*, male BYU 23883, female BYU 23629.

Fig. 2. A ventral view from left to right of *Crotaphytus collaris bicinctores*, female BYU 23629, male BYU 23883 and *Crotaphytus insularis vestigium*, female BYU 23337, male BYU 23338.

head. Body dorsum light brown, never green, venter cream with black patches in groin and axillary regions. First collar nearly complete dorsally and merging ventrally with black of gular area. Second collar complete dorsally, not extending onto upper arm. Dorsal body pattern rather uniformly dotted with light spots and with two diffuse cross bands. Forelegs, hindlegs, and tail brown, reticulated with white. Dorsum of tail ridged and tail compressed laterally.

DIAGNOSIS.— The Great Basin population differs from *C. c. baileyi* of the *collaris*-complex in many of the 32 characters measured and particularly in the following which are listed with their coefficient of difference (Mayr, 1969): dorsal separation of the first collar (1.63); number of spots in dorsum of first collar (1.45); number of enlarged median internasals (1.39); and brown dorsal ground color (1.33). Other characters include second collar not extending onto the arm, greater number of scales from interparietal eye to anterior edge of first collar, and more extensive black coloration of the ventral groin.

The Great Basin form can be distinguished from the Baja California and Angel de la Guardia Island populations by a more complete first (1.4) and second (1.84) collar dorsally. It is distinguished from *C. c. dickersonae* by its dorsal brown coloration, back pattern, and several other characters which considered alone are not significant but that give good population separation when computed together in the clustering program (Table 1).

RANGE.— Extends throughout the Great Basin region. Apparently does not occur east of the Colorado River in Utah, but does cross the Green River and may intergrade with *C. c. auriceps* in this region. The Colorado River continues as a barrier south to Oatman, Mohave Co., Arizona, where we have captured the Great Basin subspecies. Twenty miles to the east in Kingman, Arizona, *C. c. baileyi* is found. This is an area of possible intergradation that needs further investigation. The Great Basin form continues on the east side of the Colorado River down to Yuma Co., Arizona. The area of intergradation with *C. c. fuscus* and *C. c. dickersonae* is incompletely known. In southern California, it extends to the San Gorgonio Wild Area and the Whitewater River Canyon northwest of Palm Springs, Riverside Co., and apparently crosses the the narrow sandy valley of the San Gorgonio Pass to reach the eastern foothills of the San Jacinto Mountains where *C. i. vestigium* is found (Fig. 3).

Crotaphytus insularis vestigium, subsp. nov.

HOLOTYPE.— Adult male, Brigham Young University no. 23338, collected in Guadelupe Canyon, Juarez Mountains, Baja California, 15 July 1965, by James W. Heinrichs.

PARATYPES.— BYU nos. 23337, 23339, 22298-99 (all topotypes) Guadalupe Canyon, Juarez Mts., Baja Calif.; BYU 33321, Mt. Springs, Imperial Co., Calif.; BYU 2422, 2432, 2435, Chino Canyon, Palm Springs, Riverside Co., Calif.; BYU 2429-30, Snow Canyon, Palm Springs, Riverside Co., Calif.; SDSNH 1687, 11951, Palm Can-

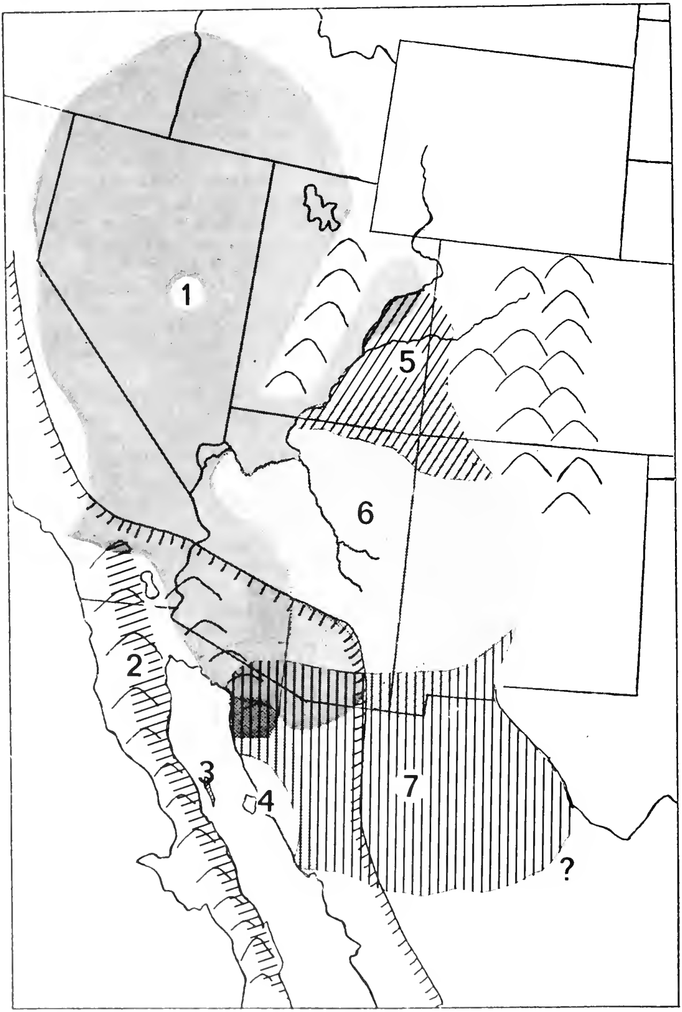

Fig. 3. Geographical distribution of the western subspecies of *Crotaphytus collaris*: 1, *C. c. bicinctores*; 2, *C. i. vestigium*; 3, *C. i. insularis*; 4, *C. c. dickersonae*; 5, *C. c. auriceps*; 6, *C. c. baileyi*; and 7, *C. c. fuscus*.

yon, San Diego Co., Calif.; SDSNH 11088, Pinon Mt., San Diego Co., Calif.; SDSNH 22327, Sentenac Canyon, San Diego Co., Calif.; LACM 16997-98, Los Angeles Bay, Baja Calif.; CAS-SU 17048, Sierra San Pedro Martir, Baja Calif.; CAS-SU 18822, 9 miles W San Ignacio, Baja Calif.; CSCLB LWR670619-1 and 670619-2, 11 miles W Santa Rosalia; CUM 45855-6 and 45858, 14.8 miles S Puerto Citos; CUM 45857, Okies Landing; and CUM 45859-61, S end San Luis Gonzalga, N Puerta Final, Baja California.

Description of Type.— Snout-vent length 111 mm, tail length 252 mm, width of head at angle of jaw 23.8 mm, hindleg length from midline to tip of fourth toe 102 mm, femoral pores 18-21, supralabials 15-16, infralabials 16-15, fused interorbitals 0, frontoparietals 3, loreal-lorilabial series 10, postmentals in contact with infralabials, gular scale rows from angle to angle of jaw 67, scales from rostral to interparietal 16, scales from interparietal to anterior edge of first collar 40, second collar absent, total dorsals 180, total ventrals 205, scales within dorsal separation of first collar 17, number of spots within dorsal separation of first collar 0, subdigital lamellae of second toe of right hind foot 20, subdigital lamellae of fourth toe 40, subdigital lamellae of fifth toe 23.

The type is described from a museum specimen in which the coloration compares favorably with live specimens seen from the foothills NW of Palm Springs. Reticulation of head present as in *C. c. bicinctores* but with larger freckles; body dorsum brown with large oblong spots and three nearly complete light colored cross bars. First collar widely separated dorsally and merging ventrally with black of gular area. Second collar absent. Forelegs light, spotted with brown hindlegs and tail brown, spotted with white. Dorsum of tail ridged and compressed laterally.

Diagnosis.— Similar to *C. c. bicinctores* in many respects but with greater dorsal separation of the first and second collars, with distinct dorsal light cross bars, and a smaller second collar length/snout-vent length index. The Baja subspecies can be distinguished from *C. i. insularis* Van Denburgh and Slevin (1922) to which it is most similar, by fewer toe lamellae on the second and fourth toe, larger second collar/s-v index, and a smaller dorsal separation of both the first and second collars.

Range.— East side of the mountains from central Baja California, north to Palm Springs, Riverside Co., California. It does not occur on the western Pacific slopes in California, and apparently does not intergrade with *C. c. bicinctores*, although these papulations are in close proximity in the Palm Springs area.

Specimens Examined

A total of 150 specimens from eight populations were used to make comparisons. Twenty from each population except *C. i. insularis* and *C. c. dickersonae*, where only 17 and 13 were available respectively for the computer analysis.

C. c. bicinctores

California: Kern Co., BYU 31948; Riverside Co., BYU 32099.

Idaho: Butte Co., BYU 30772; Owyhee Co., BYU 2834.

Nevada: Clark Co., BYU 461; Nye Co., BYU 18815, 22194, 23882, 30088.

Utah: Emery Co., BYU 20090; Millard Co., BYU 8755, 8883, 21000, 21703; Tooele Co., BYU 14818, 14820-21; Utah Co., BYU 1455, 13041; Washington Co., BYU 12875.

C. c. dickersonae

Tiburon Island: CAS 14005-06, 14008-12, 53263-64; SDSNH 46003-06.

C. i. insularis

Angel de la Guardia Island: CAS 21948, 50874-76, 50878-79, 86754-55, 86783-84; CAS-SU 22712; LACM 4001-02, 9854; SDSNH 46001.

C. i. vestigium

Baja California: Canyon Guadalupe, Juarez Mtns., BYU 23337-39, and BYU 22298-99; North of Canipole, SDSNH 30109-111; Coyete, SDSNH 52999; Baja Sur, SDSNH 30107; Los Angeles Bay, SDSNH 19789-90, 41612, 52950; Las Palmitos, SDSNH 17052; North Gonzaga Bay, SDSNH 19791-92; Sierra San Pedro, CAS-SU 17048; Santa Rosalia, CSCLB LWR670619-1 and 670619-2.

C. c. baileyi

Arizona: Apache Co., BYU 497; LACM 16895; UIMNH 7524; USNM 29184. Coconino Co., BYU 506, 11388; UIMNH 6543, 35945; USNM 15821. Graham Co., UIMNH 24507; USNM 5153, 51737. Mohave Co., BYU 32116; UIMNH 74778, 74781. Navajo Co., BYU 13574. Pima Co., LACM 3983; SDSNH 15214. Yavapai Co., BYU 33322; UIMNH 5900.

C. c. auriceps

Colorado: Mesa Co., BYU 11342. San Miguel Co., CUM 1333, 4448, 4450, 4451, 4453.

Utah: Grand Co., BYU 1625, 10338, 12854. San Juan Co., BYU 1461, 1464, 12619, 13006-08, 16484, 21706, 32088; UU 1461, 2427.

C. c. fuscus

Mexico: Chihuahua, BYU 13383-86, 13410, 14211; KU 3378, 33789; UC 70704; USNM 14242.

New Mexico: Dona Ana Co., LACM 3971; USNM 22268. Luna Co., BYU 31940; USNM 44955, 80072. Sierra Co., LACM 3981.

Texas: El Paso Co., USNM 59351, 59352; UTEP 52; UU 493.

C. c. collaris

COLORADO: Los Animas Co., CUM 1292, 2939.

KANSAS: Montgomery Co., BYU 22167. Wilson Co., KU 41, 45, 46, 48, 54.

NEW MEXICO: Chaves Co., LACM 3974, 3975. Lincoln Co., LACM 16990. Quay Co., USNM 44940.

OKLAHOMA: Carter Co., BYU 500, 1574.

TEXAS: Garza Co., CUM 32277. Randall Co., CUM 13554-56. Roberts Co., USNM 32866. Stephens Co., BYU 13177.

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A NEW SPECIES OF *STENAMMA* (HYMENOPTERA: FORMICIDAE) FROM UTAH

Robert E. Gregg[1]

Abstract.— *Stenamma knowltoni* is described as a new species from various localities in northern Utah and southern Idaho. The new species falls clearly into the large-eyed group of M. R. Smith's monograph of *Stenamma*.

Recently a number of excellent collections of ants from Utah were received, and I am indebted to Dr. George F. Knowlton for these specimens. Among the numerous vials are examples of a new species of *Stenamma* which is herewith described.

Stenamma knowltoni, sp. nov.

Worker.— Length, 3.36 mm; head length (excluding mandibles), 0.86 mm; head width, 0.76 mm; head index, 0.884; thorax length, 1.056 mm.

Head distinctly longer than broad, subrectangular in shape; occipital border flat, occipital corners definite but rounded, sides of head straight and parallel; median lobe of clypeus elevated and produced forward, anterior border denticulate, and lateral lobes receding diagonally to mandibular insertions; frontal area depressed, triangular; frontal carinae parallel in front, slightly divergent behind, and lobes partially covering antennal insertions. Antennae 12-segmented, funicular segments 2-6 very slightly broader than long, last four segments forming a club whose terminal segment almost equals in length two preceding it; scapes fail to reach occipital corners by an amount less than length of funicular segment 1. Eyes very large for a *Stenamma*, with about 12 facets across greatest diameter, approximately 70 facets in entire eye; eyes placed a little anterior to middle of head from occiput to mandibles, and measuring 0.165 mm in diameter. Mandibles bear seven teeth gradually reduced in size from apex to basal border.

Thorax moderate in width, humeral angles rounded, dorsal surface in profile gently convex, and meso-epinotal impression distinct but shallow. Epinotal base coordinate with plane of promesonotum, but sloping downward and backward to spines. Epinotal spines short (0.033 mm and half as long as their interbasal distance), triangular sharp, and pointing abruptly upward. Epinotal declivity vertical. Petiolar node rounded, subconical, wider than long from above, peduncle long, slender and constricted; in profile anterior face of node sloping but distinct from peduncle; ventral surface of petiole straight and furnished with a minute spine at anterior end. Postpetiole globular from above, as wide as long; in profile convex above, flat below. Gaster of usual myrmicine shape, first segment occupying most of this tagma.

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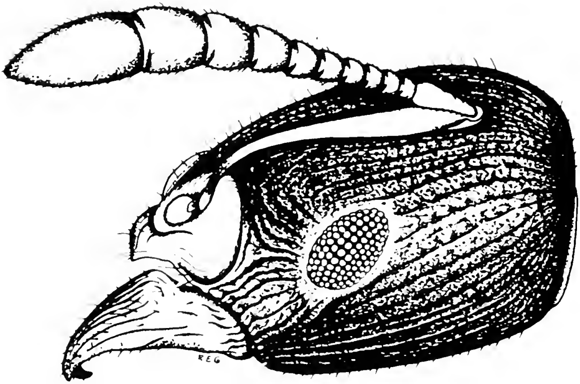

Fig. 1. Head of *Stenamma knowltoni* Gregg.

Sculpture: Head covered with longitudinal rugae, becoming vaguely reticulate on posterior portion; interspaces rather coarsely punctate, general appearance opaque to subopaque, or at most only slightly shining. Clypeus with multiple carinulae. Mandibles finely rugulate or striate, with widely spaced punctures, and shining. Dorsum of thorax longitudinally rugose, rugae widely spaced, but with a few transverse rugae at anterior end. Pronotal collar punctate. Pronotum lightly punctate, mesonotum heavily punctate between rugae. Epinotal base punctate, declivity smooth and shining. Propleurae almost devoid of rugae, smooth and shining; mesopleurae coarsely punctate especially in lower half, opaque; epinotal pleurae rugose and coarsely punctate. Petiole and postpetiole more finely punctured dorsally and laterally, postpetiole having in addition coarse longitudinal rugae on its dorsolateral aspect. Gaster smooth and shining (faint shagreening), and with extremely short but distinct basal striae. Whole insect opaque to subopaque, except gaster, epinotal declivity smooth and shining, and pronotal dorsum and extreme occipital border quite shining despite their sculpturing.

Pilosity: Delicate, rather long, pointed yellowish hairs on all parts of body including appendages. Hairs uneven in length, shorter and numerous on head, longer and sparser on thorax, pedicel, and gaster.

Color: Head and gaster dark brown, thorax and pedicel slightly lighter and with reddish tinge. Legs, antennae, mandibles, clypeus, and pronotal collar light reddish brown.

FEMALE (deälate).— Length, 4.4 mm; head length (excluding mandibles), 0.92 mm; head width, 0.79 mm; head index, 0.857; thorax length, 1.32 mm.

Similar to the worker in most respects except size and proportions of thorax. Eye very large, 16 to 17 facets in greatest diameter, and with a total of 135 to 140 facets. Ocelli distinct, not protuberant. Scape fails to reach occipital border by an amount less than length of funicular joint 1, and is similar in other respects to that of worker.

Sculpture like that of worker in most details, but differing in that promesonotum has more widely spaced rugae with fewer punctures and therefore a more shining surface; propleurae rugose but interspaces shining and without punctures; mesopleurae rugose dorsally, almost sculptureless and shining ventrally; epinotal pleurae with strong wavy rugae, few punctures, and shining. Base and declivity of epinotum without sculpture and strongly shining. Petiolar and postpetiolar nodes rugose. Epinotal spines longer, proportionately more slender than in worker, and blunt at tips. Fore coxae rugose. Color and pilosity very similar to that of worker.

Discussion.— A single alate female among the material sent to me was compared to figures of the wing venation given by Smith (1957) on page 137. The venation of the anterior wing of this specimen fits precisely that shown for Figure 2, a female of *brevicorne*, and thus belongs to the "*brevicorne* type," as designated by Smith, for it possesses one submarginal cell only in addition to the discoidal, and this condition is produced by the disappearance of vein r-m. Mf3 and Mf4 are retained. The pattern of venation is thus consistent with other characters which cause the new species (*knowltoni*) to key out to the couplet separating *brevicorne* and *meridionale*.

When Dr. Smith monographed the genus *Stenamma* he distinguished and described eleven species, and among these described three as new. These ants are small, slow moving, soil and litter species, secretive in habits, and generally not easily noticed in their normal habitats. The total number of forms known is small (less than 30 for the world according to Smith) and mostly Holarctic in their general distribution. No new species in the United States fauna have been discovered since Smith wrote, but the recent specimens from Utah prove to be a heretofore unknown form and quite distinct from any of those recognized previously. Smith went to some pains to divide the group into species with small eyes and those with large eyes, but this is only partially satisfactory; for, while it is convenient, there is enough gradation in eye-size from the smallest to the largest that no sharp break occurs among the forms on this basis alone. Nevertheless, it is a useful procedure, and anyone wishing to identify these ants must consider this character. In Smith's key the new species comes out on the "large eye" couplet (5 - 12 ommatidia), and then runs to the alternate separating *brevicorne* from *meridionale*. All of the very small-eyed species are therefore easily eliminated, but of the remainder several require that careful distinction be made. To judge from the characters given, *knowltoni* might be confused with *huachucanum* because of a somewhat bicolored appearance, but can be separated on the basis of its sculpture which is longitudinally rugose rather than punctulate, the epinotal spines which are not tuberculate or vestigial as in *huachucanum*, the petiolar node which is not unusually high, and the presence of basal gastric rugulae or striae. *S. carolinense* has one of the largest eyes of any of the species (10 - 12 facets in greatest diameter), but it also has transverse pronotal and mesonotal rugae, a more pronounced meso-epinotal impression, and extremely blunt tuberculate spines, all of which traits differ from *knowltoni*. *S. brevicorne* has a large eye but only 8 to 10 facets across its greatest diameter. Further, it has a strong meso-epinotal impression, and the epinotum is furnished with a distinct transverse welt immediately behind the impression. The epinotal spines are relatively long and sharp. The whole aspect of the insect is subopaque with coarse longitudinal rugulae on the dorsum of the promesonotum, and the color of the body is reddish brown with the gaster light at the base. *S. meridionale*, also among the larger-eyed species, has, again, only 8 to 10 ommatidia in the greatest diameter. The meso-epinotal impression is pronounced, but an epinotal welt is lacking. Epinotal spines are large, digitiform (Smith), and sharp. The petiolar node is antero-posteriorly compressed and rather quadrate from above (not conical), and the postpetiole is subcampanulate (not oval).

HOLOTYPE.—Worker, in the author's collection. PARATYPES: four workers and one deälate female deposited in the author's collection. These four workers and one queen were collected in mossy sagebrush duff at Cedar Creek Junction, near Kelton Pass, Box Elder Co., Utah, on 16 April 1969, by George F. Knowlton. The species is dedicated to Dr. Knowlton who has generously given me many fine series of ants from various localities in Utah. Additional paratype material also collected by Knowlton is available as follows: one worker, sagebrush duff, Kelton Pass, Box Elder Co., Utah, 1 May 1969; six workers, rangeland, Cedar Creek, Box Elder Co., Utah, 1 April 1969; seven workers, dead grass, Kelton Pass, 5000 feet, Box Elder Co., Utah, 16 April 1969.

Specimens belonging to the new species but not part of the type material were found by Knowlton at the following stations: three workers, sagebrush duff in canyon, 6 miles east of Holbrook, Oneida Co., Idaho, 16 April 1969; four workers, juniper duff, desert, 10 miles southwest of Twin Springs, Elmore Co., Idaho, 1 November 1969 (#389); two workers, greasewood duff, southeast of Black Pine, Oneida Co., Idaho, 18 October 1969 (#354); two workers, sagebrush duff, Holbrook Summit, 6115 feet, Oneida Co., Idaho, 22 October 1969 (#359); one alate female, desert biome, Curlew Reservoir, Curlew National Grassland, Oneida Co., Idaho, 22 October 1969 (#367).

Specimens of *Stenamma knowltoni* have been deposited in the collections of W. S. Creighton and the United States National Museum.

Before undertaking the description of this new species, I submitted specimens to Dr. Creighton who was able to compare them with examples of all known North American species of *Stenamma* (including the little known *foveolocephalum*), except *carolinense*. I am indebted to him for confirming my supposition that *knowltoni* represents a new species. He also drew my attention to a curious situation in Smith's paper concerning eye-size in *Stenamma*, which could be a potential hazard to anyone not aware of it. I take the liberty to quote from his letter: "Cushman is a fine illustrator and his figures can be trusted implicitly, but this is not the case in the four outline drawings (5,6,7,8) on page 143 of Smith's monograph. I am ready to agree that these figures are not drawn to the same scale, *S. huachucanum* and *impar* are much smaller ants than *occidentale* and *schmitti*. But in Smith's descriptions you will find that in all four the maximum diameter of the eye is given as 0.10 mm. Furthermore, the number of ommatidia across the greatest diameter of the eye is closely similar for all four species; *huachucanum* 5-7, *impar* 5-6, *occidentale* 4-6, *schmitti* 4-6. In short, they are all small-eyed species. In my opinion the eyes of *schmitti* are shown as too small and those of *impar* and *huachucanum* as too large. On the basis of the figures, however, one would wonder why *impar* and *huachucanum* were not brought out on the key split with the large-eyed species. The only one of the four figures in which the eye-size is correctly shown is *occidentale*."

Despite the use of eye-size by Smith as a convenient method for grouping the species of *Stenamma*, it appears that he relied heavily upon thoracic sculpture in his revision. The extremely detailed and accurate rendering of this sculpture by Cushman greatly facilitates the separation of these species. I have indicated above how *knowltoni* differs from its most closely allied species, but it is well to emphasize here that its thoracic sculpture differs markedly from almost all the other forms of *Stenamma*. The dorsum of the thorax is longitudinally rugose for the most part, with a few transverse rugae anteriorly, and the only species with which it might be confused are *impar* and *brevicorne*. Of these two ants, however, the former has very small eyes and the latter has intermediate sized eyes as well as other differences.

Finally, although eye-size will continue to be a useful character in the taxonomy of *Stenamma*, it should be stressed that no clear-cut distinction is possible between a small-eyed and a large-eyed group of species. This can be demonstrated by expressing the eye-size for all species, as Smith has done, in terms of the number of facets in the greatest diameter, as follows: *heathi*, *sequoiarum*, *impar*, *diecki*, *schmitti*, and *occidentale* 4-6; *huachucanum* 5-7; *foveolocephalum* 7-8; *brevicorne* and *meridionale* 8-10; *carolinense* and *knowltoni* 10-12.

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NEW SYNONYMY IN THE BARK BEETLE TRIBE CRYPHALINI (COLEOPTERA: SCOLYTIDAE)[1]

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ABSTRACT.— A lectotype designated for *Bostrichus asperatus* Gyllenhal resulted in the clarification of the status of *Cryphalus* Erichson and the removal of *Trypophoeus* Fairmaire from synonymy. All species described by A. D. Hopkins in *Hypothenemus* Westwood and *Stephanoderes* Eichhoff were reviewed. New synonymy included: *Bostrichus asperatus* Gyllenhal (= *B. abietis* Ratzeburg); *H. birmanus* (Eichhoff) (= *H. maculicollis* Sharp, *S. perkinsi* Hopkins, *S. sterculiae* Hopkins, *S. psidii* Hopkins); *B. crudiae* (Panzer)(= *B. plumeriae* Nördlinger, *Cryphalus hispidulus* LeConte, *S. differens* Hopkins, *S. paraguayensis* Hopkins, *S. polyphagus* Costa Lima, *S. uniseriatus* Eggers, *S. hivaoea* Beeson, *S. lebronneci* Beeson); *H. californicus* Hopkins (= *H. tritici* Hopkins); *H. dipterocarpi* Hopkins (= *H. mangarivanus* Beeson); *H. erectus* LeConte (= *H. validus* Blandford, *S. puncticollis* Hopkins, *S. cubensis* Hopkins); *H. eruditus* Westwood (= *Cryphalus basjoo* Niisima, *Cosmoderes schwarzi* Hopkins, *H. bradfordi* Hopkins, *H. ferrugineus* Hopkins, *H. flavipes* Hopkins, *H. flavosquamosus* Hopkins, *H. heathi* Hopkins, *H. koebelei* Hopkins, *H. lineatifrons* Hopkins, *H. mali* Hopkins, *H. myristicae* Hopkins, *H. nigricollis* Hopkins, *H. parvus* Hopkins, *H. punctipennis* Hopkins, *H. sacchari* Hopkins, *H. tenuis* Hopkins, *H. webbi* Hopkins, *S. elongatus* Hopkins, *S. flavicollis* Hopkins, *S. pygmaeus* Hopkins, *S. subconcentralis* Hopkins, *S. unicolor* Hopkins, *H. intersetosus* Eggers, *S. erythrinae* Eggers, *H. dubiosus* Schedl).

On the following pages are presented (a) a lectotype designation for *Bostrichus asperatus* Gyllenhal, 1813, type-species of the genus *Cryphalus* Erichson, 1836, and the consequent effect of this act on the genera *Cryphalus* and *Trypophoeus* Fairmaire, 1868, and (b) a review of all species of bark beetles described by A. D. Hopkins in the genera *Hypothenemus* Westwood and *Stephanoderes* Eichhoff. Comments on the synonymy of *Ernoporus* Thomson are also included.

Cryphalus Erichson

Cryphalus Erichson (1836:61). Three species.

As originally proposed by Erichson (1836) the genus *Cryphalus* contained three species, *Apate tiliae* Panzer, *A. fagi* Fabricius, and *Bostrichus asperatus* Gyllenhal, as defined by references to Fabricius (1801:383) for the first two species and to Gyllenhal (1813:368) for the third species. Thomson (1859:46) designated *B. asperatus* as the type-species of the genus *Cryphalus* and transferred *A. tiliae* to his new genus *Ernoporus*. Thomson (1865:360) later transferred *A. fagi* to *Ernoporus*, thus leaving *B. asperatus* as the only original species remaining in *Cryphalus*. By definition the antennal funicle of *Cryphalus* contained four segments.

Ratzeburg (1839:199) named *Bostrichus* (*Cryphalus*) *abietis* and commented that until then this species had been known by his coworkers as *B. asperatus* Gyllenhal, presumably including Erichson.

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Based on syntypes in the Germar collection, now in the Zoologisches Museum, at Berlin, Ratzeburg (1839:198-199) redefined the true *B. asperatus* Gyllenhal and described several new species, one of which was *B.* (*Cryphalus*) *binodulus*.

On the basis of the 5-segmented antennal funicle, Fairmaire (1868:105) transferred *B. binodulus* Ratzeburg, 1839, to his new genus *Trypophoeus*. Later, Eichhoff (1878:139) placed *B. binodulus* as a junior subjective synonym of *B. asperatus* in the genus *Glyptoderus* Eichhoff, 1878, = *Trypophoeus* Fairmaire, 1868, even though *B. asperatus* was the type-species of *Cryphalus* Erichson, 1836. Eichhoff's usage continued until the error was pointed out by Wood (1954:988).

In an effort to clarify the nomenclatural confusion and to conserve the traditional usage of the name *Cryphalus*, an appeal to the International Commission on Zoological Nomenclature was prepared (Wood, 1967) requesting that *B. abietis* Ratzeburg, 1839, be designated the type-species of *Cryphalus* since Erichson's concept of *B. asperatus* apparently was based on erroneously identified specimens of *B. abietis*. When the appeal was considered by the Commission, a request was made that all type material be examined by me before any action be taken on this appeal. The following is a report on my examination of that material.

The Fabricius collection at the Universitetets Zoologiske Museum, at Copenhagen, contains several specimens of *A. tiliae* Panzer, all of which are of the species currently known as *Ernoporus tiliae* (Panzer); also present there is one damaged specimen labeled *A. fagi* Fabricius, although it actually is of *A. tiliae*, and almost certainly is not the type of the Fabricius species. The Germar collection at the Berlin Museum did not contain original specimens of *A. fagi* either.

Six syntypes of *B. asperatus* Gyllenhal and two of *B. asperatus* var. B of Gyllenhal were located; three syntypes and the two variants are at the University of Uppsala, in Gyllenhal's Insecta Suecia collection, and three syntypes are at the Berlin Museum in the Germar material. The latter three syntypes apparently are those used by Ratzeburg (1839:198-199) for his redescription of the species. All six syntypes and the first of the two variants are identical and represent the same species described as *B.* (*Cryphalus*) *abietis* Ratzeburg, 1839. The other variant of *B. asperatus* Gyllenhal is of *Trypophoeus spiculatus* Eggers, 1927. Therefore, *B. binodulus* Ratzeburg, 1839, and *Trypophoeus* Fairmaire, 1868, the genus for which it is the type-species, have no bearing whatever on the synonymy of *Cryphalus* Erichson, 1836, or on its type-species *B. asperatus* Gyllenhal, 1813. I here designate as the lectotype of *B. asperatus* Gyllenhal the first syntype in the above-mentioned Gyllenhal Insecta Suecia series at the University of Uppsala Museum.

Cryphalus asperatus (Gyllenhal)

Bostrichus asperatus Gyllenhal (1813:368). Lectotype, male; presumably from Sweden; Univ. Uppsala Mus., present designation, above.

Bostrichus (*Cryphalus*) *abietis* Ratzeburg (1839:198). Syntypes; presumably destroyed with the Hamburg Museum. *New synonymy.*

As indicated in the above discussion, the type series of *Bostrichus asperatus* Gyllenhal was incorrectly identified by Eichhoff (1878) and subsequent workers. These specimens are of the same species that has been known since 1839 as *abietis* Ratzeburg. Specimens of *abietis* at the U.S. National Museum and the British Museum (Natural History) compared to the types by Eggers, Eichhoff, and, presumably, Blandford were used as a basis for this species.

Ernoporus Thomson

Ernoporus Thomson (1859:147). Type-species: *Apate tiliae* Panzer, monobasic.

Schedl (1962:92-94), apparently using antennal characters exclusively, treated *Ptilopodius* Hopkins, 1915, *Stephanorhopalus* Hopkins, 1915, *Ernoporicus* Berger, 1917, *Allernoporus* Kurenzov, 1941, and *Eocryphalus* Kurenzov, 1941, as synonyms of *Ernoporus.* Authenticated specimens of the type-species of each of these genera are at hand or were recently studied by me, as well as all known species of *Ernoporus*, four additional species of *Ptilopodius* (sensu Hopkins), and two species erroneously placed in *Ptilopodius* by Schedl, except for *Eocryphalus* which is known to me only from the description. From this material it is apparent that *Ptilopodius* and *Stephanorhopalus* are completely unrelated to the other genera; the similarity of the antennae to other species mentioned here is superficial at best. (These genera will be treated in greater detail at a later date.) *Ernoporicus spessivtzevi* Berger, type-species of the monotypic genus *Ernoporicus*, is a typical *Ernoporus* except for the smaller antennal club and very obscure sutures on the club; I agree with Schedl in transferring it to *Ernoporus.* My specimen of *Allernoporus evonymi* Kurenzov is very closely allied to *Ernoporus*, but the antennal funicle is 3-segmented and the club is totally devoid of sutures; until more material is available for study I prefer to retain this species in *Allernoporus.*

Hypothenemus Westwood

Hypothenemus Westwood (1836:34). Type-species: *Hypothenemus eruditus* Westwood.

Hopkins (1915) described 106 species in the genera *Hypothenemus* Westwood, 1836, and *Stephanoderes* Eichhoff, 1871. Since then *Stephanoderes* has been placed in synonymy (Browne, 1963:53) under *Hypothenemus.* The species named by Hopkins in this taxon were based on unique females, and most of them have not been examined by specialists of the group since then. Recently it was my privilege to study holotypes of all of the Hopkins species named in these genera as well as to study the types of a few other species of special interest in a review of the Hopkins material. Several of the American species were previously placed in synonymy (Wood, 1954).

A review of all species named by Hopkins follows. Valid names are presented in alphabetical order with synonyms and my comments listed beneath them. Of the 106 species named by Hopkins 21 are considered valid and 85 are treated as synonyms.

Hypothenemus africanus (Hopkins)

Stephanoderes africanus Hopkins (1915:30). Holotype, female; Capetown, South Africa; USNM, 7542.

This species is allied to *setosus* (Eichhoff). Specimens have been examined from the following new localities. Jamaica, 13-IX-35, in Poinciana pods; Lagunillas, Merida, Venezuela, 12-I-70, 1000 m elevation, *Mimosa* twig, S. L. Wood; Buitenzorg, Java, 7-VIII-35 (host not legible), L. G. E. Kalshoven; Singapore, Malaya, IX-64, *Mangifera indica*, N. L. H. Krauss.

The above Java specimen was received from Kalshoven and bears an unsigned label in his handwriting "*Stephanoderes multipunctatus* Schedl." This specimen bears the same data as Schedl's type of *multipuncatus*. Although Schedl's type was not available for study, it is highly probable that it is a junior synonym of *africanus*.

Hypothenemus brunneus (Hopkins)

Stephanoderes brunneus Hopkins (1915:31). Holotype, female; Texas; USNM, 7545.

The name *Stephanoderes frontalis* Hopkins is a synonym of *brunneus* (Wood, 1954:1031). This species almost certainly was introduced to America from Africa where all near relatives appear to have originated, although no African specimens have been examined. It is closely allied to *setosus* (Eichhoff).

Hypothenemus birmanus (Eichhoff)

Triarmocerus birmanus Eichhoff (1878:42, 486). Holotype, female; Burma; presumably lost in Hamburg Mus.

Hypothenemus maculicollis Sharp (1879:101). Syntypes; Oahu, Hawaiian Islands; British Mus. Nat. Hist. *New synonymy.*

Stephanoderes perkinsi Hopkins (1915:31). Holotype, female; Honolulu, Hawaii; USNM, 7594. *New synonymy.*

Stephanoderes sterculiae Hopkins (1915:32). Holotype, female; Calapan, Philippine Islands; USNM, 7551. *New synonymy.*

Stephanoderes psidii Hopkins (1915:32). Holotype, female; Calapan, Philippine Islands; USNM, 7552. *New synonymy.*

Previously designated synonyms include *Stephanoderes alter* Eggers, *S. pacificus* Beeson, and *S. castaneus* Wood (Wood, 1960:35). The syntypes of *maculicollis* Sharp, and the holotypes of *S. perkinsi* Hopkins, *S. sterculiae* Hopkins, and *S. psidii* Hopkins were studied and all agree with my specimens that were compared to material Schedl compared to the type of *birmanus*. It is a common species in Indonesia, southern Asia, the Pacific Islands, Central America, and southern Florida.

Hypothenemus californicus Hopkins

Hypothenemus californicus Hopkins (1915:19). Holotype, female; Pomona, California; USNM, 7364.

Hypothenemus tritici Hopkins (1915:19). Holotype, female; Dallas, Texas; USNM, 7526. *New synonymy.*

This species occurs in the southern United States, California, Mexico, and one series was seen from Liberia in western Africa. It is very closely allied to other African species, including *albipilus* Reitter, and probably was introduced to America from Africa. Wood (1954:1055) treated *H. tritici* Hopkins as a subspecies and *H. thoracicus* Hopkins as a synonym of *tritici*. In view of the extended distribution into Mexico, with intergradation, and its discovery in Liberia, the status of *tritici* should be reduced to that of a junior subjective synonym.

Hypothenemus ceibae Hopkins

Hypothenemus ceibae Hopkins (1915:20). Holotype, female; Cayamas, Cuba; USNM, 7583.

Apparently this is a distinct species similar to but larger than *H. eruditus* Westwood, with very slender interstrial scales.

Hypothenemus columbi Hopkins

Hypothenemus columbi Hopkins (1915:18). Holotype, female; Columbus, Texas; USNM, 7361.

This common distinctive species occurs from the southern United States to Colombia and Venezuela. Previously published synonyms of Hopkins's species include *H. abdominales*, *H. rufopalliatus*, *H. brunneipennis*, and *H. amplipennis* (Wood, 1954:162).

Hypothenemus crudiae (Panzer)

Bostrichus crudiae Panzer (1791:35-38). Syntypes.

Stephanoderes obscurus: Eggers (1929:50, nec Fabricius, 1801).

Bostrichus plumeriae Nördlinger (1856:74). Syntypes: Venezuela.

Cryphalus hispidulus LeConte (1868:156). Syntypes. *New synonymy.*

Stephanoderes differens Hopkins (1915:25). Holotype, female; San Bernardino, Paraguay; USNM, 7541. *New synonymy.*

Stephanoderes paraguayensis Hopkins (1915:26). Holotype, female; San Bernardino, Paraguay; USNM, 7377. *New synonymy.*

Stephanoderes polyphagus Costa Lima (1924, nec Eggers, 1924). Syntypes? *New synonymy.*

Stephanoderes uniseriatus Eggers (1924:103). Lectotype, female; Luebo, Congo; USNM, 60169. *New synonymy.*

Stephanoderes hivaoca Beeson (1935:105). Holotype, female; Tahauku Hivaoa, Marqnesas Islands; Bishop Mus. *New synonymy.*

Stephanoderes lebronneci Beeson (1935:104). Syntypes. *New synonymy.*

The types of *crudiae* (Panzer) and *plumeriae* Nördlinger have not been examined by me. The usage of these names is based on series in the Eggers collection, at the U.S. National Museum, that apparently were based on authentic specimens. These specimens agree with syntypes of *hispidulus* LeConte, *polyphagus* Costa Lima, *lebronneci* Beeson, the lectotype of *uniseriatus* Eggers, and the holotypes of *differens* Hopkins, *paraguayensis* Hopkins, and *hivaoea* Beeson. The series of three specimens of *Hylesinus obscurus* Fabricius in the Copenhagen Museum does not include a specimen of this species (see *H. obscurus*, below). Hopkins's names previously placed in synonymy under this species include *brasiliensis*, *guatamalensis*, and *lecontei* (Wood, 1954:1041). The origin of this pantropical species is uncertain, but it probably is American.

Hypothenemus cylindricus (Hopkins)

Stephanoderes cylindricus Hopkins (1915:25). Holotype, female; Trece Aguas, Alta Verapaz, Guatemala; USNM, 7564.

Hypothenemus pallidus Hopkins (1915:18). Holotype, female; Mount Coffee, Liberia; USNM, 7590. *New synonymy.*

Stephanoderes transatlanticus Eggers (1941:99). Holotype, female; Trois Rivières, Guadeloupe; Paris Mus. *New synonymy.*

Hopkins's holotypes of *cylindricus* and *pallidus* and two cotypes of *transatlanticus* Eggers were compared directly and apparently all represent the same species. The option available to me to ignore page priority is exercised and I select *cylindricus* as the name for this species, because large series of American specimens are available for study.

Hypothenemus dipterocarpi Hopkins

Hypothenemus dipterocarpi Hopkins (1915:17). Holotype, female; Calapan, Mindoro, Philippine Islands; USNM, 7588.

Hypothenemus mangarevanus Beeson (1940:196). Holotype, female; Aukena, Margareva Islands; Bishop Mus. *New synonymy.*

The holotypes of both *dipterocarpi* Hopkins and *mangarevanus* Beeson were compared to my Micronesia specimens to establish the above synonymy. The interstrial bristles are scalelike on the disc and hairlike on the declivity of this distinctive species.

Hypothenemus dolichocola Hopkins

Hypothenemus dolichocola Hopkins (1915:19). Holotype, female; Canton, China; USNM, 7580.

This species resembles *eruditus* Westwood in all respects, except the frons. The frons is shallowly, transversely impressed; it is about intermediate between *vafer* Blandford and *eruditus* on the lower half of the frons. Apparently it is a valid species, but additional material should be examined.

Hypothenemus erectus LeConte

Hypothenemus erectus LeConte (1876:356). Lectotype, female; Texas; Mus. Comp. Zool., present designation.

Hypothenemus validus Blandford (1904:228). Holotype, female; Motzorongo, Veracruz, Mexico; British Mus. Nat. Hist. *New synonymy.*

Stephanoderes puncticollis Hopkins (1915:32). Holotype, female; Tampico, Tamaulipas, Mexico; USNM, 7547. *New synonymy.*

Stephanoderes cubensis Hopkins (1915:32). Holotype, female; Cayamas, Cuba; USNM, 7553. *New synonymy.*

The holotypes of *H. validus* Blandford, *S. puncticollis* Hopkins, and *S. cubensis* Hopkins and a syntype of *erectus* LeConte were all examined and were found to represent the same species. The only syntype of *erectus* LeConte remaining in the LeConte collection and labeled as the type, is here designated as lectotype of this species. A cotype of *Stephanoderes sambesianus* Eggers, in the Eggers collection at the U.S. National Museum, apparently is conspecific with *erectus.* It is also noted that three cotypes of *S. mozambiquensis* Eggers and one cotype of *S. dispar* Eggers are doubtfully distinct from this species. More material from additional African localities should be studied before this synonymy is established.

Since this species has no close relative in America that was not introduced through commerce, and since all closely allied species are from Africa, I suspect this species is of African origin. Its introduction into America evidently occurred long before it was described. It is common from southern Texas to Venezuela.

Hypothenemus eruditus Westwood

Hypothenemus eruditus Westwood (1834:36). Syntypes, England?

Cryphalus basjoo Niisima (1910:9). Syntypes; Tokyo, Japan. *New synonymy.*

Cosmoderes schwarzi Hopkins (1915:11). Holotype, female; Haw Creek, Florida; lost except slide mount of antenna in USNM. *New synonymy.*

Hypothenemus bradfordi Hopkins (1915:15). Holotype, female; Honolulu, Hawaii; USNM, 7567. *New synonymy.*

Hypothenemus ferrugineus Hopkins (1915:20). Holotype, female; Trece Aguas, Alta Verapaz, Guatemala; USNM, 7584. *New synonymy.*

Hypothenemus flavipes Hopkins (1915:18). Holotype, female; Cayamas, Cuba; USNM, 7575. *New synonymy.*

Hypothenemus flavosquamosus Hopkins (1910:15). Holotype, female; Mount Coffee, Liberia; USNM, 7591. *New synonymy.*

Hypothenemus heathi Hopkins (1915:20). Holotype, female; Independencia, Parahyba, Brazil; USNM, 7521. *New synonymy.*

Hypothenemus koebelei Hopkins (1915:17). Holotype, female; Brazil; USNM, 7572. *New synonymy.*

Hypothenemus lineatifrons Hopkins (1915:17). Holotype, female; Cayamas, Cuba; USNM, 7570. *New synonymy.*

Hypothenemus mali Hopkins (1915:17). Holotype, female; Capetown, South Africa; USNM, 7573. *New synonymy.*

Hypothenemus myristicae Hopkins (1915:16). Holotype, female; Buitenzorg, Java; USNM, 7589. *New synonymy.*

Hypothenemus nigricollis Hopkins (1915:16). Holotype, female; Capetown, South Africa; USNM, 7568. *New synonymy.*

Hypothenemus parvus Hopkins (1915:17). Holotype, female; Cayamas, Cuba; USNM, 7574. *New synonymy.*

Hypothenemus punctipennis Hopkins (1915:20). Holotype, female; Capetown, "West" Africa; USNM, 7585. *New synonymy.*

Hypothenemus sacchari Hopkins (1915:17). Holotype, female; Nevis, West Indies; USNM, 7379. *New synonymy.*

Hypothenemus tenuis Hopkins (1915:16). Holotype, female; Trece Aguas, Alta Verapaz, Guatemala; USNM, 7569. *New synonymy.*

Hypothenemus webbi Hopkins (1915:17). Holotype, female; Calapan, Mindoro, Philippine Islands; USNM, 7587. *New synonymy.*

Hypothenemus intersetosus Eggers (1928:85). Lectotype, female; Sao Paulo, Brazil; USNM, 60153. *New synonymy.*

Stephanoderes elongatus Hopkins (1915:25). Holotype, female; Cayamas, Cuba; USNM, 7561. *New synonymy.*

Stephanoderes flavicollis Hopkins (1915:24). Holotype, female; Cayamas, Cuba; USNM, 7559. *New synonymy.*

Stephanoderes pygmaeus Hopkins (1915:24). Holotype, female; Pagbilao, Philippine Islands; USNM, 7560. *New synonymy.*

Stephanoderes subconcentralis Hopkins (1915:25). Holotype, female; Cayamas, Cuba; USNM, 7563. *New synonymy.*

Stephanoderes unicolor Hopkins (1915:25). Holotype, female; Cayamas, Cuba; USNM, 7562. *New synonymy.*

Stephanoderes erythrinae Eggers (1936:628). Holotype, female; Sakalaspur, India; British Mus. Nat. Hist. *New synonymy.*

Hypothenemus dubiosus Schedl (1940:207). Syntypes; Hamburgfarm, Ebene Limon, Costa Rica. *New synonymy.*

In establishing the above synonymy, the following specimens were examined and compared to my material and to one another: *Cryphalus basjoo* Niisima, 4 cotypes; Hopkins's holotypes of *bradfordi*, *ferrugineus*, *flavipes*, *flavosquamosus*, *heathi*, *koebelei*, *lineatifrons*, *mali*, *myristicae*, *nigricollis*, *parvus*, *punctipennis*, *sacchari*, *tenuis*, *webbi elongatus*, *flavicollis*, *pygmaeus*, *subconcentralis*, and *unicolor;* the lectotype of *intersetosus* Eggers; a cotype of *erythrinae* Eggers; and a syntype labeled "type" of *dubiosus* Schedl. In addition, the balsam mount of the antenna of *Cosmoderes schwarzi* Hopkins was examined (the type was lost). Since this antenna is entirely typical of *eruditus*, because Hopkins did not have a taxonomic knowledge of the group with which he was working, and in view of the fact that the description of the type fits *eruditus* (except for the erroneously described antenna), *schwarzi* is placed in synonymy under *eruditus*.

Into this species I have grouped similar forms in which the hair-like setae of the elytra vary from uniseriate and sparse strial rows to confused and moderately abundant. There appears to be a complete transition from one extreme to the other. With that exception, interstrial scales, features of the head, pronotum and elytra are rather uniform.

Hypothenemus flavus Hopkins

Hypothenemus flavus Hopkins (1915:17). Holotype, female; Java; USNM, 7571.

This species evidently is distinct. It is allied to *eruditus* Westwood.

Hypothenemus glabripennis (Hopkins)

Stephanoderes glabripennis Hopkins (1915:32). Holotype, female; Angat, Philippine Islands; USNM, 7548.

This distinctive species is well known to specialists.

Hypothenemus gossypii (Hopkins)

Stephanoderes gossypii Hopkins (1915:25). Holotype, female; Cayamas, Cuba; USNM, 7557.

The synonymy between *gossypii* Hopkins and *H. beameri* Wood has been established (Wood, 1962, Gt. Basin Nat. 22:78). Since *H. gossypii* Sampson evidently is a *nomen nudum* Hopkins's name is used here.

Hypothenemus hampei (Ferrari)

Cryphalus hampei Ferrari (1868:11, 12). Syntypes.

Stephanoderes punctatus Eggers (1924:101). Lectotype, female; Eala, Congo; USNM, 60160. *New synonymy.*

The lectotype of *punctatus* Eggers and the holotype of *cooki* Hopkins were compared to my series of this well-known species and were found to be identical. It is an important pest of coffee.

Hypothenemus interstitialis (Hopkins)

Hypothenemus interstitialis Hopkins (1915:28). Holotype, female; Victoria, Texas; USNM, 7555.

Stephanoderes obliquus Hopkins (1915:30). Holotype, female; Cayamas, Cuba; USNM, 7538. *New synonymy.*

The holotypes of *interstitialis* Hopkins and *obliquus* Hopkins were compared directly to establish the above synonymy. Wood (1954:1033) also placed Hopkins's *interpunctus*, *approximatus*, *flavescens*, *opacipennis*, and *quadridentatus* in synonymy under *interstitialis*.

Hypothenemus liberiensis (Hopkins)

Stephanoderes liberiensis Hopkins (1915:31). Holotype, female; Mount Coffee, Liberia; USNM, 7593.

This species is very closely allied to *erectus* (LeConte), but the pronotal asperities are smaller, and the lateral areas of the pronotal disc are rugulose. The holotype is 1.8 mm in length.

Hypothenemus mallyi (Hopkins)

Stephanoderes mallyi Hopkins (1915:32). Holotype, female; Capetown, South Africa; USNM, 7549.

Stephanoderes soussouensis Eggers (1943:74). Holotype, female; Sone, Zambeze; Paris Mus. *New synonymy.*

The holotype of *mallyi* Hopkins and the cotype of *soussouensis* Eggers in the Eggers collection at the U.S. National Museum, were compared and found to represent the same species. It is allied to *rotundicollis* (Eichhoff).

Hypothenemus multidentatus (Hopkins)

Stephanoderes multidentatus Hopkins (1915:28). Holotype, female; Tampico. Tamaulipas, Mexico; USNM, 7532.

Stephanoderes ferrugineus Hopkins (1915:29, nec Hopkins, 1915:20). Holotype, female; Livingston, Guatemala; USNM, 7535. *New synonymy.*

Stephanoderes nitidifrons Hopkins (1915:31). Holotype, female; Tampico. Tamaulipas, Mexico; USNM, 7546. *New synonymy.*

The holotypes of Hopkins's *multidentatus*, *ferrugineus*, and *nitidifrons* were compared directly to one another. They all represent a species that is very close to *interstitialis* Hopkins.

Hypothenemus obscurus (Fabricius)

Hylesinus obscurus Fabricius (1801:395). Lectotype, female; Essequibo, British Guiana; Copenhagen Mus., present designation.

Hypothenemus künnemanni Reitter (1902:140). Lectotype, female; Breman, Germany, in Brazil nuts; Budapest, Mus., present designation. *New synonymy.*

Stephanoderes moschatae Schaufuss (1905:8, reprint p. 2). Holotype, female; Guadeloupe; presumably lost with Hamburg Mus. *New synonymy.*

Stephanoderes rufescens Hopkins (1915:29). Holotype, female; Allegheny, Pennsylvania; USNM, 7527. *New synonymy.*

Stephanoderes buscki Hopkins (1915:30). Holotype, female; Trinidad, West Indies; USNM, 7537. *New synonymy.*

Stephanoderes amazonicus Eggers (1934:78). Lectotype, female; Manaos, Brazil; USNM, 60142. *New synonymy.*

The entire type series of *obscurus* Fabricius, *künnemanni* Reitter, *rufescens* Hopkins, and *buscki* Hopkins were examined, as well as the lectotype of *amazonicus* Eggers. Several specimens of *moschatae* Schaufuss compared by Eggers to the type were also examined. All of these were compared to my homotypes.

This very common species occurs from Costa Rica and Puerto Rico to Brazil where it breeds in twigs, nuts, and fruits of a wide variety of hosts. It is best known from infested Brazil nuts that are transported through commerce to virtually all parts of the world.

The type series of *obscurus* Fabricius consists of three female specimens in the Copenhagen Museum. The first two are of this species, the third (Kiel specimen) is in poor condition and probably is of *pulverulentus* Eichhoff, but might possibly be of *crudiae* Panzer. Since the second specimen is in better condition than the first, I designate it as lectotype of *Hylesinus obscurus* Fabricius; a red, printed lectotype label was placed on the pin bearing this specimen.

The Reitter syntypes of *künnemanni* consisted of five identical females labeled "Bremen, XII - 1900, Paranüse." The second specimen was in the best condition and was labeled and is here designated the lectotype of *Hypothenemus künnemanni.*

Hypothenemus parallelus Hopkins

Hypothenemus parallelus Hopkins (1910:25). Holotype, female; Tampico, Mexico; USNM, 7556.

This form is essentially identical to *eruditus* Westwood except for the frons which bears a small, low nodule at the center. It probably represents a genetic variation within a normal population, but due to the breeding habits and (suspected) partial parthenogenesis the frontal character appears to have greater importance than is warranted. Series in my collection are from Mexico and the Hawaiian Islands.

Hypothenemus pilosus Hopkins

Hypothenemus pilosus Hopkins (1915:20). Holotype, female; Cayamas, Cuba; USNM, 7586.

In this distinctive species the rows of interstrial setae are hairlike from the elytral base to the apex. Apparently it is very rare.

Hypothenemus pubescens Hopkins

Hypothenemus pubescens Hopkins (1915:19). Holotype, female; Key West, Florida; USNM, 7524.

Hypothenemus subelongatus Hopkins (1915:19). Holotype, female; Victoria, Texas; USNM, 7581. *New synonymy.*

Stephanoderes opacifrons Hopkins (1915:25). Holotype, female; Aguadilla, Puerto Rico; USNM, 7565. *New synonymy.*

This species is almost identical with *sparsus* Hopkins, but it possesses rows of strial hair and lacks interstrial granules. In addition to the localities cited above it occurs in Mexico and Hawaii. It breeds in the axis of fruiting stems of various grasses, including the genera *Andropogon*, *Cynodon*, and *Paspalum*.

Hypothenemus pulverulentus (Eichhoff)

Stephanoderes pulverulentus Eichhoff (1871:33). Syntypes(?), female; Mexico; presumably lost with Hamburg Mus.

Stephanoderes vulgaris Schaufuss (1897:209). Syntypes, female; La Digue, Sechelle Islands; presumably lost with Hamburg Mus.

Stephanoderes georgiae Hopkins (1915:27). Holotype, female; Georgia; USNM, 7385. *New synonymy.*

Stephanoderes tamarindi Hopkins (1915:27). Holotype, female; Manila, Philippine Islands; USNM, 7530. *New synonymy.*

Stephanoderes niger Hopkins (1915:31). Holotype, female; Brownsville, Texas; USNM, 7382. *New synonymy.*

Stephanoderes nitidipennis Hopkins (1915:29). Holotype, female; Cayamas, Cuba; USNM, 7533. *New synonymy.*

Stephanoderes fiebrigi Hopkins (1915:27). Holotype, female; San Bernardino, Paraguay; USNM, 7387. *New synonymy.*

Stephanoderes minutus Hopkins (1915:26). Holotype, female, evidently defective; Cayamas, Cuba; USNM, 7366. *New synonymy.*

Hypothenemus emarginatus Schedl (1942b:11). Syntypes, female; Buitenzorg, Java. *New synonymy.*

Stephanoderes darwinensis Schedl (1942a:178). Syntypes; Australia. *New synonymy.*

Stephanoderes andersoni Wood (1954:1045). Holotype, female; Coconut Grove, Florida; USNM. *New synonymy.*

Stephanoderes liquidambarae Wood (1954:1046). Holotype, female; Jacksonboro, South Carolina; Snow Ent. Mus., Univ. Kansas. *New synonymy.*

This abundant, widely distributed species is distinguished with difficulty from *obscurus* (Fabricius) by characters of the frons and elytral surface. It is possible that *multidentatus* Hopkins is a population variant at the upper limits of size. The above synonymy was based on a study of the holotypes of Hopkins's *georgiae*, *tamarindi*, *niger*, *nitidipennis*, *fiebergi*, and *minutus*; on syntypes of *emarginatus* Schedl and *darwinensis* Schedl; and on holotypes of *andersoni* Wood and *liquidambari* Wood. The holotype of *minutus* evidently is defective. There is a certain amount of variation in the minute details of sculpturing of the frons and in the shape of the interstrial scales. After examining many hundreds of specimens from America, the Pacific area, and the Indo-Australian region, I see no alternative to grouping all of the above under one name. The difficulty is complicated by the intensive inbreeding coupled with (suspected) partial parthenogenesis which may produce morphologically uniform local populations. When all of these local populations are studied, however, they intergrade completely. Previously published synonymy of Hopkins's species was established for *texanus*, *pini*, *salicis*, *floridensis*, *ficus*, *soltaui lucasi*, *virentis*, *pecanus*, and *niger* (Wood 1954:1035, 1048). The basis for the names *pulverulentus* and *vulgaris* was specimens identified by and presumably compared to the types by Eggers.

Hypothenemus rotundicollis (Eichhoff)

Stephanoderes rotundicollis Eichhoff (1878:45, 145). Syntypes(?), female; America septentrionalis; presumably lost with Hamburg Mus.

The synonymy of this species with one Hopkins's species, *quercus*, has been established (Wood, 1054:1024). In addition to its distribution in the eastern and southern United States, it occurs in the states of Tamaulipas and Nayarit in Mexico. Allied species occur in Central America.

Hypothenemus setosus (Eichhoff)

Hypoborus (?) *setosus* Eichhoff (1867:391). Syntypes; Guadeloupe.

Stephanoderes bananensis Eggers (1922:167). Two syntypes; Banana, Congo; one in Eggers collection. *New synonymy.*

Stephanoderes kalshoveni Schedl (1939:35). Syntypes; Pasoeroean, Java; Buitenzorg Mus. *New synonymy.*

Stephanoderes subagnatus Eggers (1940:101). Holotype, female; Eala, Congo; Tervuren Mus. *New synonymy.*

Hopkins's species for which synonymy previously was established include *obesus* and *philippinensis* (Wood, 1957:402). The above new synonymy was based on a syntype of *bananensis* and two syntypes of *subagnatus*. Several specimens of *kalshoveni* received from Kalshoven and taken by him from the same branch as the syntypes, were used to establish the synonymy of Schedl's species.

It is difficult to establish the origin of this species at the present time, but it evidently reached America from Africa where several allied species occur, or less probably from the Indo-Malayan area.

Hypothenemus squamosus (Hopkins)

Stephanoderes squamosus Hopkins (1915:26). Holotype, female; Cayamas, Cuba; USNM. 7566.

This distinctive species occurs from southern Florida and Cuba to Mexico. Its nearest relative occurs in Mexico.

Hypothenemus sparsus Hopkins

Hypothenemus sparsus Hopkins (1915:20). Holotype, female; Columbus, Texas; USNM. 7368.

Two of Hopkins's species, *similis* and *tridentatus*, have been placed in synonymy under this name (Wood, 1954:1040). It is rare and distinguished with difficulty from *pulverulentus* (Eichhoff) and *pubescens* Hopkins.

Hypothenemus vafer Blandford

Hypothenemus vafer Blandford (1896:241). Syntypes; Noumea, New Caledonia; British Mus. Nat. Hist.

Stephanoderes polyphagus Eggers (1924:104). Syntypes. *New synonymy.*

Hypothenemus heterolepsis Costa Lima (1928:117). Syntypes. *New synonymy.*

Stephanoderes subvestitus Eggers (1940:232). Holotype, female; Mosolo Kwenge, Kwongo, Congo; Tervuren Mus. *New synonymy.*

Stephanoderes martiniquensis Eggers (1941:99). Holotype, female; St. Pierre, Martinique; USNM. 60156. *New synonymy.*

In view of its present distribution and abundance, it is most remarkable that Hopkins did not encounter this species in his study. No examples of it were included in the collection he studied. This is the species to which I previously have referred as *arecae* Hornung (= *fungicola* Eggers, *hispidus* Eggers, etc.). Since a question has been raised as to the true identity of *arecae*, the next oldest name known to me for this species, *vafer*, will be used until the types can be examined.

The above synonymy was based on the type series of *vafer* Blandford, on two syntypes of *polyphagus* Eggers, two syntypes of *heterolepsis* Costa Lima, one cotype of *subvestitus* Eggers, and the holotype of *martiniquensis* Eggers.

It apparently is now established in southern Florida. It previously has been reported from Brazil, Martinique, Hawaiian Islands, Micronesia, Philippine Islands, the Indo-Malayan region, Ghana, and the Congo. It is polyphagous and, presumably, it can breed in nuts, twigs, or bark.

Trischidias atoma (Hopkins)

Hypothenemus atomus Hopkins (1910:15). Holotype, female; Morgantown, West Virginia; USNM. 7565.

Hopkins's species *Hypothenemus impressifrons, marylandicae, robiniae*, and *toxicodendri* were placed in synonymy under *atomus* by Wood (1954:1068) and transferred to the genus *Trischidias* Hopkins.

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THE CONTRIBUTIONS OF THE 1822 WORKS OF JAROCKI AND FLEMING TO HERPETOLOGICAL NOMENCLATURE

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Two great synoptic works on amphibians and reptiles, of considerable unfamiliarity to herpetologists yet of marked historical importance, appeared in 1822: one in English, by Fleming, the other in Polish, by Jarocki. Both works are rare and seldom examined, but Jarocki's has the additional handicap of being written in a language very little known to systematists in general. An analysis of the nomenclatural contributions of these two works, and of their mutual priority, is long overdue.

The question of priority is important because in both works some new names were proposed for the same taxa. Neave credited Fleming with priority, without documentation, but our evidence conclusively gives Jarocki priority. According to the Director of the Biblioteka Narodowa in Warsaw, Zbigniew Daszkowski, a short review of Jarocki's "Zoologia" with a statement that "three volumes have been published so far" appeared in the number (3) of *Gazeta Literacka* [the Literary Gazette] dated 19 Feb. 1822. Number 5 of the same gazette, dated 5 Mar., gave a bibliographical description of volume 3 of the "Zoologia" in a column entitled "Chronicle of National Literature—New Works Which Have Appeared in Print." The evidence justifies the conclusion that volume 3 of Jarocki's work, in which amphibians and reptiles are treated, appeared no later than February 1822.

The work by Fleming, on the other hand, was indicated by Miss Ann Lucas, British Museum (Natural History) Library, as having appeared no earlier than May and no later than June 1822. A letter received from the National Library of Scotland states that Fleming's work was entered "at Stationer's Hall" on 28 June 1822 and that an undated advertisement received during the period May-July 1822 advised that "this day is published, in two handsome volumes octavo, with engravings, price L1.10s in boards, The Philosophy of Zoology . . . "

Several inquiries elsewhere have yielded no further information pertinent to date of publication. Since the available data clearly indicate publication of Jarocki's work at least by 19 Feb. 1822, and of Fleming's work sometime during May or June but no later than 28 June, acceptance of nomenclatural priority of Jarocki over Fleming is inescapable, except by exercise of the plenary powers of the International Commission on Zoological Nomenclature.

In conjunction with a review of the names in which priority is involved, the entire nomenclatural contribution of both works, at least at the generic level, should be reviewed. We here deal with

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the herpetological names only, leaving those applied to birds, mammals, and other groups for investigation by others.

Jarocki

Sixty-five generic names were used by Jarocki, including 4 for anurans (*Bufo*, *Hyla*, *Pipa*, *Rana*), 5 for salamanders (*Axolotus*, *Proteus*, *Salamandra*, *Triton*, *Siren*), 1 for caecilians (*Coecilia*), 6 for turtles (*Chelonia*, *Chelys*, *Emys*, *Ophichelone*, *Testudo*, *Trionyx*), 3 for crocodilians (*Alligator*, *Crocodilus*, *Gavial*), 3 for amphisbaenians (*Amphisbaena*, *Bipes*, *Chirotes*), 22 for lizards (*Acontias*, *Agama*, *Ameiva*, *Angvis*, *Anolius*, *Basiliscus*, *Chalcides*, *Chamaeleo*, *Cordylus*, *Draco*, *Dracoena*, *Gecko*, *Jguana*, *Lacerta*, *Lacertus*, *Lophyrus*, *Monitor*, *Ophisaurus*, *Polychrus*, *Scincus*, *Stellio*, *Uroplatus*), and 21 for snakes (*Acanthophis*, *Acrochordus*, *Boa*, *Bungarus*, *Coluber*, *Crotalus*, *Elaps*, *Erix*, *Erpeton*, *Hurria*, *Hydrus*, *Langaia*, *Naja*, *Platurus*, *Pseudoboa*, *Python*, *Scytale*, *Tortrix*, *Trimesurus*, *Typhlops*, *Vipera*).

Of these 65 names, 3 were not listed by Neave: *Angvis*, *Dracoena* and *Jguana*. Neave explicitly equated *Angvis* and *Anguis* and implicitly equated *Jguana* and *Iguana*; both of these alternate names have priority over Jarocki's usages, the different characters of which are character-equivalents with early classical Latin (u was written as *v*, *j* as *i*). *Dracoena*, not listed by Neave or Romer, has apparently been regarded as an erroneous subsequent spelling, judging from the fact that it was explicitly based upon the tautonym *Lacerta dracoena* Linnaeus, which was originally spelled *dracaena*. The least disturbing and therefore most acceptable conclusion at this point is to assume that both spelling variants (*Dracoena*, *dracoena*) in Jarocki were inadvertent errors which have no nomenclatural status. Even if the generic spelling were regarded as an occupied name, it would remain a junior synonym of *Dracaena* Daudin, 1802.

The only acceptably new names, at least not previously used, are *Axolotus*, *Langaia*, *Ophichelone*, and *Trimesurus*. *Axolotus* was suppressed by the International Commission (1963:102) in order to conserve *Ambystoma* Tschudi, 1838. *Ophichelone*, based upon *Testudo serpentina* Linnaeus, is antedated by *Chelydra* Schweigger, 1814. *Langaia* is a junior synonym and an invalid emendation of *Langaha* Brugnière, 1784, but has previously been attributed, erroneously, to Fleming (1822). *Trimesurus*, erroneously attributed first to Gray, 1840, is a junior synonym and an invalid emendation of *Trimeresurus* Lacépède, 1804. Had Jarocki's *Lacertus*, based on *Lacerta orbicularis* Linnaeus, not been antedated by *Lacertus* Lacépède, 1788, an invalid emendation of *Lacerta* Linnaeus, 1758, it would be available for *Phrynosoma* Wiegmann, 1828.

Fleming

Seventy-two generic names were used by Fleming, including 4 for salamanders (*Apneumona*, *Salamandra*, *Sirena*, *Triton*), 4 for anurans (*Bufo, Hyla, Pipa, Rana*), 1 for caecilians (*Cecilia*), 8 for turtles (*Chelonia, Chelonura, Chelys, Cistuda, Coriudo, Emys, Testudo, Trionix*), 3 for crocodilians (*Alligator, Crocodilus, Gaviala*), 3 for amphisbaenians (*Amphisbaena, Bipes, Chirotes*), 24 for lizards (*Acontias, Agama, Ameiva, Anguis, Anolius, Ascalabotes, Basiliscus, Calotes, Chalcides, Chameleon, Cordylus, Custa, Dracaena, Draco, Iguana, Lacerta, Lophurus, Mastigura, Monitor, Ophisaurus, Polychrus, Scincus, Stellio, Trapelus*), and 25 for snakes (*Acanthophis, Acrochordus, Boa, Caudisona, Cerastes, Chersea, Cobra, Coluber, Crotalus, Elaps, Erpeton, Hemachatus, Hydrophus, Langaia, Natrix, Naja, Pelamis, Platurus, Pseudoboa, Scytalus, Tortrix, Trigonocephalus, Trimeresura, Typhlops, Vipera*).

Neave regarded 14 of these generic names as new and not previously used: *Apneumona, Chameleon, Chelonura, Chersea, Cistuda, Coriudo, Custa, Gaviala, Hemachatus, Hydrophus, Langaia, Lophurus, Mastigura, Trimeresura.* As indicated in the preceding discussion, Jarocki's *Langaia* antedates and therefore replaces Fleming's *Langaia*, leaving but 13 names not used before Fleming. Romer rejected *Ascalabotes* of Cuvier, 1817, originating the name with Lichtenstein, 1823. Were the rejection of Cuvier, 1817, as a source for this name upheld (we are aware of no reason, however), Fleming's usage would antedate Lichtenstein's, restoring the total of 14 names originating with Fleming.

The 13 names we believe properly credited as originating with Fleming are allocated as follows: *Apneumona*=junior synonym of *Proteus* Laurenti, 1768; *Chameleon*=junior synonym and invalid emendation of *Chamaeleo* Laurenti, 1768; *Chelonura*=junior synonym of *Chelydra* Schweigger, 1812; *Chersea*=junior synonym of *Vipera* Laurenti, 1768; *Cistuda*=junior synonym of *Terrapene* Merrem, 1820; *Coriudo*=junior synonym of *Dermochelys* Blainville, 1816; *Custa*=junior synonym of *Tupinambis* Daudin, 1803 (Peters et al., 1970:271); *Gaviala*=junior synonym and invalid emendation of *Gavialis* Oppel, 1811; *Hemachatus*=valid, recognized name; *Hydrophus*=junior synonym of *Aipysurus* Lacépède, 1804; *Lophurus*=junior synonym of *Lyriocephalus* Merrem, 1820; *Mastigura*=junior synonym of *Uromastix* Merrem, 1820; and *Trimeresura*=junior synonym and invalid emendation of *Trimeresurus* Lacépède, 1804.

Type-Species

Neither Jarocki nor Fleming indicated author for their generic names, and likewise neither usually indicated whether any given name was proposed as new or not. Accordingly, we regard as "new" only those names not previously used in that exact spelling. For such names it is important that type-species be known in order to permit an incontrovertible nomenclatural allocation.

A total of 17 occupied (i.e., acceptable for nomenclatural consideration) generic names originated with either Jarocki or Fleming. Three other names used by Jarocki are not considered as occupied and therefore do not exist nomenclaturally: *Angvis, Dracoena,* *Jguana* (see preceding account for explanation). The 17 occupied names have the following type-species:

1. *Apneumona* Fleming (1822:303), type-species by monotypy "*A. anguina*"=*Proteus anguinus* Laurenti.

2. *Axolotus* Jarocki (1822:179), type-species by subsequent designation (Smith and Tihen, 1961:216) "*Axolotus pisciformis*," *ex Siren pisciformis* Shaw=*Ambystoma mexicanum* Shaw. For an English translation of the section of Jarocki on *Axolotus*, see Szarski, Smith, and Smith (1970:6-7).

3. *Chamelon* Fleming (1822:272), no species listed; as an apparent unjustified emendation of *Chamaeleo* Laurenti, 1768, it thereby takes the type-species of the latter name, to wit, *Chamaeleo parisiensium* Laurenti=*Chamaeleo chamaeleon* (Linnaeus, 1758). The earlier generic name *Chamaeleon* Gronovius, 1763, was eliminated by the International Commission on Zoological Nomenclature (Opinion 89, 1925) through rejection of Grovonius's work of 1763 for nomenclatural purposes.

4. *Chelonura* Fleming (1822:270), type-species by monotypy "*Testudo serpentina*" [Linnaeus, 1758]=*Chelydra serpentina* (Linnaeus).

5. *Chersea* Fleming (1822:295), type-species by monotypy "*C. vulgaris*," *ex Vipera vulgaris* Sonnini and Latreille, 1802=*Vipera aspis* (Linnaeus, 1758).

6. *Cistuda* Fleming (1822:270), no species mentioned; type-species by present designation *Testudo carolina* Linnaeus, 1758=*Terrapene carolina* (Linnaeus). The name *Cistudo* Say, 1825, long used for this genus in the 19th century literature, was an emendation of Fleming's *Cistuda* and therefore invalid at the outset, since Article 69 of the International Code states that generic names published without species names, prior to 1931, are not thereby unavailable but take as type-species the first one subsequently designated for it.

7. *Coriudo* Fleming (1822:271), type-species by monotypy "*Testudo coriacea*" [Linnaeus, 1766]=*Dermochelys coriacea* (Linnaeus).

8. *Custa* Fleming (1822:274), type-species "*L. teguexin*" *ex Lacerta teguixin* Linnaeus, 1758=*Tupinambis teguixin* (Linnaeus), by subsequent designation (Peters and Donoso-Barros, 1970:271).

9. *Gaviala* Fleming (1822:276), type-species by monotypy *Lacerta gangetica* [Gmelin, 1789]=*Gavialis gangeticus* (Gmelin).

10. *Hemachatus* Fleming (1822:295), type-species by monotypy "*H. vulgaris*," a new species-group name (although not so designated by Fleming), a junior synonym, almost universally overlooked, of *Coluber haemachata* Lacépède, 1789=*Hemachatus haemachatus* (Lacépède).

11. *Hydrophus* Fleming (1822:292), type-species by monotypy "*H. ayspisurus*." Neave regarded this name as an emendation

of *Hydrophis* Latreille, 1801; since Fleming did not so state, and did cite a species name, the latter must be regarded as the type-species, and *Hydrophus* an independently new name, not a substitute new name. The species name is also new, although not so designated, and has almost universally been overlooked. It appears to be derived, with a misspelling, from Lacépède's *Aipysurus laevis* of 1804, of which it is here designated a synonym. Therefore *Hydrophus ayspisurus* Fleming, 1822=*Aipysurus laevis* Lacépède, 1804, and the genus *Hydrophus* Fleming, 1822, becomes a junior synonym of *Aipysurus* Lacépède, 1804, instead of *Hydrophis* Latreille, 1801.

12. *Langaia* Jarocki (1822:102), type-species *Langaia nasuta ex Langaha nasuta* Brugniére, 1784, by monotypy. It is by no means certain whether the Jarocki spelling was a deliberate emendation (and therefore nomenclaturally occupied) or an inadvertent misspelling (and therefore unoccupied); Neave and most others considered it occupied, and we accept that decision.

13. *Lophurus* Fleming (1822:278) was treated without any species-group names. It might be regarded as an emendation of *Lophyrus* Dumèril, 1806, itself unavailable as a junior homonym of *Lophyrus* Poli, 1791, a molluscan; to so conclude, however, would effect replacement of *Gonocephalus* Kaup, 1825, a long-established genus. Precisely what species Fleming had in mind is not evident, but it is illuminating to observe that the two species Jarocki placed in his probably equivalent genus *Lophyrus* were *Lacerta scutata* and *Lacerta superciliosa*, both Linnaean names. The latter is now placed in the monotypic genus *Uranoscodon* Kaup, 1825; the former is placed in the monotypic genus *Lyriocephalus* Merrem, 1820. The least disruptive allocation of *Lophurus* Fleming is to the genus *Lyriocephalus*, of which it would be a junior synonym; accordingly, we here designate *Lacerta scutata* Linnaeus the type-species of *Lophurus* Fleming, 1822, a junior synonym of *Lyriocephalus* Merrem, 1820.

14. *Mastigura* Fleming (1822:277), type-species by monotypy "*M. spinipes*"=*Stellio spinipes* Daudin, 1802=*Uromastix spinipes* (Daudin), type-species also of *Uromastix* Merrem, 1820 (the name was also spelled *Uromastyx* by Merrem in the same work, but that spelling has not been adopted and is thus invalid).

15. *Ophichelone* Jarocki (1822:21), type-species by monotypy *Testudo serpentina* Gmelin *ex Testudo serpentina* Linnaeus, 1758=*Chelydra serpentina* (Linnaeus).

16. *Trimeresura* Fleming (1822:291) is presumably an emendation of *Trimeresurus* Lacépède, 1804, the type-species of which (*Vipera viridis* Daudin, 1803) automatically becomes that of *Trimeresurus* also. The result would be the same if Fleming's name were regarded as independently proposed, for the only species placed in it is "*T. viridis*"=*Trimeresurus gramineus* (Shaw, 1802).

17. *Trimesurus* Jarocki (1822:103) is also clearly an emendation or *lapsus* for *Trimeresurus* Lacépède, 1804. Neave stated that

the orthography *Trimesurus* originated with Gray, 1840, perhaps regarding one usage deliberate, the other inadvertent. We see no reason for discrimination in this way and regard the spelling as deliberate with Jarocki and therefore originating in 1822. The type-species is therefore the same as for *Trimeresurus* Lacépède, namely *Vipera viridis* Daudin, 1803=*Coluber gramineus* Shaw, 1802=*Trimeresurus gramineus* (Shaw).

Summary

Jarocki (1822) has priority over Fleming (1822), the former appearing at least by February, the latter in May or June. The only new generic names originating from Jarocki are *Axolotus*, *Langaia*, *Ophichelone*, and *Trimesurus*, none of which is valid today: all are junior synonyms except *Axolotus*, which has been suppressed in order to conserve *Ambystoma* Tschudi, 1838. The only new generic names originating from Fleming are *Apneumona*, *Chameleon*, *Chelonura*, *Chersea*, *Cistuda*, *Coriudo*, *Custa*, *Gaviala*, *Hemachatus*, *Hydrophus*, *Lophurus*, *Mastigura*, and *Trimeresura*, only one of which (*Hemachatus*) is valid today. The type-species and present allocation of all genera are summarized. *Lacerta scutata* Linnaeus, 1758, is here designated the type-species of *Lophurus* Fleming in order to prevent replacement of *Gonocephalus* Kaup, 1825, or *Uranoscodon* Kaup, 1825. Two generally overlooked species-group names were created by Fleming: *Hemachatus vulgaris*, a junior synonym of *Hemachatus haemachatus* (Lacépède), and *Hydrophus ayspisurus*, a junior synonym of *Aipysurus laevis* Lacépède. The spelling variants *Angvis*, *Jguana*, and *Dracoena* occurring in Jarocki are regarded as having no nomenclatural status: they are "unoccupied."

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PREY STAGE DISTRIBUTION, A FACTOR AFFECTING THE NUMERICAL RESPONSE OF *TYPHLODROMUS OCCIDENTALIS* TO *TETRANYCHUS MCDANIELI* AND *TETRANYCHUS PACIFICUS*[1]

B. A. Croft[2]

ABSTRACT.— The ability of *Typhlodromus occidentalis* to oviposit and numerically increase when consuming various life stage distributions of *Tetranychus mcdanieli* and *Tetranychus pacificus* were studied at several interaction levels. On field-collected apple leaves and 6x6 cm artificial substrates, oviposition rates and rates of increase (r) were higher when predators were fed populations of spider mites with high proportions of eggs and larvae as compared to prey colonies composed mainly of deutonymphs-male adults and female adults. Feeding studies indicated that reproductive differences were mainly due to increased predation and food intake when predators were offered eggs and larvae of *Tet. pacificus* and a decreased capture and food consumption when only provided with the larger prey stages. Samples taken throughout a growing season in apple trees and an orchard suggested that during early-season, prey stage distributions were most favorable to predator increases and would undoubtedly contribute to a rapid numerical response by predators. The affect of less favorable stage distributions was much less apparent as these stage proportions occurred during short intervals in early season, at intermediate prey levels, and were most unfavorable at high densities or late season after spider mites overexploited their host plant.

A predator's reproductive rate is greatly influenced by the density, nutritional suitability, and behavioral acceptability of its prey. For example, Chant (1961) reported that the rate of oviposition of the phytoseiid mite, *Typhlodromus occidentalis* Nesbitt, was closely correlated with the number of Pacific spider mites (*Tetranychus pacificus* McGregor) it consumed. Burrell and McCormick (1964) reported differential oviposition rates for *T. occidentalis* when feeding on various tetranychid prey; and *Amblyseius potentillae* (Garman) consumes fewer prey/day per equivalent rate of egg production when feeding on *Panonychus ulmi* (Koch) reared on leaves having a high nitrogen level, as compared to *P. ulmi* reared on leaves with low nitrogen content (van de Vrie and Boersma, 1971).

Many phytoseiid mites prefer feeding on a particular stage or stages of certain tetranychid mites (Chant, 1959; Putnam,

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1962; Croft and Jorgensen, 1969; van de Vrie and Boersma, 1971). Croft and McMurtry (1972a) reported that *T. occidentalis* preferred feeding on the egg, larval, and protonymphal stages of *Tet. pacificus*, rather than on late nymphal-male adult or female adult mites. When provided with different stage groups of *Tet. pacificus* [(a) eggs, (b) unfed larvae, (c) deutonymphs-male adults, (d) female adults], predators exhibited marked differences in oviposition rates. Estimates were twofold greater when *T. occidentalis* females were fed prey eggs or larvae as compared to deutonymphs—male adults and female adults. The relationship between the prey stage consumed and the oviposition rate of predators suggested that the stage distribution of the prey mites might affect the ability of *T. occidentalis* to numerically increase and control *Tet. pacificus* and *Tetranychus mcdanieli* McGregor in the field. The investigations reported herein were conducted to test this hypothesis. This relationship was studied at several interaction levels; in the laboratory on confined 6 x 6 cm paper substrates, apple leaves, and 2.5 cm diameter apple-leaf disks and in the field on apple leaves, in apple trees, and in an apple orchard throughout a growing season.

General Methods

Rearing methods for the predator and prey populations have been described elsewhere (Croft, 1970). Stock colonies of *T. occidentalis* originally were collected from an apple orchard at Wenatchee, Washington. *Tetranychus pacificus* was started from a colony maintained by L. R. Jeppson at the University of California, Riverside. All laboratory experiments were conducted, unless specified otherwise, at 75 ± 3°F and 50 ± 10% RH in the insectary at the University of California, Riverside. Field experiments, samples and populations of *Tet. mcdanieli* were all taken in apple orchards at Oak Glen, near Yucaipa, California. With respect to taxonomy, morphology, and behavior, *Tet. pacificus* and *Tet. mcdanieli* are closely related species, and *T. occidentalis* is well adapted to either prey (Flaherty, 1967;[3] Hoyt 1969).

Predators Reared on Paper Substrates

Methods.— The potential of *T. occidentalis* to numerically increase when fed four life stage groups of *Tet. pacificus* was tested on waterproofed construction paper units (6 x 6 cm). These arenas were placed on a water-saturated, plastic foam base and were contained in a 15 x 15 x 3 cm stainless steel pan. Cellucotton strips bordered each unit and were saturated with water to insure the isolation of each predator-prey population. Life stage groups of *Tet. pacificus*: (a) eggs-larvae, (b) larvae-protonymphs, (c) deutonymphs-male adults, and (d) female adults were collected by the method described by Scriven and McMurtry (1971). An abundance

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[3] Flaherty, D. 1967. The ecology and importance of spider mites on grape vines in the southern San Joaquin Valley with emphasis on the role of *Metaseiulus occidentalis* (Nesbitt). Doctoral Dissertation, Univ. of Calif., Berkeley.

of each prey group was added three times weekly to units where 30 newly oviposited eggs of the predator previously had been placed. A single pan contained four replicates of each treatment. After female predators had developed to maturity, morality (1_x) and oviposition (m_X) measurements were collected daily during the entire oviposition period (16-29 days). Six parameters, including (1) mean eggs produced/female, (2) mean egg production per female/day, (3) mean length of the oviposition period, (4) mean generation time (T), (5) net reproductive rate per female/generation (R_o), and (6) instrinsic rate of increase (r), were measured. A previously reported sex ratio (Croft, 1970) of 1:1.7 (♂:♀) for *T. occidentalis* was used in all calculations.

Results.— Table 1 contains the six respective parameters for adult females of *T. occidentalis* when fed on each stage group of *Tet. pacificus.* The mean total egg production for females fed on each prey group were similar. Mean egg production per female/day and the mean length of the oviposition period were inversely correlated; high oviposition rates were associated with short oviposition periods and vice versa. If similar mortality (l_X) values had been obtained for each stage type, mean generation time (T) would have positively correlated with the length of the oviposition period. However, a greater mortality occurred among predators when feeding on deutonymphs-male adults and female adults as compared with those predators feedings on eggs-larvae or larvae-protonymphs. It is not known if these mortality differences are also associated with the consumption of the larger prey stages as occurs in the field. The lower mortality (l_X) values also caused the mean generation time (T) for predators fed on deutonymphs-male adults and female adults to be similar to those values obtained for mites fed on eggs-larvae and larvae-protonymphs. The number of progeny produced per female (R_o) in each generation (T) was greater among mites feeding on eggs-larvae and larvae-protonymphs as compared to those feeding on the larger prey stages. Intrinsic rates of increase (r) were positively correlated with the mean estimates for egg production per female/day.

Table 1. Oviposition and rate of increase parameters for *Typhlodromus occidentalis* when fed each of four life stage groups of *Tetranychus pacificus.*

Life Stage type	Mean Total Eggs/Female	Mean Eggs/ Day/Female	Mean Length of Oviposition (Days)	T	R_0	r
Egg-larvae	36.8	2.3	16.0	14.4	21.6	0.213
Larvae-protonymph	35.7	1.9	19.0	16.4	21.3	0.186
Deutonymphs-male adult	38.0	1.7	23.0	15.4	15.0	0.176
Female adult	37.7	1.3	29.0	16.7	16.8	0.169

Predator Oviposition Responses on Apple Leaves

Methods.— The oviposition response of *T. occidentalis* when fed *Tet. mcdanieli* was tested on field-collected apple leaves. Leaves with densities of *ca.* 60 and 200 prey mites/leaf were selected to insure that searching for prey was not a factor affecting predator egg production. These prey also provided sufficient food to allow the predators to oviposit for four to six days. Leaves were placed on foam plastic pads in pans of water. Cellucotton strips bordered individual leaves to discourage predator or prey migrations from the unit. The initial stage distribution of the prey population was noted for each leaf and then recounted on successive days during the experiments. A mean stage distribution value, as the percentage of all preferred stages (i.e., eggs, larvae, and protonymphs) present during the interaction period was estimated from the running percentage means of the preferred stages present each day. Sufficient female predators were added to each leaf to insure the destruction of the prey populations before six days had elapsed. Leaves with lower prey densities (60 mites/leaf) received 1-3 female predators; those with higher levels (200 mites/leaf) received 6-14. Oviposition rates per female/day were calculated, and mean oviposition rate for the entire period was estimated from the daily means, excluding data from the first day of oviposition and all days after prey density was lower than predator density. Prior to test termination, predator populations were largely composed of eggs, larvae, and nymphs which had a low prey-consumption rate. Searching for prey was not a significant factor affecting oviposition during the testing period. Although these experiments were helpful in relating prey stage distribution to the numerical increase of the predators, the limitations of a detached leaf and the methods of estimating the stage distribution values are emphasized.

Results.— When first introduced to a leaf, predators initially fed on the smaller, more preferred prey stages of *Tet. mcdanieli*. Predators consumed over 90 percent of the adult female prey and oviposition was 44 percent less during the latter half of the test periods as the more preferred stages were not available. Figure 1 presents a linear regression fit for the relationship between prey stage distribution and predator oviposition rates for 20 leaf interactions at each density level. A positive regression slope was found at both density levels, and the sample regression coefficients (b) for both density treatments were not significantly different. Predator oviposition rates were high when the mean percent of preferred prey was high and, conversely, were low when prey populations had a low proportion of the preferred stages. Estimated oviposition rates (Y) also were not significantly different between the two prey density levels.

Feeding Responses of Predators After Periods of Starvation

Several factors may contribute to the differential oviposition responses of *T. occidentalis* females to differing stage distributions of

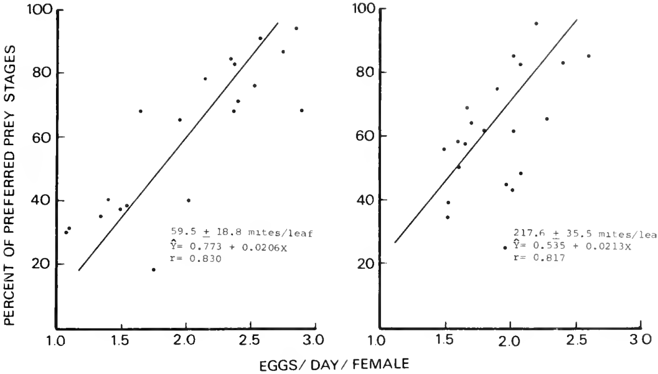

Fig. 1. Regression relationships between the combined percentage of eggs, larvae, and protonymphs (preferred prey stages) available for food and the oviposition rates of *Typhlodromus occidentalis* for 20 predator-prey interactions on apple leaves at two prey density levels.

Tet. pacificus and *Tet. mcdanieli*: Croft and McMurtry (1972a) estimated that *T. occidentalis* females after feeding on *Tet. pacificus* eggs produced five times more eggs than did predators fed on an equivalent weight of adult female prey. On the basis of equivalent number of prey, predators oviposited only 41 percent as many eggs when fed eggs as compared to feeding on adult female prey. Unfed larvae were 1.9 times and 16 percent for the same respective parameters. Also, comparisons of oviposition and prey consumption rates for *T. occidentalis* fed on prey eggs v. larvae (Croft and McMurtry, 1972a) indicated that an increased feeding response occurred as predators consumed about 2.5 times as many larvae as eggs, yet maintained a similar level of egg production (2.3 eggs per female/day). When preying on adult female prey, predator oviposition rates were lower (1.3 eggs per female/day) even though an abundance of food was provided. Data suggested that eggs and larvae were more acceptable stages to the predator females than were the larger prey stages.

METHODS.— To test the above hypothesis, standard-sized (2.5 cm in diameter) leaf disks without prey were placed on water-saturated, foam plastic pads. A uniform starvation schedule prior to the initiation of the experiments provided female adult predators in a similar hunger state. These mites were placed singly on each disk, and at logarithmically-spaced time intervals they were offered a particular prey stage (eggs, larvae, or female adults). All tests were made concurrently; 20 predators per replicate and three replicates (60 total mites) were tested for each stage group at each time interval. Predators which had been offered a particular prey stage (e.g., eggs only) in previous tests were given a different type (e.g., larvae or female adult mites) at the next time period to insure that treatment conditioning did not occur. The percentage of predators effecting a successful capture after two contacts with a particular prey stage was recorded at each test period. Direct frontal approaches to adult female prey nearly always resulted in an avoidance response by the predators at all starvation times. These contacts were not counted. After a predator had captured a particular prey stage and had assumed the feeding position, the prey was withdrawn. Predators obtained little, if any, food and were further starved until the next test period.

Results and Discussion.— Figure 2 shows the feeding response curves of *T. occidentalis* females to each prey stage after varying periods of starvation. Successful capture and acceptance of prey larvae were extremely high at all starvation periods, reaching 98 percent at 48 hours after the initiation of the tests. Eggs were slightly less acceptable than larvae at most test periods. Adult female prey were almost unacceptable during the early periods of the tests (3-6 hr), increasing to 65 percent successful captures at the most responsive period (48 hr). In the initial tests (3-6 hr), predators often made normal feeding approaches to adult female prey, holding

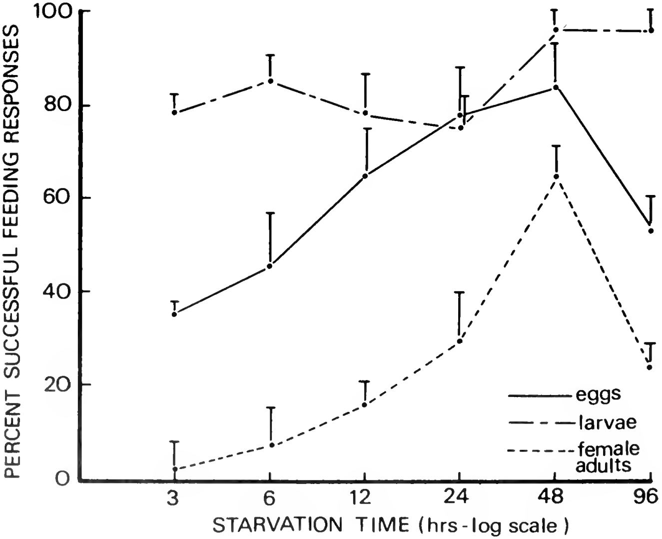

Fig. 2. Feeding response curves for *Typhlodromus occidentalis* to 3 prey stages of *Tetranychus pacificus* after varying periods of starvation.

them with their front pair of legs; however, they usually released the larger mites and did not feed.

During the late stages of starvation (48-96 hr), many predators ceased searching and remained still until a prey encountered them or until they died. If a prey larva contacted a starving predator, the predator would immediately respond and a high percent of successful captures (95 percent at 96 hr) was effected. Few eggs were encountered by predators in this condition. The decline in adult female consumption at 96 hr resulted from the inability of the starved predators to overcome and feed on the larger prey stages.

Although these tests were helpful in comparing the hunger thresholds of *T. occidentalis* to each prey stage, the interpretation of these data in terms of field populations should be qualified. Predators were never 100 percent successful in obtaining prey at any test period. However, under field conditions, these mites may contact the prey mites more than twice during each time interval or more than 12 times in 96 hours of searching. We may interpret these data in terms of field populations by suggesting that when prey densities are sufficiently high, and a high proportion of the preferred prey stages are present, predators feed mainly on eggs and larvae. Adult prey consumption mainly occurs when the density of the preferred stages is reduced and the hunger level of the predators becomes high enough to elicit a feeding response on the larger prey stages.

Colonization Pattern and Changes in Prey Distribution

The data discussed previously in this paper have dealt with the numerical response of *T. occidentalis* to different stage distribution of *Tet. pacificus* and *Tet. mcdanieli* on a paper substrate and apple leaf surfaces. Predator-prey interactions at tree and orchard levels are of greater interest if spider mite control is to be attained. Subsequent portions of this paper deal with the effect the previously described response on individual leaves may have, in toto, on the larger sample units in the field.

In southern California, adult females of *Tet. mcdanieli* overwinter at the base of apple trees and under bark scales in the trunk region. During April and May, females move up the trunk onto leaves on water-sprout growth and to leaves on the inner branches of the scaffold limbs. The initial distribution of prey mites during this period is typically confined to a low percentage of leaves (1-5 percent) in the lower central portion of the tree. Progeny of the first generation complete their development on this foliage. At maturity, many of the newly molted females migrate to noninfested leaves in the upper central portions of the tree and a lateral spread occurs in subsequent generations. By 1 July, from 20-60 percent of the leaves in a tree are infested by prey mites (Croft and Barnes, 1971; Croft and McMurtry, 1972b).

The colonization habits of the predator, *T. occidentalis* are adapted to those of *Tet. mcdanieli.* Adult females overwinter in the debris at the base of trees and under bark scales on the trunk and scaffold branches (Hoyt, 1969; Leetham and Jorgensen, 1969). Female predators move from these hibernacula during the same period as do the prey mites and initially disperse to the lower, central region of the tree where the prey population also occurs.

The initial density and distributional relationships between prey and predator populations vary. On occasion, these relationships favor the predators, which reduce the initial prey populations to a low density level (Croft and Barnes, 1972). When no alternate prey species is present, the early prey reduction results in a starvation decline in predator populations, a later increase in prey levels, and a second numerical response by the predators.

Occasionally an equilibrium ratio of prey:predators is present, and a less fluctuating interaction develops with the predator population maintaining a reduced density just sufficient to maintain the prey at a low equilibrium level. The author has observed this condition in naturally developing populations (Croft and Barnes, 1972) and during minimum release tests (Croft and McMurtry, 1972b).

Most often, the initial numerical and distributional relationships of predators and prey favor the increase of prey populations. Predators contact the prey, increase on a limited number of leaves, and initially have a much lower density and poorer distribution than do the prey mites. However, some time after prey density has surpassed a certain minimal level (*ca.* 2-5 mites/leaf, Croft and McMurtry, 1972b), predator populations numerically respond to the extent of overcoming and reducing the prey to a low level.

In the latter case, the interaction sequence is generally similar on individual leaves and in the entire tree. The overwintering female adult predators disperse to individual leaves in the lower central region of the tree and encounter a prey population of a certain density and stage distribution. Either one or both of these two factors affect the predator's rate of numerical increase during the period of interaction on the leaf. The mean rate of predator increase or decrease on all leaves determines the prey density attained and the length of time a particular prey level persists in the tree.

If prey density on the leaf is sufficiently high and predator searching is not a limiting factor, the stage distribution and the acceptability of these prey to the predators influence the rate of increase on that leaf. The r values in Table 1 give the possible range of effects this factor might have. One might conclude from mean tree estimates that the above conditions occur only at high prey densities; but even at low mean levels (1-5 mites/leaf) the few leaves with prey have many mites present and the majority are without prey. If prey density on a leaf is low or zero, searching for prey is the major factor limiting the rate of numerical increase or decrease among predators. During this period, the effect of a differential stage distribution is not greatly expressed. This also applies to those periods of low prey density on leaves after the predators have numerically increased and reduced the prey to a low level.

The following interaction sequence in early season was observed in repeated studies of the numerical response of *T. occidentalis* to populations of *Tet. mcdanieli* on leaves where prey initially were abundant (Croft and Barnes, 1971, 1972; Croft and McMurtry, 1972b): the immature progeny from eggs oviposited by the over-winter female predators completed development on the originally colonized leaf. If prey density was still sufficiently high, a second generation developed on the leaf. Prior to the complete extincting of all prey, the original female predators and/or gravid females of subsequent generations migrated to other infested leaves. Further prey consumption by developing immature predators most often resulted in the complete extinction of prey from the leaves until later migrations occurred. At maturity the newly molted female predators were mated and shortly thereafter dispersed to leaves with prey and the interaction sequence was repeated. As the predator density increased in the tree, population distribution (percentage of leaves infested) also increased at a proportional rate (Croft and Barnes, 1971; Croft and McMurtry, 1972b). Eventually a predator population numerically increased and was distributed throughout the tree to the extent of overcoming further prey increases, and control was attained.

Assuming that the above sequence describes a typical numerical response of *T. occidentalis* to populations of *Tet. mcdanieli* in an individual apple tree, tests were conducted to measure changes in the stage distribution of the prey mites as related to density and time upon leaves, in trees, and in an apple orchard. These measurements were taken to suggest the stage distributions that dispersing predator populations would encounter in enacting control of the pest.

Prey Infestation on Individual Apple Leaves

As the density and distribution of *Tet. mcdanieli* initially increased in the tree, a common development was for a single gravid female prey to disperse to an uninfested leaf. Later, several females would disperse to uninfested leaves as density further increased and intraspecific competition intensified. At high density levels, large numbers of mites would occupy almost all available leaves, and the remaining uninfested leaves would soon be colonized by high densities of migrant female mites. These infestations assume single migrations by various densities of prey mites, but also an infinite number of continuous migrations may occur at any time (i.e., a single female colonizes a leaf but is joined by one or more additional females at day 2, day 3, etc., or any other random time).

Methods.— To simulate these infestations, leaf spurs without mites were collected from a single branch of a "Standard Delicious" apple tree. All leaves except one of uniform size were removed from each spur. The spurs were placed in leaf cages and maintained in a greenhouse under long day photoperiods at 70-90 F, and 50-70 percent R.H. At the initiation of the test, a leaf was infested with either 1, 2, 4, or 16 field-collected prey mites (*Tet. mcdanieli*, female adults) of an unknown age. One treatment contained a leaf on which 1 adult female was added the first and each successive day.

Prey density and stage distribution were counted every three days until test termination. Each of the five treatments was replicated 10 times and the reported data are mean values for all replicates in each treatment.

Results.— Figure 3 A-F presents the results from the infestation experiments. The following generalizations were made from these data: (1) At the lower density levels after colonization had begun, the percentage of prey in the egg, larval, and protonymphal stages was extremely high and would be optimally favorable for the numerical increase of predator populations (Fig. 3 A-E). (2) As density further increased, the prey population contained a lower percent of preferred stages (Fig. 3 A-E). (3) If 1, 2, 4, or 16 female prey mites dispersed to an uninfested leaf and no other mites moved to that leaf before the first generation was completed, there was a short period of time (3-6 days in the laboratory) at the end of the first generation when the stage distribution of the prey was mostly composed of the large prey stages and would be less favorable for the numerical increase of the predator (Fig. 3 A-D). (4) The periodic introduction of additional females to a previously infested leaf tended to dampen fluctuation (extreme variations in successive sample dates) in stage distribution on the leaf (Fig. 3E). However, the slope of decreasing stage favorability (Fig. 3E) was not markedly different from the other treatments which supported similar densities, but were

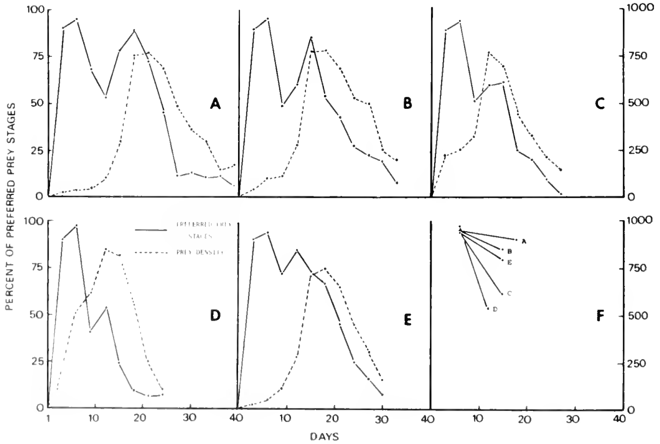

Fig. 3 A-F. Prey stage distribution and density changes for individual leaf infestations of *Tetranychus mcdanieli* originating fro msingle introductions of 1 (3A), 2 (3B), 4 (3C), 16 (3D female mites, one periodic release treatment of 1 adult female mite/day (3E) and a combined slope comparison of all treatments (3F).

started by a single infestation rather than a periodic introduction of prey mites (Fig. 3 A-D). (5) Depending on the number of prey introduced initially, the period of time that preferred stages would be available to predators was lessened and the slope of decreasing stage favorability was steeper as the introduction density of mites was increased (Fig. 3F).

Discussion.— These experiments had implications to the colonization of apple leaves by prey populations under field conditions. Previous population studies in a *T. occidentalis-Tet. mcdanieli* system (Croft, 1970;[4] Croft and Barnes, 1972) indicated that most often the initial contact and subsequent numerical increases of predator populations were begun in early spring as prey populations were beginning to increase and total tree densities were low (<5 prey mites/leaf, but individual leaf densities may be high). During this period, the stage distribution of the prey would be optimally favorable for the numerical response of the predator. This factor undoubtedly contributes to a rapid numerical increase of predators and the remarkable ability of *T. occidentalis* to control *Tet. mcdanieli* populations during early season (Croft and McMurtry, 1972b).

Also, during early season, populations of *Tet. mcdanieli* show considerable developmental synchronization as generations are somewhat discrete. Samples (total tree estimates) taken prior to the maturity of the first generation of prey mites will often include leaves where the proportion of late nymphal newly and molted adult mites is high (Croft, unpublished data). These conditions of less favorable stage distribution only persist for short periods in early spring when temperatures are low.

A comparison of slope differences at each introduction density (Fig. 3 E) indicated that the period of time in which a highly favorable stage distribution was present on a leaf, lessened as the introduction density was increased. Data suggest that as prey increased, the prey stage distribution at the leaf, tree, and orchard levels would also become less favorable to predator increases.

Seasonal Prey Distribution on Apple Leaves

Methods.— Field samples collected throughout the season were sampled to test the above hypothesis. Leaves were randomly collected from 5 trees at one-month intervals throughout the growing season. A sufficient number of leaves were collected at each sample period to insure that 50 were selected with prey mites present. Mean total tree densities during the summer increased from 0.88-162.3 prey/leaf, but individual leaf densities ranged between 1-1000 prey of all stages.

Results.— Figure 4 represents a plot of the combined percentage of prey in the egg, larval, and protonymphal stages (preferred

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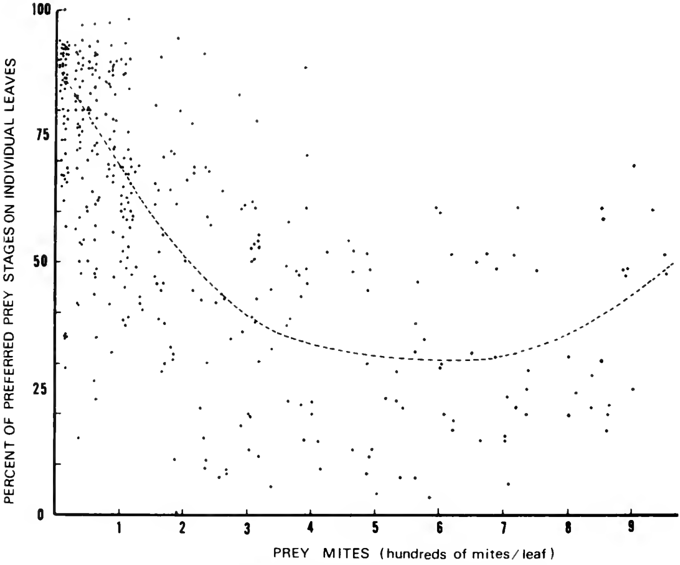
[4] Croft, B. A. 1970*b*. Comparative studies on four strains of *Typhlodromus occidentalis* Nesbitt (Acarina:Phytoseiidae). Doctoral Dissertation, Univ. Calif., Riverside.

prey stages) as related to the density of the total prey population on individual leaves. The broken line in Figure 4 represents the mean percent of preferred prey stages at increasing density levels. A large variation in stage distribution was present on individual leaves at all leaf density levels (Fig. 4). The mean curve declined rapidly as prey density increased from 0-200 mites/leaf, flattened to an almost horizontal line from 200-700 prey/leaf, and upturned slightly between 700-1000 prey/leaf. Although a curve decline occurred at increasing prey densities, the mean percentage of preferred prey remained above 25 percent at all levels and did not attain <10 percent which would result in the magnitude of *r* differences as were reported for eggs and female adult prey in Table 1. The slight upturn at high prey densities (Fig. 4, 700-1000 host/leaf) occurred as the highest prey densities and the more uniform stage distributions developed just before the plant was overexploited by *T. mcdanieli*. As leaves became damaged and were unsuitable food for the spider mites, their density declined and only the larger mature stages were present on the leaves.



Fg. 4. A scatter plot of the combined percentage of eggs, larval and protonymphal stages (preferred stages) of *Tetranychus mcdanieli* as related to the density of spider mite populations on individual apple leaves at Oak Glen, California (1970).

Seasonal Prey Distributions in Trees and an Orchard

Methods.— Changes in prey distribution also were measured throughout the summer of 1970 in the 5 trees selected for the previous test. Twenty leaves were collected as described by Croft and Barnes (1971) from each tree at two-week intervals throughout the season. The number of each stage type on all leaves were counted at each interval. Density relationships at tree and orchard levels were also estimated.

Results and Discussion.— Figure 5 presents the combined percentage of eggs, larvae, and protonymphs (preferred prey stages) present in two of the trees where fluctuations in stage distribution were the greatest and a mean measurement for the entire orchard (5 trees). As expected, data for the individual trees were more variable than was the orchard measurement. Individual tree and orchard data did not reflect the extreme stage distribution differences that were observed in the individual leaf samples. This probably was due to the temporal heterogeneity between individual leaf interaction within any given tree and the masking effects of lumping individual leaf counts together. However, individual tree and orchard curves did show a rapid rise to a peak of host favorability during the initial phases of colonization, a slow decline during the midseason, and a rapid decline at the end of the growing season.

From a biological control standpoint, the most favorable time for predators to numerically respond and enact control of the prey would be when prey density had just surpassed the minimum density required to maintain an increasing predator population (Fig. 5). Subsequent increasing predator population would encounter less favorable prey stages and denser populations. Also, *Tet. mcdanieli* populations at Oak Glen in 1970 (Fig. 5) attained a lower density and developed later in the season when compared to the dynamics of this species in 1968 or 1969. In seasons that prey populations attain high densities earlier in the season, less favorable stage distri-

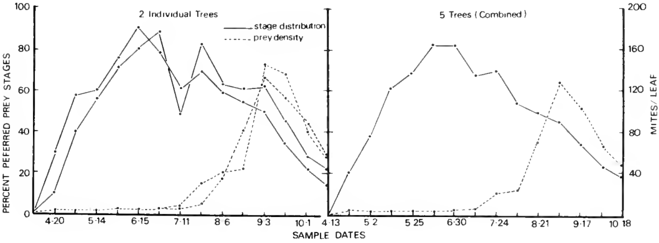


Fig. 5. The combined percentage of eggs, larvae, and protonymphs (preferred prey stages) and total population density of *Tetranychus mcdanieli* in 2 individual apple trees and an apple orchard (mean of 5 trees) at Oak Glen, California (1970).

bution probably would be present earlier and over a greater period of time.

CONCLUSIONS

The studies discussed in this paper demonstrate that prey stage distribution of *Tet. mcdanieli* and *Tet. pacificus* is an important factor influencing the numerical increase of *T. occidentalis* in small interaction arenas (apple leaves, 6 x 6 cm construction paper substrates). The direct effect of this factor at larger interaction levels (apple trees and orchards) was not obtained. This effect is likely a complex function of stage distributions, densities, dispersal patterns, and spatial distributions for both predators and prey and other interacting features of the entire predator-prey-host plant system. However, measures of prey stage distribution, in the absence of predators, suggested possible types that *T. occidentalis* would encounter in enacting control of *Tet. mcdanieli.*

At low and intermediate densities, prey stage distributions were optimally and generally favorable for the numerical increase of predators. During short periods early in the season as prey generations were synchronized and as prey densities became high or overwintering conditions approached, the stage distribution became less favorable for the numerical increase of predators.

It is likely that the prolonged periods of prey stage favorability contributes to the ability of *T. occidentalis* to numerically respond at a rapid rate in early or midseason. However, it is unclear from these studies if the period of prey stage unfavorability is ever of a duration or magnitude to have a significant effect on the rate of numerical response in predator populations. Also, the temporal asynchrony between leaf interactions may be sufficient to dampen the effect of these differences on the mean rate of predator increase at the tree and orchard levels. From an applied biological control consideration, the effects of unfavorable stage distributions would most often occur at high densities. Effective control interactions should have occurred long before these destructive prey levels were attained. For mass release programs, the most favorable period for predator release would be shortly after a minimum prey density to sustain a numerical increase of predators was attained. Not only would pest density be reduced, but a highly favorable prey stage distribution would be available to the released predators.

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A REVISION OF THE *PSORALEA LANCEOLATA* COMPLEX (LEGUMINOSAE)[1]

C. A. Toft[2] and S. L. Welsh[3]

ABSTRACT.— The *Psoralea lanceolata* complex is widely distributed in western North America from Saskatchewan to Texas and westward to Washington, Oregon, Nevada, and Arizona. The complex has received many interpretations, mostly on the basis of provincial floras and manuals. The present paper attempts to summarize the treatments of previous workers and to present an overview of the complex. The *Psoralea lanceolata* var. *stenophylla* is proposed. Distribution maps and illustrations of all entities are included.

The lemon scurf-pea or lemon-weed, *Psoralea lanceolata*, is a plant of arid regions and of sandy soils. It often invades disturbed sites and is an important pioneer on sand dunes, making it a significant plant in erosion control (Hopkins, 1951; Huelett and Coupland, 1966). The *P. lanceolata* complex is notable for its intraspecific variability (Isely, 1962; Matthews, 1969); indeed the variation within the complex has never been well understood or well documented. The treatment by Rydberg (1919) is the most recent work on *Psoralea* of North America, and his proliferation of species within this complex attests to its wide variation and to the inadequate understanding of that variation. More recent treatments of *P. lanceolata* have been in the form of regional floras (Boivin, 1967; Harrington, 1954; Hitchcock et al., 1966; Kearney and Peebles, 1960; Munz and Keck, 1959), which in the large part do not have to deal with the overall variation in the *lanceolata* complex. In any case, they are mostly only reiterations of Rydberg's original key, modified very little if at all. The most comprehensive and most recent treatment of *P. lanceolata* is that by Isely (1962). His treatment of *P. lanceolata* is not complete because of its regional nature, and the population of the north central states varies far less than the more western congeners of *P. lanceolata*.

Indications that the knowledge of variation within the *lanceolata* complex is inadequate are provided by specimens which do not fit well into the established concept of *P. lanceolata*. These specimens have been collected by a number of people at unrelated times and places and were consequently housed at various herbaria. It is the purpose of this study to examine in detail the variation within the *P. lanceolata* complex and to elucidate a current concept of this group. From the data gained in this study, it has been necessary to modify the key to embrace the actual rather than the purported variation within the group and to propose a new combination in recognition of a distinct infraspecific population of *P. lanceolata*.

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METHODS

Herbarium specimens of *P. lanceolata* from the herbaria of Brigham Young University, Utah State University, University of Utah, and Iowa State University were examined. Acknowledgments are hereby made to the curators of the herbaria of these institutions. Various measurements and data were recorded from the specimens in an attempt to enumerate evident variation within the complex. The following data were recorded: (1) measurements of the length and width of the leaflets and calculation from the measurements of the ratios and the means of the ratios for various populations; (2) measurements of raceme and peduncle length and number of flower nodes per raceme and calculation of the ratios of the measurements to each other; (3) flower color; (4) the condition of pubescence of the pod; (5) time of flowering; (6) collection locality of each specimen; (7) chemotaxonomy of the alkaloids, flavanoids, and phenols of selected populations.

In addition, opportunity was taken to observe populations in the field, because the authors acknowledge the limitations of herbarium specimens in this type study. Collections for herbarium specimens are usually of only one plant or occasionally a small number of plants, and often these are not of the average type but rather of the most robust or most unusual specimen. Nearly the opposite conditions are required for an objective study of variation, specifically: large, random, and unbiased samples. However, the herbarium specimens are still the most important tool, given that their limitations are taken into account and if accurate field observations are used to supplement them.

The composite measurements were evaluated and attempts to correlate the above characters were made using several techniques including polygonal graphs, histograms, scatter diagrams, and range maps. In addition to the evaluation of the statistics of each plant, the authors beforehand separated the herbarium sheets into various piles on a purely visual basis, using "intuition" and accumulated experience with the group. Later, these segregates could be compared with the evaluated data, and in this way not only provide another means of correlation but also help to reduce any bias which might occur.

TAXONOMY

Psoralea lanceolata Pursh Fl. 1814. Amer. Sept. 475.

Erect perennial from creeping branched rootstocks; stems 1-6 dm high (usually 2-3 dm), single or clustered, diffusely branched and often forming bushy clumps, inconspicuously strigose, glandular-punctate, aromatic; leaves mostly palmately 3-foliate; leaflets 1.5-4 cm long, the basal ones obovate to oblanceolate, narrower upward, the uppermost linear or remaining oblanceolate, acute to rounded or mucronate at apex, rounded to cuneate at base, strongly glandular-punctate, petioles 1-2.5 cm long; stipules linear-lanceolate to subulate, 3-10 mm long; peduncles 2-24 cm long, from barely exceeding

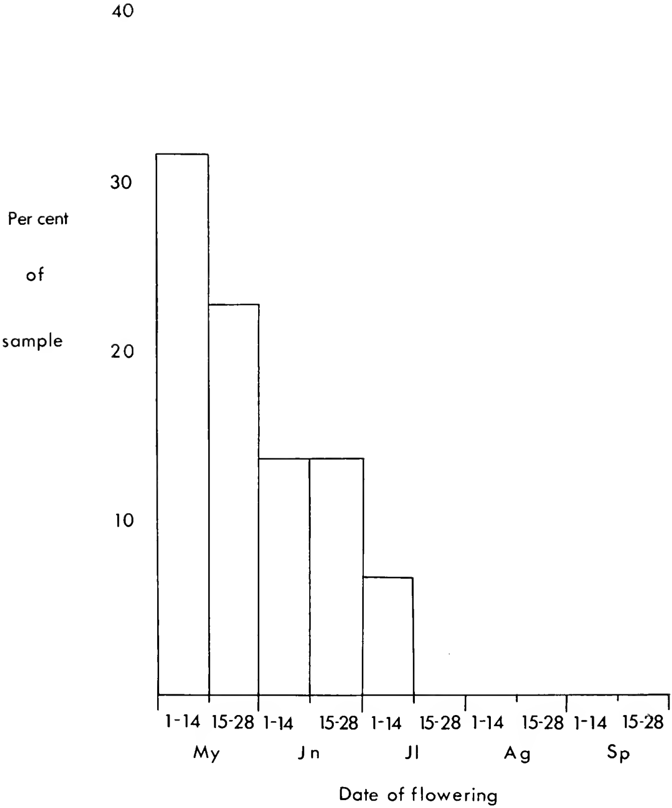

Fig. 1. Distribution of flowering dates of *Psoralea lanceolata* var. *stenophylla*.

the leaves to nearly as tall as the plant; racemes 0.5-17 cm long, from compact and short to lax and elongate; bracts minute, early deciduous; calyx campanulate, inconspicuously strigose, 2 mm long, not enlarging in fruit, teeth nearly equal, shorter than the tube, obtuse, glandular-punctate; corolla 3-7 mm long, whitish with purple-tipped keel or entire corolla dark blue to violet, banner almost orbicular, but with distinct auricles, blades of the wings obliquely oblong-oblanceolate, keel-petals scarcely lobed at base; stigma capitate, fruit exposed, subglobose when mature, with short beak, 4-6

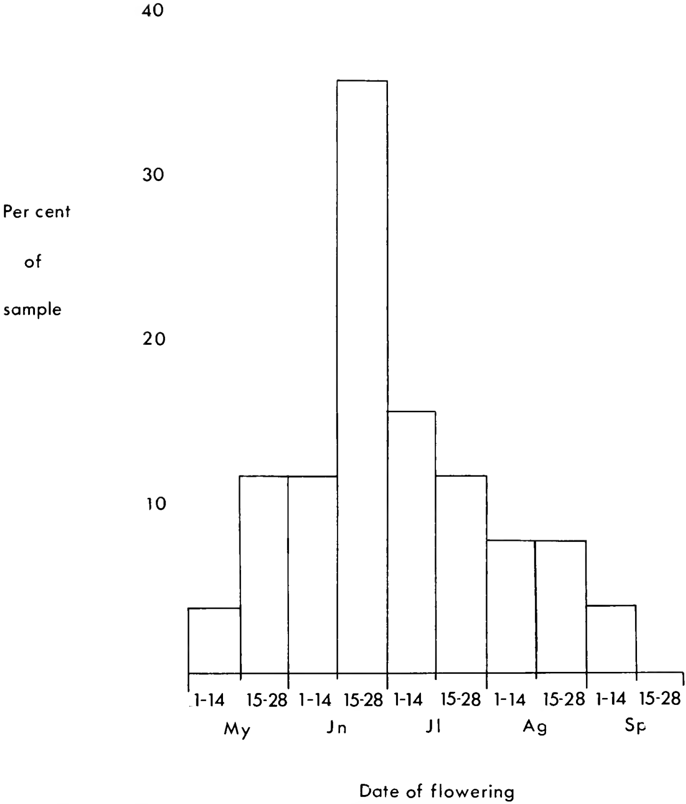

Fig. 2. Distribution of flowering dates of *Psoralea lanceolata* var. *lanceolata* within same geographical area as var. *stenophylla*.

mm in diameter, conspicuously glandular-warty, sparingly strigose to densely villous, pericarp rigid, not breaking at maturity.

Distribution and Habitat.— Saskatchewan, North Dakota, South Dakota, south to Texas, west to Washington, Oregon, California, Arizona. This species occupies a variety of habitats, almost all of which show signs of disturbance. In the eastern portion of its range, it may occupy native prairie (Isely, 1962). In arid regions, it is often found on sand dunes and in other sandy areas. However, where moisture is readily available, it may become weedy and aggressive. It is often found on roadsides, bottomlands, and other disturbed areas (Isely, 1962).

DISCUSSION.— In addition to the well-documented variation in leaflet width (Isely, 1962), the present study has indicated two significant types of phenotypic variation in the complex that were previously overlooked. They are flower color and raceme length. No flora or treatise which the authors have studied has acknowledged that *P. lanceolata* may have dark blue or violet flowers. Indeed, in regions where *P. lanceolata* and *P. tenuiflora* occur together, the regional keys are written in such a way that flower color separates the two species (Isely, 1962; Rydberg, 1919; Tidestrom and Kittell, 1941), with *P. lanceolata* having white flowers with purple-tipped keels and *P. tenuiflora* having dark blue or violet flowers. However, in the populations west of the Rocky Mountains, the blue flowered form may be far more prevalent than the white. In *P. lanceolata* var. *purshii*, the blue flowered individuals seem to be more common over most of its range. Also, in some small pockets of the Great Basin *P. lanceolata*, the two color phases grow side by side. This condition occurs in the *P. lanceolata* population of the white sand dunes of Juab County, Utah. In this isolated population, the specimens of *P. lanceolata*, which grow densely in the interdune areas, are mostly blue flowered; however, a white flowered form occurs on the edge of a blue flowered population. A similar situation occurs in Garfield County, Utah, and probably in other isolated pockets as well.

The variable raceme was recognized by Rydberg who named two species from the *lanceolata* complex on the basis of the lax and elongate raceme, *P. stenostachys* and *P. stenophylla*, respectively. However, subsequent authors have ignored raceme variability. In the present study raceme variation was investigated and found to be significant.

For the most part the total inflorescence length is quite variable; however, the flowers are almost always densely clustered on the raceme (Fig. 3). An exception to this was found in the population in southern and eastern Utah. In Utah there are two distinct forms of *lanceolata*, one which is typical with a dense raceme and one which has a very lax raceme (Fig. 3). The authors believe that this latter form is distinct and a separate entity from typical *lanceolata* for the following reasons: (1) It occurs only in a restricted geographic location, whereas typical *lanceolata* occurs uniformly over a much wider area (Figs. 3, 4). (2) The authors have never observed the phase with the lax raceme growing in the same habitat with typical *P. lanceolata*, even though the two types are apparently sympatric when plotted on distribution maps. It appears, therefore, that there is segregation of the phases on an ecological basis. (3) The phase with the lax raceme appears by all evidence to bloom at an earlier date than the typical *P. lanceolata* in that area (Figs. 1 and 2 summarize collection dates taken from specimens in flower on herbarium sheets for all plants collected in the area where the two forms are sympatric, i.e., Kane, Garfield, San Juan, Wayne, and Grand

FIG. 3

Fig. 3. Summary of variation within the *Psoralea lanceolata* complex. A. var. *purshii*. Flowers (predominantly blue), racemes compact, pods densely villous, leaflets broad, uniform. B. var. *purshii* - var. *lanceolata* intermediates. Pods strigose, leaflets intermediate. C. var. *lanceolata*. Flowers predominantly white, racemes compact, pods sparingly strigose, leaflets narrow, variable. D. var. *stenophylla*. Flowers predominantly blue, racemes elongate, pods sparingly strigose, leaflets narrow, variable. E. var. *lanceolata*, western phase. Flowers commonly blue, racemes compact, pods sparingly strigose, leaflets narrow, variable.

counties of Utah). (4) The entity with lax racemes is morphologically well separated from typical *P. lanceolata*, and intermediate forms have not been observed.

The phase with the elongate raceme is the same entity which was described by Rydberg as *Psoralea stenophylla.* Thus, the correct name for this entity is *Psoralea lanceolata* var. *stenophylla* (Rydb.) Toft and Welsh comb. nov., based on *Psoralea stenophylla* Bull. Torr. Club 40:46. 1913.

A brief investigation of the alkaloid, flavinoid, and phenol chemotaxonomy was made. A solvent system of butanol-acetic acid-water (4:1:5) was used, and spots were detected by Dragendorf's reagent for the alkaloids and by ultraviolet light for the flavinoids and phenols. It was found that the infraspecific populations of *P. lanceolata* did not differ significantly in any of these. However, a spot detected by Dragendorf's reagent, presumably an alkaloid,

FIG. 4

Fig. 4. Range of *Psoralea lanceolata* Pursh and *P. juncea* Eastw.
P. lanceolata var. *lanceolata* and var. *purshii* (solid dot).
P. lanceolata var. *stenophylla* (star).
P. juncea (asterisk).

was present in *P. lanceolata* samples at Rf = 0.4 and was missing for samples of *P. juncea*. Unfortunately, not all varieties of *P. lanceolata* could be investigated to determine if this spot had any taxonomic significance.

A key which embraces the variation in this study is proposed in order to distinguish *Psoralea tenuiflora* and *P. juncea* from *P. lanceolata* which may be readily confused with the former two in taxonomic treatments.

1. Plants dropping all but a few basal leaves by flowering time; raceme extremely elongate, almost as tall as plant; flowers usually dark blue; southeastern Utah and northern Arizona .... *juncea* Eastw.

1.′ Plants retaining leaves at flowering time; racemes variable, not usually as tall as plant; flower color variable, white or dark blue; distribution various 2

2.(1) Fruits ovoid-elliptical; racemes lax, usually three flowers to a node; corolla dark blue; leaflets nearly uniform in size from base to top of plant, narrowly to broadly obovate to oblong .... *tenuiflora* Pursh

2.′ Fruits subglobose; racemes variable, from densely clustered to lax, usually two flowers to a node; corolla variable, either white with a purple keel or entire corolla blue to violet (latter, common west of Rockies); leaflets variable from top to bottom on same plant, basal ones obovate to oblanceolate, those near the top of the plant narrowly linear .... *lanceolata* Pursh

Key to the varieties of *Psoralea lanceolata* Pursh

1\. Leaflets obovate at base to oblanceolate at top of plant; leaflet variation from base to top of plant only slight; fruits densely villose or, less commonly, sparingly strigose; plants of Idaho, Nevada, Washington, Oregon .... var. *purshii*

1.′ Leaflets oblanceolate to linear at base, linear to narrowly linear at top; leaflet variation from base to top may be pronounced; fruits slightly strigose 2

2.(1) Racemes dense, flowers clustered closely; flowers white with purple keel (common in eastern portion of range) or entire flower dark blue to violet; typical *lanceolata* with wide range from Saskatchewan, North Dakota, South Dakota, south to Texas, and west to Utah and Arizona .... var. *lanceolata*

2.′ Racemes lax, the flower nodes widely separated, the inflorescence extremely elongate; blue flowers predominating; known only from arid regions of southern and eastern Utah .... var. *stenophylla*

Psoralea lanceolata var. *purshii* (Vail) Piper, Piper & Beattie. 1901. Fl. Palouse Reg. 106.

Lotodes ellipticum var. *latifolium* Kuntze. 1891. Rev. Gen. 1:193.
Psoralea purshii Vail. 1894. Bull, Torr. Club 21:94.
Psoralea scabra Nutt. 1838. *In* T. and G. Fl. N. Amer. 1:300.
Psoralea lanceolata Pursh ssp. *scabra* (Nutt. T. & G.) Piper. 1906. Contr. U.S. Nat. Herb. 11:364.
Psoralidium purshii (Vail) Rydb. 1919. N. Amer. Fl. 24:14.

Description.— Differing from typical *P. lanceolata* in having broader leaflets, basal leaflets obovate, narrower upward, the uppermost oblanceolate, leaflet variation from top to base of plant only slight; racemes dense, flowers predominantly dark blue to violet, less commonly white with purple keel; fruits densely villose, less commonly, sparingly strigose.

Distribution and Habitat.— Idaho, Nevada, Washington, Oregon. Sandy areas often associated with *Artemisia* (Munz and Keck, 1959; Tidestrom, 1925).

Flowering Time.— May to July.

Discussion.—Data gained from leaflet measurement in this study reconfirm the previously recognized var. *purshii* (Isely, 1962;

Munz and Keck, 1959; Tidestrom, 1925) in the northwestern part of the range of the complex, a variety which has broader leaflets and more uniform leaflets from the top to the base of the plant than in var. *lanceolata*. In a restricted area in northern Utah and southeastern Idaho var. *purshii* and var. *lanceolata* appear to be intergrading (Fig. 3).

Representative Specimens.— California. Mono Co.: Reveal 526 (utc); Idaho. Bingham Co.: Cronquist 2312 (utc); Davis 1508 (utc); Holmgren s.n. (utc). Butte Co.; Atwood 913 (bry); Atwood 1167 (bry). Elmore Co.: Maguire and Holmgren s.n. (utc). Fremont Co.: Maguire 17178 (utc); Raven and Gregory 19562 (isc). Jefferson Co.: Anderson 302 (utc); Atwood 996 (bry); Bench s.n. (bry). Owyhee Co.: Davis 854 (utc); Maguire and Holmgren 26264 (utc). Nevada. Elko Co.: Holmgren 517 (bry, utc). Humbolt Co.: Constance, Molseed, and Ornduff 3695 (bry, utc); Gentry and Davidse 1539 (bry, utc, isc); Holmgren and Maguire 10605 (utc); Maguire and Holmgren 22481 (utc); Moran s.n. (bry). Oregon. Morrow Co.: Cronquist s.n. (utc); Sherman Co.: Constance and Beetle 2687 (utc). Washington. Grant Co.: Moran s.n. (bry). Kittitas Co.: Maguire 17239 (utc); Klickitat Co.: Suksdorf s.n. (isc).

Psoralea lanceolata var. *lanceolata*

P. lanceolata Pursh. 1814. Fl. Amer. Sept. 475.
P. elliptica Pursh. 1814. Fl. Amer. Sept. 741.
P. arenaria Nutt. 1818. Gen. 2:103.
P. laxiflora Nutt. 1838. *In* T. and G. Fl. N. Amer. 1:299.
P. micrantha Gray. 1857. *In* Torr. Pacif. R.R. Rep. 4:77.
Lotodes ellipticum (Pursh) Kuntze var. *angustissium* Kuntze. 1891. Rev. Gen. 1:193.
Lotodes micrantha (Gray) Kuntze. 1891. Rev. Gen. 194.
P. stenostachys Rydb. 1913. Bull. Torr. Club 40:46.
Psoralidium lanceolatum (Pursh) Rydb. 1919. N. Amer. Fl. 24:13.
Psoralidium micranthum (Gray) Rydb. 1919. N. Amer. Fl. 24:14.
Psoralidium stenostachys Rydb. 1919. N. Amer. Fl. 24:14.

Description.— This is the typical and most widespread form of *P. lanceolata*. Leaflets oblanceolate to linear at base, narrower upward; leaflet variation from base to top may be pronounced; racemes dense, flowers closely clustered or less commonly lax; corolla white with purple-tipped keel (common in eastern portion of range) or entire corolla dark blue to violet (common in western portion of range); fruit sparingly strigose.

Distribution.— Saskatchewan, North Dakota, South Dakota, south to Texas, and west to Utah and Arizona.

Representative Specimens.— Arizona. Coconino Co.: Carter 1599 (utc); MacDougal 217 (isc); Toft 144 (bry). Mohave Co.: Deaver 6251 (bry). Colorado. Brown 120 (bry); Alamosa Co.: Isely 8184 (isc); Ramaley and Johnson 14994 (bry). Denver Co.: Letterman s.n. (isc). Douglas Co.: Osterhout and Clokey 3803 (utc, isc). Elbert Co.: Owneby 1369 (utc). El Paso Co.: Jones 142 (utc). Morgan Co.: Isely 6488 (isc). Weld Co.: Welsh, Moore, and Matthews 9320 (BRY). KANSAS. Fairchild s.n. 1888 (ISC); Hurr E287 (ISC). Edwards Co.: Welsh 665 (BRY, ISC). Osborne Co.: Shear 114 (UTC). MONTANA. Dawson Co.: Aeton s.n. (ISC). NEBRASKA. Banner Co.: Welsh 1067 (ISC). Box Butte Co.: Churchill s.n. (ISC); Welsh 1077 (BRY, ISC). Cherry Co.: Tolstead 4-470 (ISC); Tolstead 380 (ISC). Dawes Co.: Tolstead s.n. (ISC). Holt Co.: Burzlaff s.n. (UTC). Kearney Co.: Hapeman s.n. (UTC). Lincoln Co.: Brown 53-6 (ISC). Morril Co.: Maguire s.n. (BRY, UTC). Rock Co.: Clements 2874 (ISC). Sioux Co.: Rittenhouse 206 (UTC). Sheridan Co.: Buchanan s.n. (ISC). Thomas Co.: Isely 6070 (ISC). NEW MEXICO. Colfax Co.: Foster s.n. (ISC). Rio Arriba Co.: Flowers and Hall 130 (BRY). OKLAHOMA. Cimarron Co.: Jespersen 2715 (UTC). Logan Co.: Carleton 151 (UTC). Texas Co.: Isely 6394 (BRY, ISC). Woods Co.: Stratton 1326 (ISC), 6383 (ISC). SASKATCHEWAN. Ledingham and Yip 2225 (ISC). SOUTH DAKOTA. Badlands Natl. Mon.: Lindstrom 329 (BRY). Butte Co.: Brown 52-22 (ISC). Clay Co.: Van Bruggen 5604 (BRY). Todd Co.: Isely 6058 (ISC); Tolstead 4-30 (ISC); Welsh 1095 (ISC). UTAH. Daggett Co.: Smith s.n. (UTC); Smith s.n. (UTC). Emery Co.: Welsh and Atwood 9841 (BRY, ISC). Garfield Co.: Atwood 459 (BRY); Coles 123 (BRY); Collotzi, John, and Atwood 512 (UTC); Holmgren, Reveal, and La France 2044 (BRY, UTC); Stanton 335 (BRY, UT); Woodruff 1179 (BRY). Grand Co.: Jotter 2098 (UT); Rydberg and Garrett s.n. (UT); Welsh and Atwood 9949 (BRY, ISC); Welsh and Moore 2027 (BRY). Juab Co.: Harrison 11350 (BRY); Harrison 6550 (BRY, ISC); Harrison 354H (BRY, ISC); Harrison 11777 (BRY, ISC, UTC); Smigelski 63 (BRY); Smigelski 67 (BRY); Toft 17 (BRY); Toft 16 (BRY); Toft 148 (BRY); Toft 149 (BRY); Welsh and Moore 5128 (BRY). Kane Co.: Barnum 1324 (BRY); Castle 170C (BRY); Cottam 2712 (BRY); Harrison 11077 (BRY); Holmgren and Nelson 7191 (UTC); Maguire 12292 (BRY, UTC); Maguire 18893 (UTC); Toft 135 (BRY); Toft 136 (BRY); Toft 137 (BRY); Toft 139 (BRY); Toft 142 (BRY); Toft 143 (BRY); Welsh 1696 (BRY, ISC); Welsh and Welsh 9431 (BRY). Millard Co.: Cottam 1006 (BRY); Cottam 3782 (BRY, UT); Garrett 3937 (BRY, UT). Salt Lake Co.: Dunn 1940 (BRY); Harrison 10586 (BRY, UT, UTC); Howard s.n. (UT); McKnight 10586 (ISC). San Juan Co.: Cottam 5962 (UT); Welsh, Moore, and Canter 2927 (BRY); Welsh, Moore, and Canter 3010 (BRY, ISC). Tooele Co.: Flowers 898 (UT); Flowers 8 (BRY, UT). Uintah Co.: Jones s.n. (UTC); Welsh 446 (BRY). Washington Co.: Pendleton s.n. (UT); Weight 9192 (UT); Weight 10903 (UT). Wayne Co.: Beck and McArthur 150 (BRY); Cottam 4476 (BRY, UT); Holmgren, Boyle, and Will 7792 (UTC); Maguire 19251 (UTC); Markham s.n. (BRY); Welsh and Atwood 9850 (BRY, ISC); Welsh and Moore 3595 (BRY). Weber Co.: Brizzee 7814 (UT); Flowers 1277 (UT); Garrett 6289 (BRY, UT). WYOMING. Crook Co.: Porter and Porter 7574 (UTC). Carbon Co.: Porter 3725 (UTC). Natrona Co.: Gooding 177 (UTC, ISC); Isely 6535 (ISC); Welsh, Moore, and Matthews 9217 (BRY). Niobrara Co.: Isely 3948 (BRY, ISC). Park Co.: Greever 32 (BRY).

Psoralea lanceolata var. *stenophylla* (Rydb.) Toft and Walsh Comb. nov.

Psoralea stenophylla Rydb. 1913. Bull. Torr. Club 40:46.
Psoralidium stenophyllum Rydb. 1919. N. Amer. Fl. 24:14.

Description.— Differing from typical *lanceolata* in having elongate and lax racemes, flower nodes widely separated; flowers most commonly dark blue to violet; leaflets oblanceolate to linear at base, narrower upward, leaflet variation from base to top may be pronounced; fruits sparingly strigose.

Distribution and Habitat.— Known only from arid regions of southern and eastern Utah, i.e., Emery, Wayne, Garfield, Kane, Grand, and San Juan counties. This form is almost always found growing in sandy soils: on roadsides, in canyon and wash bottoms, talus slopes, and sandstone cliffs. It has been reported to be associated with *Amelanchier*, *Chrysothamnus*, *Coleogyne*, *Artemisia*, *Pinus*, *Juniperus*, *Quercus*, *Phragmites*, *Rhamnus*, and *Vanclevia*.

Flowering Time.— This form appears to bloom at an earlier date than typical *lanceolata* (Figs. 1, 2), beginning in early May and tapering off by mid-June.

Discussion.— Records for *P. lanceloata* var. *stenophylla* and those for *P. juncea*, an endemic plant of southeastern Utah and northern Arizona are largely sympatric (Fig. 4). This range correlation and a similarity in morphology, where var. *stenophylla* appears to be intermediate in raceme length between *P. juncea* and *P. lanceolata* var. *lanceolata*, suggest the possibility that var. *stenophylla* may be the product of hybridization between these two. However, this assertion cannot safely be made until more detailed study is made and actual hybridization attempted; thus, the authors are merely posing the question here as an impetus to further study.

Representative Specimens.— Utah. Garfield Co.: Holmgren and Goddard 9955 (ut); Kaneko 28 (bry); Welsh and Moore 7110 (bry, isc). Grand Co.: Harrison 11367 (bry). Kane Co.: Beck and Tanner s.n. (bry); Harrison 12114 (bry); Murdock 371 (bry); Welsh 1689 (bry). San Juan Co.: Welsh 5387 (bry, isc); Wilson 120 (utc). Wayne Co.: Beck s.n. (bry, isc); Cottam 9275 (ut); Welsh and Atwood 9879 (bry, isc).

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OBSERVATIONS ON THE NESTING BIOLOGY OF THE LONG-BILLED CURLEW

Dennis M. Forsythe[1]

Abstract.— Observations were made on four nesting attempts by Long-billed Curlews (*Numenius americanus*) in 1965 and 1966 in Box Elder and Cache Counties, Utah. The location, nest composition, and number of eggs of each nest are presented. In one instance eggs were laid at intervals of forty-eight hours or less. Data on weight and measurement and color of eggs are given. Data for the only two completed nests indicates incubation periods of twenty-seven and twenty-eight days respectively. The distraction display of the incubatng family is descrbed for the first time.

Both Palmer (1967) and Graul (1971) emphasized the lack of information on the breeding biology of the long-billed curlew (*Numenius americanus*). For this reason the following nesting data are presented on four pairs of curlews gathered during the 1965 and 1966 breeding seasons in Box Elder County and Cache County, Utah.

On 15 May 1965, Jack Andersen discovered a curlew nest in a grass pasture, elevation 4500 ft, situated on a bench representing the shoreline of old Lake Bonneville, two miles N of Mendon, Cache County. The nest consisted of a grass-lined depression with an inside diameter of 190 mm, which was located in a clump of grass (Gramineae) and sedge (Cyperaceae). When found, it contained two eggs whose color and pattern were as described by Reed (1965:125) and Bent (1929:101). At 17:45 on 17 May, I visited the nest and found three eggs which I color-marked. Between 17 May and 23 May, when the nest was destroyed by a farm tractor, no additional eggs were laid. Palmer (1967:183-184) gives a clutch-size of four for this species. The above data indicate the greatest interval possible between the addition of the second and third egg was 48 hours which is somewhat greater than Graul's (1971:193) observation. Also the eggs had been rotated in the nest at least once between 17 May and 22 May. On three daytime visits out of five I found a bird of undetermined sex incubating. On 17 May when I flushed a bird from the nest, it silently flew low over the ground with its tail spread, both wing tips touching the ground and neck perpendicular to the ground. No other curlews were seen in the vicinity of this nest during any visit.

K. L. Shirly found a second nest in the salt flats, elevation 4000 ft, adjacent to the Bear River, eight miles W of Brigham City, Box Elder County, at 0600 on 1 May 1966. The nest cup, constructed of desert saltgrass (*Distichlis stricta*), was located in a clump of dead saltgrass and samphire (*Salicornia rubra*). The nest contained three eggs of normal color and pattern. On 7 May at 0600, K. L. Shirly and I visited the nest and found the female incubating. This species is noticeably sexually dimorphic in size, especially the length of the

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exposed culmen (unpublished data). When we approached the curlew, it flushed from the nest in a manner similar to that described above. When 50 meters from the nest, the curlew stopped, then dragged one wing on the ground, then the other, then both. On occasion it would jump off the ground, then run along the ground with neck outstretched and bill touching the ground. This behavior lasted about one minute until the male appeared and circled over our heads giving the *Ki-keck* call (Forsythe 1970:215). The female answered with the *Curluoo* call (Forsythe 1970:215). They were joined by two males giving the *Ki-keck* call. The four birds proceeded in mobbing behavior as described by LaFave (1954:48). This lasted until we left the area 15 minutes later. When I visited the nest on 24 May, it had been destroyed by unknown causes leaving no trace of nest or eggs. No adult birds were observed in the vicinity.

I found a third nest of this species at 1600 on 3 May 1966 in an irrigated grass pasture, 4000 ft elevation, 3.3 miles W of Logan Post Office, Cache County. The nest, containing four eggs, was composed of various grasses and situated on a slight rise in the field. Both sexes incubated but only the female gave diversionary displays when flushed from the nest. These displays were similar to those already described except the bird looked back at the observer with its neck perpendicular to the ground. The eggs hatched between 0700 on 21 May and 1600 on 23 May. If we assume that they hatched at the earlier time and that eggs were laid at two-day intervals, the incubation period would be around 28 days.

K. L. Shirly and I found the last nest at 0700 on 7 May 1966 in the salt flats next to the Bear River, 10 miles W of Brigham City, Box Elder County. The location and placement of this nest were similar to those described for the 1 May nest. The nest contained four eggs. On 24 May at 0600 as I got out of the car about 150 meters south of the nest, the male was sitting on a fence post 30 meters from me. As I approached the nest, the male gave several *Curuloo* calls. The female, neck outstretched with body low and bill parallel to the ground, walked slowly off the nest toward the north. When I approached, the female flushed and gave the diversionary display with both wings. Then the male along with several other curlews mobbed me giving the *Ki-keck* and *Arc Display* calls (Forsythe 1970:214). I returned to the nest and found one egg pipped. I marked the eggs and removed them to the laboratory where they were weighed and measured (Table 1). The eggs were a darker green than described by Reed (1965:125). The first egg hatched at 1300, the second at 2025 on 25 May, and the third at 0625 on 26 May. The fourth egg was preserved before hatching and deposited in the vertebrate collection of Utah State University. The egg measurements were similar to those given by Bent (1929:101). All eggs decreased in weight during hatching (Table 1). Other aspects of the hatching process have been described by Forsythe (1967:340). Using a two-day interval between the laying of each egg, and assuming that the fourth egg would have hatched on 26 May, gives an incubation period for this nest of 27 days.

TABLE 1. Weights (g) and measurements (mm) of long-billed curlew eggs.

	Hours prior to hatching			
	36	24	12	0
Egg 1				
Weight		69.0	67.1	56.6
Length	74			
Width	56			
Egg 2				
Weight		68.9	67.1	55.6
Length	74			
Width	51			
Egg 3				
Weight	71.1	68.6		57.6
Length	71			
Width	59			
Egg 4				
Weight	X[2]			
Length	78			
Width	48			

[2] Egg 4 was preserved before it could hatch.

ACKNOWLEDGMENTS

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VEGETATION ZONES AROUND A SMALL POND IN THE WHITE MOUNTAINS OF ARIZONA

B. Ira Judd[1]

Abstract.— Because of a previous study of wet meadows, an investigation of Carnero Lake, White Mountains of Arizona, which is ecologically advancing toward a wet meadow, was undertaken. Information on eutrophication and successional patterns in ponds of the ponderosa pine is needed for better understanding of that ecosystem. Aerial infrared photographs were taken to delineate areas containing aquatic vegetation and as an aid in identifying zones around the pond. Five zones from open water to ponderosa pine were found. Abundance of vegetation by species was estimated in each zone. Protein analyses are given for 29 of the 32 species listed.

The White Mountains of Arizona encompass many small ponds which are used by migrating waterfowl for resting, feeding, and sometimes as nesting sites. Arizona is located in the Pacific Waterfowl Flyway, with most of the birds in the fall migration arriving in middle to late October. Although the state is not known for its abundance of waterfowl, small mountain ponds provide a quality type of waterfowl hunting for local people. Pond is defined here as being an area where wave action is feeble, thereby allowing a continuous vegetation cover to develop around the shoreline.

Deer, elk, and turkey can be seen around the fringes of these ponds, obtaining forage and water. Intergradations of plant communities from the emergent aquatics in the littoral zone to the ponderosa pine on dry land also provide many niches for small birds and mammals. A previous study[2] prompted the investigation of a pond that was geologically advancing toward a wet meadow. Information on eutrophication and successional patterns in ponds in the ponderosa pine is needed for a better understanding of that ecosystem.

The reduction of the Apache menace in the 1870s opened the territory of Arizona to farming and ranching. Concurrently, with the increased use of range lands, rivers and streams were dammed and water diverted for irrigation and mining purposes; one such structure in the White Mountains of Arizona was Tyler Reservoir, created by building a dam on Carnero Creek in 1878. Somewhere along the way, the name was changed to Carnero Lake, possibly by the oldtime Basque sheepherders.

Carnero Springs which empties into the lake is an old Indian prayer spring. In earlier times many prayer beads and arrowheads could be found there. The name Tyler was for Jack (Poker) Tyler, who was an eccentric character of the local neighborhood. The

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[2] Patton, D. R., and B. I. Judd. 1970. The role of wet meadows as wildlife habitat in the Southwest. J. Range Mgmt. 23(4):272-275.

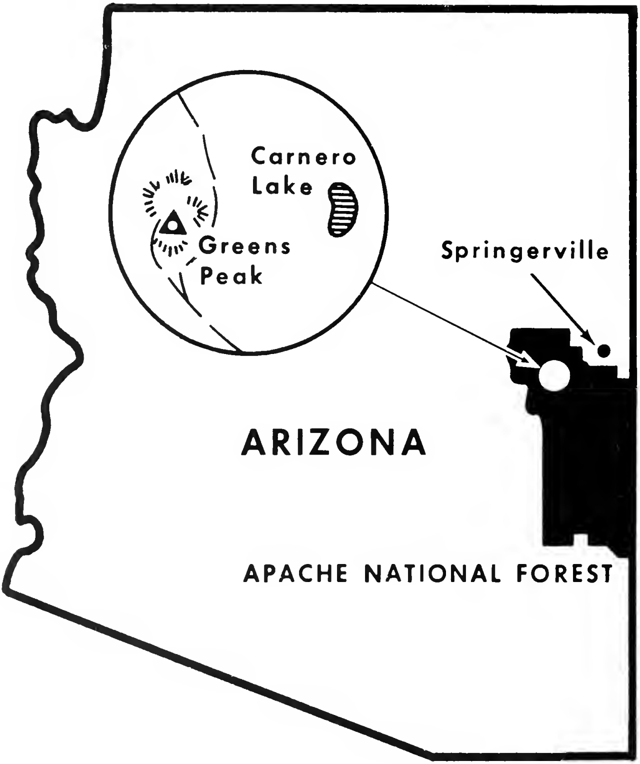

Fig. 1. Carnero Lake, Apache National Forest, Arizona.

reservoir did not contain much water until a filling ditch was constructed in 1913.

Carnero Lake is in the upper edge of the ponderosa pine forest type at an elevation of 8500 feet. It is located approximately three miles east of Green's Peak (Fig. 1). The lake occupies a portion of the eastern third of the SW ¼ of section 6, Township 8 north, Range 27 east of the Gila and Salt River Meridian.

TECHNIQUES

It was evident from reconnaissance visits that there were rather distinct vegetation zones from the pond into the ponderosa pine.

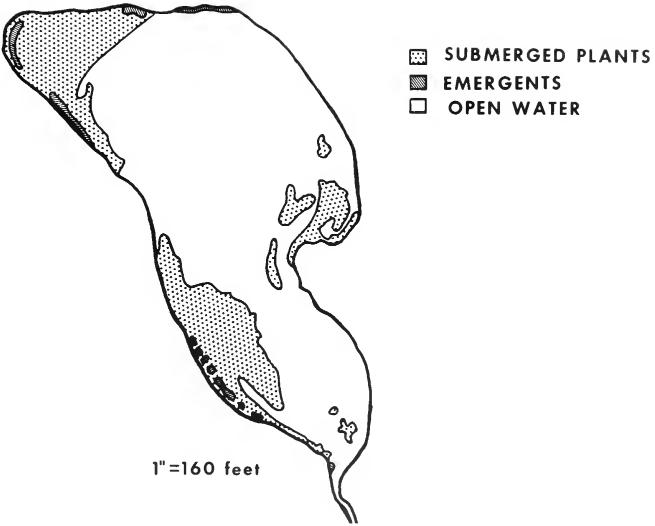

Fig. 2. Location of aquatic vegetation in Carnero Lake.

Abundance of vegetation by species was estimated in each zone as very rare, rare, infrequent, abundant, and very abundant.[3] Each species was collected for reference and a sample taken for protein analysis. Protein samples were composite samples collected in July and August. Aerial infrared photographs were taken to delineate areas containing aquatic vegetation and as an aid in identifying zones around the pond.

RESULTS AND DISCUSSION

Total surface area of Carnero Lake is 7.83 acres. Infrared photographs showed two areas containing aquatic plants. Submerged aquatics occupied 1.76 acres, emergents 0.31 acres, and open water 5.96 acres (Fig. 2).

Five vegetation zones were identified (Fig. 3):

1. Water—containing aquatic plants.
2. Wet—shoreward zone, frequently inundated.
3. Mesic—occasionally inundated, moist part of the time.
4. Intermediate—slightly moist.
5. Forest edge—drier than intermediate.

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[3] OOSTING, H. J. 1942. The study of plant communities. (2nd Ed.). W. H. Freeman, San Francisco.

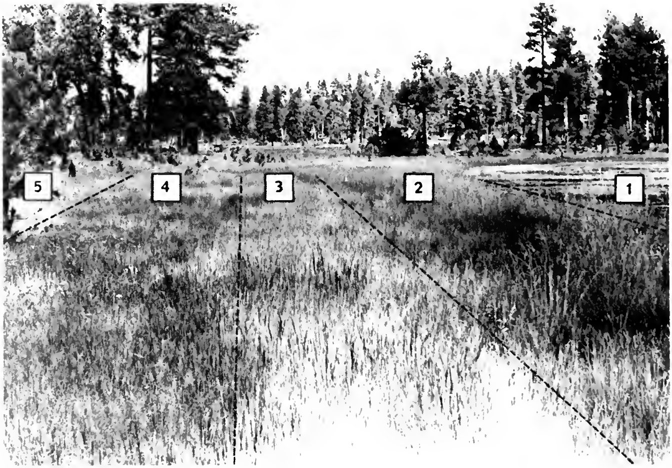

Fig. 3. Vegetation zones from open water to ponderosa pine.

Table 1 lists the species found in each zone with their abundance and protein content. The five zones contained 32 different plant species. Vegetation was well defined on the north side of the pond but the south side had a steeper bank and the zones were not well defined. One of the first species which gains a foothold on sandbars or sloping beach is Needle spikesedge, a small perennial. It is found most abundantly in the Mesic Zone.

It is interesting that Arizona fescue, normally one of the principal grasses under ponderosa pine is also found in a thin belt along the waterline. When the area was visited in early August the fescue next to the water had mature seed heads while plants of the drier site were still green.

Protein is considered the most important animal nutrient and crude protein content of plants can give an indication of forage value for wildlife. From Table 1 it is obvious that protein is variable but in general all zones leading to the forest edge contain some plants high in protein. Two species, watercress and curlydock, had exceptionally high protein content. Little information is available on watercress as a wildlife food but it is not uncommon to see deer foraging on curlydock in meadows.

The zones shown in Fig. 3 represent successful development from open water to ponderosa pine. As the pond fills with sediment and debris, mats form at the edge. Conditions are made unsuitable for the submerged aquatics and sedges and rushes advance centripetally with each zone being repeated from wet to dry conditions.

TABLE 1. List of principal species found at Carnero Lake by zones with percent protein and abundance.

Scientific Name[1]	Common Name	Percent Protein	Abundance[2]	Zone
Myriophyllum exalbescens	Water-milfoil	11.7	5	1
Ranunculus aquatilis	Water buttercup	10.3	5	1
Carex rostrata	Beaked sedge	9.5	3	1
Polygonum amphibium	Water ladysthumb	14.4	5	1
Scripus californicus	California bulrush	6.3	2	1
Carex canescens L.	Sedge	11.2	4	2
Eleocharis macrostachya	Bighead spikesedge	11.3	2	2
Festuca arizonica	Arizona fescue	6.1	3	2
Glyceria borealis	Northern mannagrass	10.8	5	2
Juncus balticus	Wire rush	12.0	4	2
Juncus saximontanus	Rocky Mt. rush	7.9	4	2
Pedicularis grayi	Wood-betony	11.6	3	2
Alopercurus aequalis	Short foxtail	9.2	4	3
Eleocharis acicularis	Needle spikesedge	8.0	2	3
Mentha arvensis L.	Field mint	12.4	4	3
Rorippa sphaerocarpa	Watercress	23.9	3	3
Achillea lanulosa	Western yarrow	14.1	4	4
Agrostis alba	Redtop bentgrass	8.3	5	4
Juncus interior	Inland rush	7.4	4	4
Trifolium pinetorum	Piney clover	10.8	4	4
Agrostis scabra	Winter bentgrass	7.9	5	5
Aster foliaceus	Aster	8.9	4	5
Campanula rotundifolia	Bluebell	**	3	3
Cirsium Parryi (Gray)	Parry thistle	7.2	3	5
Deschampsia caespitosa	Tufted hairgrass	7.4	3	5
Erigeron bellidiastrum	Fleabane	**	4	5
Hordeum brachyantherum	Northern meadow barley	8.1	4	5
Iris missouriensis	Rocky Mt. iris	9.9	4	5
Polygonus bistortoides	American bistort	12.8	3	5
Potentilla hippiana	Horse cinquefoil	11.5	3	5
Rumex crispus	Curlydock	17.1	2	5
Rumex fueginus	Dock	**	1	5

[1] Scientific nomenclature follows Kearney and Peebles (1960).

[2] 1. very rare, 2. rare, 3. infrequent, 4. abundant, and 5. very abundant.

**No data.

With some modification of abundance of individual species succession should follow the pattern below.

Pond

↓

Zone 1	Water-milfoil Water buttercup Water ladysthumb
	↓
Zone 2	Northern mannagrass Wire rush Rocky Mt. rush Carex Short foxtail Field mint
	↓
Zone 3	Redtop bentgrass Western yarrow Inland rush Piney clover
	↓
Zone 4	Winter bentgrass Fleabane Rocky Mt. iris Aster Northern meadow barley
	↓
Zone 5	Forest

ACKNOWLEDGMENT

The author is indebted to David R. Patton, research wildlife biologist, Rocky Mountain Forest and Range Experimental Station, in cooperation with ASU, for his helpful suggestions during the course of the study and wishes to express his sincere appreciation for this assistance.

A NEW SPECIES OF *GYMNODAMAEUS* FROM COLORADO (Acarina: Cryptostigmata, Gymnodamaeidae)[1]

Tyler A. Woolley[2]

Abstract.— The taxonomic history of the genus *Gymnodamaeus* is reviewed for North American species. A new species, *Gymnodamaeus chalazionus*, is described from Colorado and compared with species from both the western and eastern U.S. Among other features, the new species differs from *G. veriornatus* Higgins, 1961, in the shorter interlamellar hairs and the surface structure of the notogaster and genital plates. The new species is also compared with *G. quadricaudatus* Jacot, 1937, *G. pearsei* and *minor* Banks, 1947; with *G. gildersleeveae* and *ornatus* Hammer 1952, from Canada, and with *G. elegantulus* Hammer, 1958, from South America. Twelve scanning electron micrographs are used to delineate some of the details of integument and other features.

Relatively few species of the genus *Gymnodamaeus* have been described in the years subsequent to Berlese's earlier descriptions in 1910, 1916. Grandjean (1928) described *Gymnodamaeus hispanicus* from Spain and differentiated it from all other species described prior to his article on the basis of the ornamentation of the notogaster. He assumed that the surface structure was the result of secreted materials. He also indicated that no descriptions of larvae or nymphs had been made prior to his article, in which he included some descriptions of these stages.

Jacot (1937) described, but did not figure, the species *G. quadricaudatus* from Bent Creek Experimental Forest, N. C., a small form (0.40mm by 0.23mm) with four posterior notogastral nubbins. Banks (1947) described and figured *G. pearsei* and *G. minor* from Duke Forest and Durham, N. C. Hammer (1952) found *G. ornatus* and *G. gildersleeveae* in Canada. Later (1958), she described *G. elegantulus* from the Andes mountains. In the same year, Balogh (1958) described, but did not figure, *G. tunicatus* from tropical Africa.

Higgins (1961) described *G. veriornatus* as a new species from Utah and compared it with Hammer's species from the McKenzie Delta of northern Canada.

Grandjean (1965) discussed the Gymnodamaeoidea as a new superfamily in the context of a subnormal tracheal system, but did not delineate any new species within the family or superfamily.

A collection of mites from Mt. Meeker Camp Ground, Colorado, in 1952 had a series of nine specimens of the genus *Gymnodamaeus*, which at the time were not assignable to a species category. These specimens were later observed and determined to constitute a new species but have remained undescribed until now. The new species has been compared with specimens of *G. veriornatus* and checked against other described species in the literature. With the discovery

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of additional specimens from other locations, and the use of representatives of this species in SEM research, it is expedient that the description be published.

Gymnodamaeus chalazionus, n. sp.

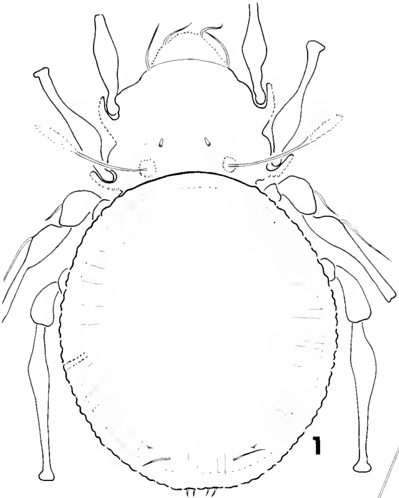
(Figs. 1-5;6-17)

Diagnosis.— With ornate tubercles on both dorsal and ventral surfaces and legs, hence the name *chalazionus*, from the Greek: hailstones, tubercles or knobs (all of which are applicable to the appearance of the tubercles in this instance); interlamellar hairs short, conelike, smooth compared to short, fine, filiform interlamellar hairs in *G. veriornatus;* sensillum clavate, head about twice as broad as in *veriornatus;* medial margins of genital plates toothed, as in *veriornatus*, but plate shorter and wider (see Figs. 4 and 5); without arrangements of six posterior notogastral hairs and reticulate dorsal sculpturing as in *G. veriornatus*, slightly smaller in dimensions than the latter, but both of these species are larger than all other North American species described so far.

Description.— Color dark reddish brown, surface of prodorsum, dorsum of notogaster, venter covered with cerotegument consisting of tubercles; tubercles domelike on dorsum, bothridium and legs (Fig. 6-10), rounded, reticulate, mammiform; tubercles of ventral surface thimble shaped (Figs. 12-15); prodorsum about half as long as notogaster, broadly triangular in shape; rostral and lamellar hairs of about equal length, decurved; lamellae or costulae absent, but a sclerotized line extending medially between lamellar hairs (Fig. 1); interlamellar hairs simple, short, conical, inserted in medial apex of sclerotized, arched, curved bars anteromediad of pseudostigmata; pseudostigmata rounded, with lip erected above surface of prodorsum, covered internally and externally with mammiform tubercles, sensillum clavate, spined, length nearly twice as long as distance between pseudostigmata; tectopedia I and II covered with tubercles.

Hysterosoma nearly rounded in outline, with crenulated margin and wrinkled surface surrounding slightly raised central dome, tubercles arranged in somewhat radiating lines as in drawing (Fig. 1) and SEM micrograph (Fig. 8); posterior margin of notogaster with six hairs and two lyriform pores as indicated in Figure 1.

Camerostome about half the length of propodosoma, mentum broad, rutella narrowed anteriorly; apodemata as shown in Figure 2, ventral setae obscured by integumental covering; apodermata IV arched anteriorly over genital aperture, consisting of a double-ridged arrangement; genital and anal apertures contiguous along entire width; genital covers serrated on medial margin, each cover with 6 genital setae and with nine short medial dentes interlocking covers, surface of covers with tuberculated cerotegument; a sclerotized ring around genital aperture and continuous with similar ring around anal aperture; anal covers longer than wide, with tuberculated cerotegument.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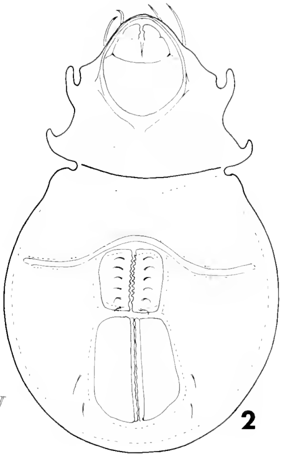
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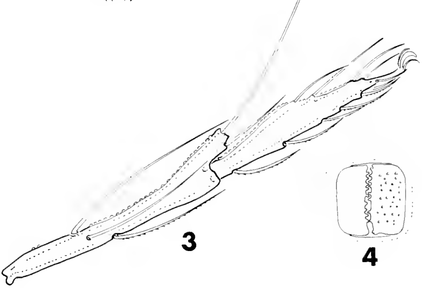
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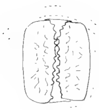
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Figs. 1-4. *Gymnodamaeus chalazionus*: 1, dorsal aspect, legs partially omitted; 2, ventral aspect, legs omitted; 3, tibia and tarsus of leg I of female specimen; 4, genital plates.

Fig. 5. *Gymnodamaeus veriornatus* genital plates, drawn to same scale as Figure 4.

Legs with elongated articles, surface covered with mammiform tuberculated integument, similar tubercles on hairs; tibia of leg I with elongated apophysis from which solenidion emerges (Fig. 3); all legs heterotridactylous, median claw larger than laterals.

Measurements.— Of the measurable specimens, the size

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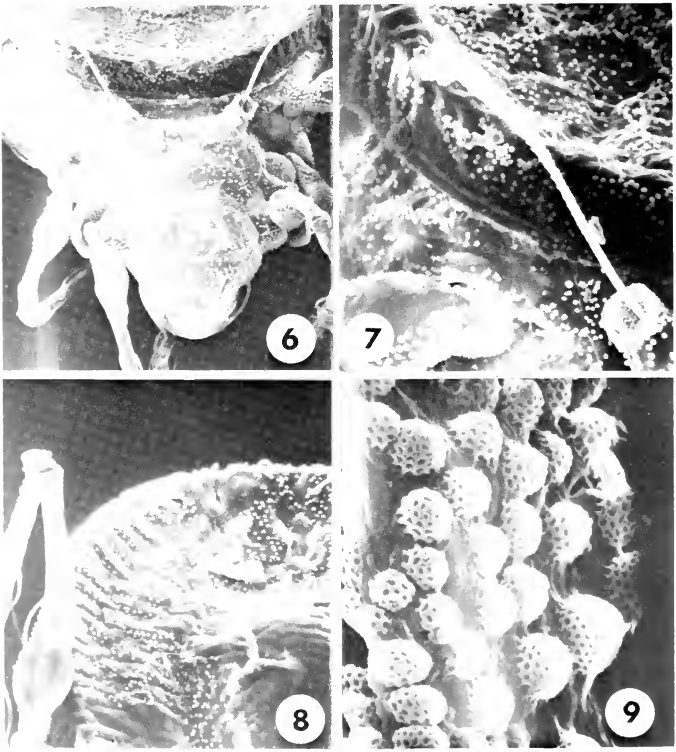
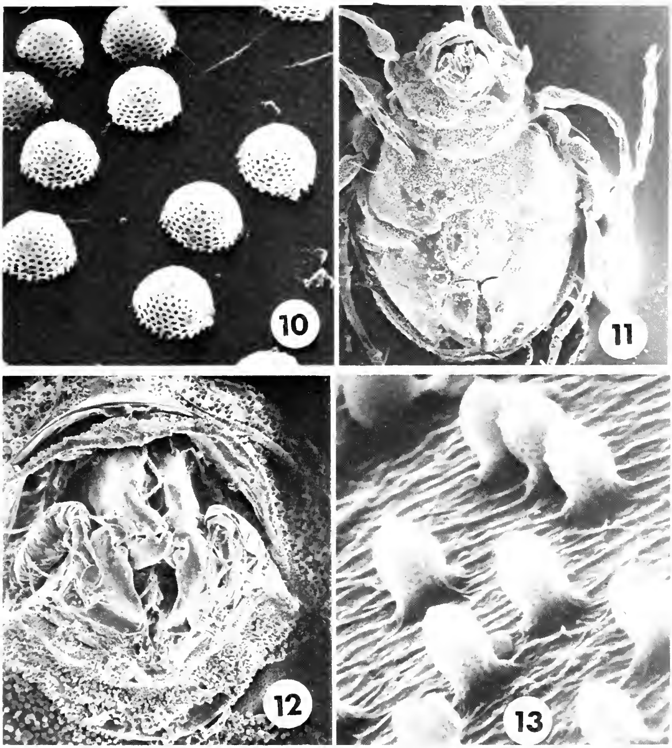
*Magnifications of all micrographs are plate size. Reductions of the micrographs for printing may alter this dimension slightly.



Figs. 6-9. *Gymnodamaeus chalazionus* scanning electron micrographs: 6, prodorsum, 200X*; 7, pseudostigmata and sensillum, anterior margin of notogaster, 500X; 8, notogaster and leg III, 300X; 9, rim of pseudostigmata and enlarged view of integumental tubercles inside pseudostigmatal cup, 10,000X.

ranges are for length: 804-768 μ; for width: 510-450 μ; average length 791 μ; average width 553 μ.

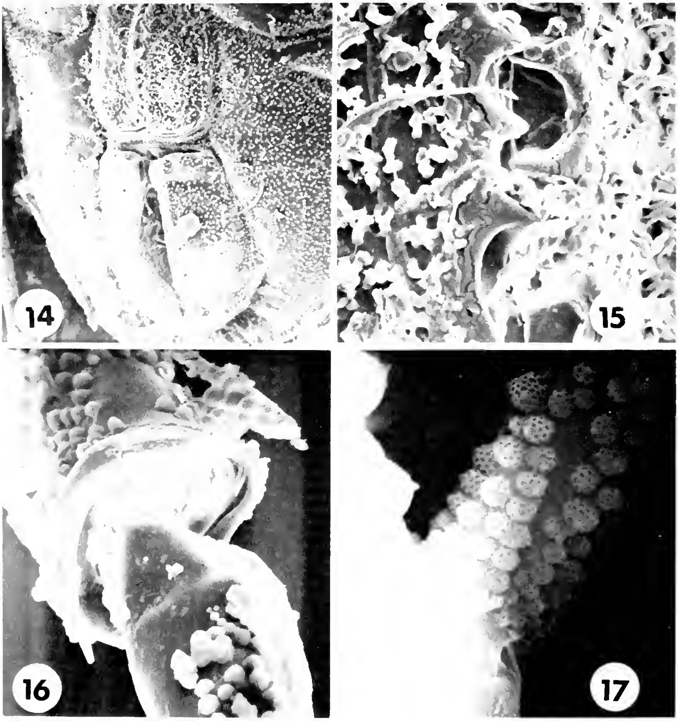
Nine specimens of the species (6 males, 2 females, 1 undetermined sex) taken from Mt. Meeker Camp Ground, Boulder Co., Colorado, 17 July 1952, by T. A. Woolley; numerous additional specimens taken near Fort Collins on different dates, most recently (1971) taken near Hayden, Colorado. The male holotype and one paratype are in the U.S. National Museum, the remaining paratypes are in my collection.



Figs. 10-13. *Gymnodamaeus chalazionus* scanning electron micrographs: 10, mammiform tubercles of notogastrial surface, 10,000X; 11, ventral aspect, 150X; 12, *en face* view of infracapitulum, showing dorsal chelicerae, veneral rutella and lateral palps, 700X; 13, tubercles of ventral integument, 10,000X.

Discussion.— Seven species of *Gymnodamaeus* were reviewed for this paper, among which is a species of Koch, illustrated and described by Schweizer (1922) under the name *Damaeus femoratus*. The illustrations show that this should be changed to the genus *Gymnodamaeus* as it does not belong in the genus *Damaeus*. Schweizer indicated that the species was found in Algeria, Italy, and Germany.

Of the North American species *Gymnodamaeus veriornatus* Higgins is the largest in size (0.93mm x 0.54mm), with *G. chalazionus*,



Figs. 14-17. *Gymnodamaeus chalazionus* scanning electron micrographs: 14, genital and anal plates, 300X; 15, serrate margin of genital plates 5,000X; 16, leg joint, 300X; 17, leg and leg hair showing integumental tubercles, 10,000X.

next in size (804 μ x 510 μ. Hammer's species *G. ornatus* is intermediate in dimensions (0.68mm x 0.37mm); *G. gildersleeveae* and *G. elegantulus* have identical measurements (0.41mm x 0.23mm). Banks's species are in between others in size, with *G. minor* at 0.35 mm long and *G. pearsei* measuring 0.50mm in length.

Specimens of *G. chalazionus* were used in scanning electron microscopic research and the accompanying micrographs of this species show a three-dimensional detail that is not possible with the diagrams. Although the micrographs are self-explanatory in many respects, it should be noted that the tubercles of the dorsum, the interior of the bothridium, and the surface of the legs and leg hairs are similar—appearing as perforated mammiform structures (Figs. 7-10). The tubercles of the venter are more elongated than those of the dorsum or the other locations (Figs. 11-15).

As stated earlier, Grandjean (1928) assumed that the surface integument of *Gymnodamaeus* was a secreted material. This is borne out by the SEM micrographs (Figs. 6, 8, 11-15) of *G. chalazionus*. Specimens of this species were treated with xylene to determine if the tubercles could be separated or removed from the integument. They remained in place and appear to be wax blooms of different configurations on the dorsum and the venter. Further investigations with the SEM should disclose more details about the structure and chemical composition of these integumental structures in this new species of oribatid.

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THE SONORAN SUBSPECIES OF THE LIZARD *CTENOSAURA HEMILOPHA*

Hobart M. Smith[1]

Abstract.— Five subspecies of *Ctenosaura hemilopha* are recognized, including *C. h. hemilopa* from Baja California; *C. h. insulana* from Isla Cerralvo, Gulf of California; *C. h. conspicuosa* from Isla San Esteban and (?) Isla Lobos. Gulf of California; and two new subspecies: *C. h. macrolopha* from Sonora and northern Sinaloa, and *C. h. nolascensis* from Isla San Pedro Nolasco, Gulf of California. The species is thought to have evolved from *C. pectinata*, through the somewhat similar *C. h. macrolopha* or its forerunner. Its range probably extended at an earlier time northward around the Gulf of California, thence southward through Baja California, with populations reaching certain Gulf islands from the peninsula, not from mainland Mexico, despite greater proximity of some of the islands inhabited to Sonora than to the peninsula.

It has long been known that populations of *Ctenosaura hemilopha* (Cope) of Sonora and adjacent areas differ from those of Baja California (Smith, 1935: 140-141; Lowe and Norris, 1955: 90). The peninsular subspecies was identified as *C. h. interrupta* Bocourt, 1882, by Lowe and Norris (*loc. cit.*), the mainland subspecies as *C. h. hemilopha* (Cope), 1863. The type-locality of *Cyclura* (*Ctenosaura*) *hemilopha* Cope is, however, "Cape St. Lucas," Baja California, and therefore Bocourt's *Ctenosaura interrupta* (type-locality Baja California) is a junior synonym of it, as noted by Hardy and McDiarmid (1969: 122). Accordingly, the mainland subspecies is presently nameless. It is here named

Ctenosaura hemilopha macrolopha, subsp. nov.

Holotype.— Chicago Natural History Museum 108705 (formerly E. H. Taylor 235), La Posa, San Carlos Bay, 10 mi NW Guaymas, Sonora, 30 June 1934, E. H. Taylor coll. Paratypes: Univ. Illinois Mus. Nat. Hist. 20232 (formerly E. H. Taylor 121), 5 mi SW Hermosillo, Sonora, 26 June 1934, E. H. Taylor; Univ. Colorado Mus. Nat. Hist. (UCMNH) 42536, Yepáchic, Chihuahua, 5800 ft, summer 1970, Campbell Pennington; Brigham Young Univ. 14616-24, Urique, Chihuahua.

Diagnosis.— A mainland Mexican geographic segment of *C. hemilopha* with a long middorsal crest reaching to groin and usually with 8 or more whorls of enlarged caudal scales separated from adjacent such whorls by no more than a single intercalary row of scales at any point.

Description of holotype.— A mature male, 194 mm s-v; pattern as depicted in Smith (*op. cit.*: pl. 23) and measurements as given in the same work (*op. cit.*:141).[2]

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[2] Art. 13 of the International Code of Zoological Nomenclature permits "a definite bibliographic reference" even to the required "statement that purports to give characters differentiating the taxon"—i.e., the "diagnosis" of a new name. Since that statement is given here, a bibliographic reference to the nomenclaturally less essential *description* is presumably acceptable.

COMPARISONS.— The species *C. hemilopha* differs trenchantly from *C. pectinata*, its nearest neighbor, by having the whorls of small scales between the whorls of enlarged scales reduced to less than two complete whorls (except on the middorsal line, where there is often one spine) over a large part of the tail, whereas on no part of the tail in *pectinata* are there fewer than two complete whorls of small scales (except at the middorsal line). In addition,

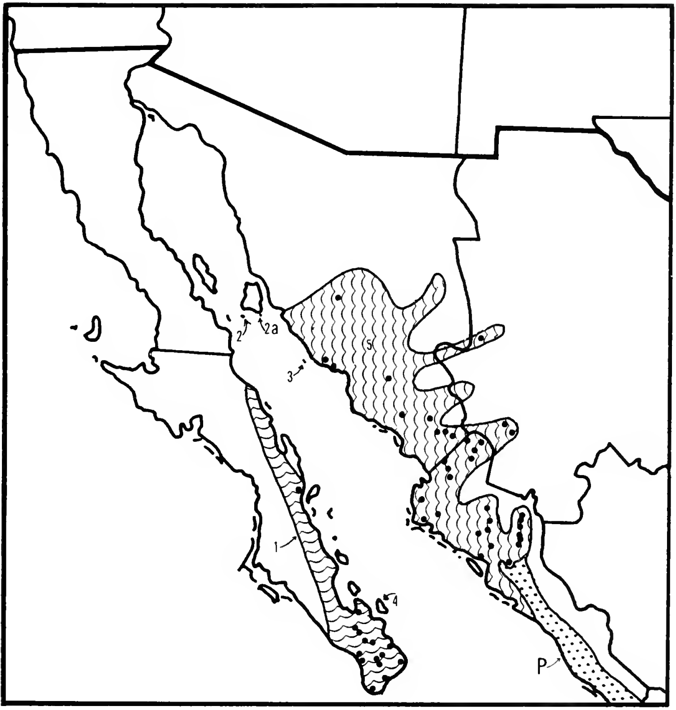

Fig. 1. Ranges of the subspecies of *Ctenosaura hemilopha* and of nearby populations of *C. pectinata*. The dots indicate localities of record. 1, *C. h. hemilopha;* 2, *C. h. conspicuosa* on Isla San Esteban; 2a, *C. h. conspicuosa* (?) on Isla Lobos; 3, *C. h. nolascensis* on Isla San Pedro Nolasco; 4, *C. h. insulana* on Isla Cerralvo; 5, *C. h. macrolopha;* P, *C. pectinata*. The projected range of *C. h. hemilopha* corresponds with the limits of the San Lucan herpetofaunal area as mapped by Savage (1960:194). Localities and ranges in Sinaloa were drawn largely from Hardy and McDiarmid (1969:231). The projected range in Sonora is based largely upon Nelson and Goldman (1926: fig. 13). Base map courtesy Roger Conant.

the middorsal crest in all forms of *hemilopha* extends no farther posteriorly than a point somewhat anterior to the level of the groin; whereas in *pectinata* the crest extends to the level of the sacrum, terminating anywhere from the level of its anterior border to the base of the tail. *C. hemilopha* is also brownish in adults and subadults; whereas *pectinata* exhibits grayish or greenish tones throughout life, developing black markings on a gray background in adults. These distinctions hold throughout the 20 *C. pectinata* examined from the states of Sinaloa, Nayarit, Michoacán, Morelos, and Oaxaca, and 28 *C. hemilopha* representing all subspecies.

The mainland examples of *hemilopha* differ from all other populations of that species in possessing the longest dorsal crest occurring in the species, extending posteriorly nearly to the level of the groin, not quite reaching the level of the sacrum (as in *pectinata*); in all other populations of *hemilopha*, the dorsal crest ends at a level no more than 4/5 the distance from axilla to groin. In addition, the mainland population differs from all other subspecies of *hemilopha* except *insulana* and *hemilopha* in usually having no evidence whatever of a second whorl of small scales between at least 8 adjacent whorls of enlarged scales, in the central region of the tail. Two of 10 *macrolopha* examined for this character failed to meet this criterion, having one or no whorl-set at all completely reduced to one intercalary row. In the other eight, the incomplete second row begins at points varying from the 16th whorl-set to the 24th, and in three the second row is not evident in any distal whorl posterior to the basal 4 or 5 whorl-sets. Adults retain narrow light bars on the forelegs.

REMARKS.— The subspecific name *macrolopha* (Gr., long crest) refers to the exceptionally long crest, reaching to level of groin, in the mainland population, as contrasted with the short crest (presumably the implication of *hemilopha*, Gr., half crest), reaching only a little beyond midtrunk in other populations of the species. In this respect *macrolopha* is intermediate between *pectinata*, with a crest uninterrupted or narrowly interrupted at sacrum, and insular-peninsular *C. hemilopha*. *C. pectinata* extends northward as far as about parallel 25°N, north of Culiacán about 20 miles, where its range meets, blends with or overlaps that of *C. hemilopha* (Hardy and McDiarmid, 1969:119-124, 231, fig. 44). Possibly, although the trenchant differences do not suggest it, the two populations hitherto designated as the species *C. pectinata* and *C. hemilopha* intergrade in the Culiacán area; if not, a certain amount of interspecific introgression seemingly occurred prior to attainment of reproductive isolation, accounting for the *pectinata*-like long crest in the mainland populations of *hemilopha*. Further field work will be required for a definitive conclusion.

RANGE.— The subspecies *C. h. macrolopha* ranges from the vicinity of Hermosillo, Sonora, through the northern third of Sinaloa, and inland as far as extreme western Chihuahua (Batopilas, Urique, Yepáchic). Bogert and Oliver (1945:334) conjecture that *C. hemi-*

lopha may once have occurred well north of its present range limits, the peninsular and mainland ranges being continuous north of the Gulf of California. The hypothesis is perhaps strengthened by the long-unconfirmed record of the species from Nogales (Bailey, 1928:21, et. al.). If valid in the context at least of former distribution, the record is no doubt referable to *macrolopha.* It occurs on no island, so far as now known.

Contrary to comments by Smith (*op. cit.*) and Lowe and Norris (*op. cit.*), the population on Isla San Pedro Nolasco, Sonora (about 13 mi W of the coast near Guaymas), differs sharply from *C. h. macrolopha* in having a short middorsal crest and at least partial second rows of small scales between most whorls on the tail. The specimen figured by Bailey (1928: pl. 5) from that island has a short crest, contrary to Smith's (*op. cit.*) interpretation. The greatest similarity in scutellation is to *conspicuosa*, but the pattern of the San Pedro Nolasco population is distinctive. That population is here named

Ctenosaura hemilopha nolascensis, subsp. nov.

HOLOTYPE.— Univ. Colo. Mus. Nat. Hist. No. 26391, a subadult male, taken on Isla San Pedro Nolasco, Sonora, 16 August 1964, by T. Paul Maslin et. al. PARATYPES: Thirteen, all topotypes: UCMNH Nos. 26388-90, 26392-4, 35174-7, and one unnumbered; Mus. Comp. Zool. 13178-9.

DIAGNOSIS.— A geographic segment of *C. hemilopha* restricted to Isla San Pedro Nolasco, with enlarged scales of middorsal crest extending posteriorly no farther than a level about two-thirds the distance from axilla to groin; with rare exception, all whorls of enlarged scales separated from adjacent whorls by at least a partial second row of small scales on ventral surface of tail; a second row at least partially represented on dorsal surface through anterior 3-12 whorls (seldom more than 6); a third row at least partially represented in 5-7, usually 6 whorls; ventral surfaces of subadults with scattered rounded dark spots about ⅓ diameter of tympanum; arm all black, lacking light bars, in adults; hind leg reticulated with black above, bars scarcely evident, in adults.

DESCRIPTION OF HOLOTYPE.— Enlarged scales of dorsal crest extending posteriorly about 4/7 distance from axilla to groin; at least one complete intercalary row of scales between each pair of adjacent whorls of enlarged scales; a second intercalary row extending across ventral surface between all whorls, and represented dorsally also in the basal 6 sets of whorls, and in the 18th and following sets; at least part of a 3rd intercalary row present in the basal 7 sets of whorls, 4 in the basal 5, 5 in the basal 3, 6 in the basal 2 (the first set of whorls is arbitrarily counted as the one following the anteriormost whorl containing scales at least twice as large as those immediately preceding it); femoral pores 6-7. Snout-vent 167 mm; tail complete except for the terminal regenerated 50 mm, unregenerated part 248 mm.

Color in preservative a brownish slate; body unicolor above except for numerous small rounded dark flecks (each covering 1-9 scales, on sides of body, dim or absent near median line), two broad brownish black crossbands (one on shoulder, one just posterior to axilla, joined laterally), and a small round blackish brown spot on middorsal line at rear of neck; a few faint light spots on a dorsolateral line on neck; forelegs black above, with poorly defined, narrow, light crossbars; hind leg essentially dark reticulated on a lighter background, the reticulum evidencing the broad dark bars and intervening light bands (about ⅓ as wide as dark bars) of juveniles; tail with broad dark rings, 4 to 5 times as wide as intervening light rings, beginning at about 15th set of whorls. Throat and chest to near level of axilla dusky, with scattered lighter brown dots; rest of chest progressively less dusky posteriorly, lighter midventrally; ground color still lighter on ventral surfaces of legs and base of tail; numerous, randomly scattered, rounded, dark brown spots on ventral surfaces of abdomen, hind legs and base of tail, especially prominent on legs, somewhat larger than those on sides of abdomen, in general about ⅓ the lesser diameter of tympanum.

VARIATION.— Smaller individuals have light crossbars on the back, 7 between axilla and groin; the legs are more prominently barred, the dark spotting on the ventral surfaces more extensive (the spots often arranged in transverse rows on abdomen) and the chin and lips prominently dark-and-light barred. A large adult male (estimated 400 mm s-v) is solid black over the throat, chest, forelegs, axilla, and shoulders; chin, lips, sides, and dorsal surface of neck gray brown; black crossing dorsum in two bands on shoulder; rounded median black spot on nape prominent; abdomen, both dorsally and ventrally, a light gray brown, with numerous very small black flecks laterally; groin rather heavily pigmented, but ventral surface of thigh with extensive light areas; dorsal surface of thigh densely but not coarsely reticulated, very little evidence of barring; feet and shank reticulate but barred.

Ten of the 11 paratypes examined for characteristics of the caudal whorls and crest have at least part of a second intercalary row (ventrally) between all adjacent pairs of whorl-sets; the one exception, No. 35176, has one intercalary row only in the 13th whorl-set. Five to 7 (usually 6) basal whorl-sets have at least parts of at least 3 intercalary rows, 3-5 (usually 4) have at least 4 or parts thereof. Three to 12 basal whorl-sets have at least 2 rows of intercalary scales represented dorsally. The enlarged scales of the dorsal crest extend posteriorly from 4/7 to 4/5 the distance from axilla to groin, usually about 4/7.

COMPARISONS.— *C. h. nolascensis* differs more conspicuously from its geographically nearest population, in Sonora (*C. h. macrolopha*), than from any other subspecies. In *macrolopha* the dorsal crest extends nearly to groin, exceeding the limit of 4/5 the distance from axilla to groin that marks the greatest extent in *nolascensis* and other subspecies. In addition, at least 8 whorl-sets in *macrolopha* possess no more than one intercalary row, whereas that figure in *nolascensis* exceeds no more than one.

C. h. nolascensis is less markedly distinct from the other geographically more remote subspecies. *C. h. insulana* is similar to *macrolopha* (but differs from *nolascensis*) in having a large number of whorl-sets with no more than one row of intercalary scales (14 in the single specimen examined); its limbs are more prominently banded, and light crossbars persist on the trunk throughout life. *C. h. conspicuosa* loses the light crossbars in the postthoracic region and on limbs in adults, but is similar to *nolascensis* in caudal scutellation; the two specimens examined have 4-5 basal whorl-sets with more than two at least partial intercalary rows, 2-3 basal whorl-sets with more than three, and 2-4 basal whorl-sets with more than two intercalary rows dorsally; but it is likely that no real differences in these characters exist in comparison with other subspecies. *C. h. hemilopha* (4 specimens examined) has much the same scutellation as *insulana* and retains the light crossbars on the postthoracic region and hind limbs; in both these characters, it differs from *nolascensis*.

Unfortunately, it has not been possible to examine the caudal scutellation of an adequate series of all taxa. We have examined sufficient material of *pectinata*, *h. macrolopha,* and *h. nolascensis* to be confident of reliability of the characters observed, but the other subspecies of *hemilopha* (*insulana*, *conspicuosa*, *hemilopha*) need further observation not practical at the present time. Additionally, fieldwork in the area of contact of *pectinata* and *h. macrolopha* will be required to establish conclusively the interrelationships of these taxa, although we remain confident that no genetic interchange now takes place there and that the taxa are of specific rank relative to each other.

Phylogeny

The evolution of *hemilopha* and its subspecies is of major interest. Because *macrolopha* is more like *pectinata* than is any other race of *hemilopha*, and is geographically adjacent, it seems reasonable to hypothesize that *hemilopha* is a derivative of *pectinata* or a *pectinata*-like ancestor and that *macrolopha* more closely resembles the ancestral form of *hemilopha* than does any other race of the species. Because of the trenchant difference between insular-peninsular races on the one hand and the mainland race on the other, the close geographic proximity of the former group to the mainland, and the relative uniformity of characteristics of the members of the insular-peninsular group, it seems unlikely that the species radiated across the Gulf of California to the Peninsula. A more likely probability is that the species extended northward at one time, and thence into the Peninsula, and subsequently became more restricted in range, separating two components, one on the Peninsula and one on the mainland. *C. h. macrolopha*, remaining with or reestablishing contact with *pectinata* or its ancestor, maintained or developed a character displacement that accentuated the basic difference in caudal scutellation between the two species, although *macrolopha* retained an intermediate character-state in extent of the crest, or perhaps introgression was responsible for the intermediacy.

The peninsular population diverged in character while in isolation, accentuating the brevity of the dorsal crest. Its range became essentially relic in nature, restricted to the southern third of the peninsula, except as a few waif populations in a sweepstake pattern reached a number of the Gulf islands. In their isolation from contact with other forms of the genus, these residual populations lost to varying degrees part of the unique caudal scale pattern, approaching but not achieving the presumably ancestral condition of *pectinata.*

With taxonomic recognition given to five geographically isolated populations of *hemilopha*, virtually all that exist (Soulé and Sloan, 1966:140), it is unlikely that any other extant subspecies will require recognition in the future, except perhaps for the population on Isla Lobos recorded by Lowe and Norris (1955:95). That population, so close to Tiburón island (not the Isla Lobos S of Guaymas), may perpetuate the group that no doubt formerly occurred on the larger island but is now extinct, probably due to human predation. Whether the Tiburón-Lobos populations have diverged sufficiently from others to merit recognition remains to be seen (Soulé and Sloan, 1966:140, refer Lobos material to *h. conspicuosa*). In any event, their relation to the peninsular-insular group as opposed to the mainland group is of major interest.

Acknowledgments

I am much indebted to Drs. T. Paul Maslin and Wilmer W. Tanner for the privilege of studying material in the museums of the University of Colorado and Brigham Young University, respectively; to Richard Holland, Tom Bauer, and Dr. Ronald A. Brandon for specimens they provided for the museum; and to Alan Savitzky for aid in studying the material. This work was supported in part by publication grant LM 00925 from the National Library of Medicine, National Institutes of Health, U.S. DHEW; and in part by the Biology Department of the University of Colorado.

Key to the Ctenosaura of Northwestern Mexico

1. All whorl-sets of tail containing at least two complete intercalary rows of scales (except sometimes on mid-dorsal line); dorsal crest extending to, onto or through sacral region; general color tone green (in juvenile) to gray (adults) .... *pectinata*

No more than 6 basal whorl-sets of tail containing two complete intercalary rows of scales (excluding mid-dorsal line); dorsal crest not reaching sacral region; general color tone green (very young) to brown (subadults, adults)—*hemilopha* 2

2(1). Dorsal crest extending posteriorly nearly to groin, posterior to a point about 4/5 distance from axilla to groin; usually at least 8 central caudal whorl-sets with no evidence whatever of a second intercalary row of scales .... *h. macrolopha*

Dorsal crest terminating posteriorly near a point usually about ⅔ distance from axilla to groin, or anterior thereto; central caudal whorl-sets with a partial second intercalary row or not 3

3(2). At least 8 central caudal whorl-sets with no evidence whatever of a second intercalary row of scales; light bars on limbs and postthoracic trunk retained throughout life 4

No more than 1 or 2 caudal whorl-sets with no evidence whatever of a second intercalary row of scales; pattern diverse 5

4(3). Dorsal crest terminating posteriorly near a point about ⅔ distance from axilla to groin .... *h. hemilopha*

Dorsal crest terminating about at midabdomen .... *h. insulana*

5(3). Juvenile and young adults only with round dark spots (about ⅓ lesser diameter of tympanum) scattered over ventral surfaces of trunk, hind legs and base of tail, becoming small dark flecks in adults; dark and light markings on limbs not sharply contrasted .... *h. nolascensis*

Rounded dark marks on ventral surfaces of juvenile retained at least on hind limbs throughout life; light and dark markings of hind limbs sharply contrasted both above and below .... *h. conspicuosa*

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DEAD GREAT BLUE HERON FOUND AT 11,000 FOOT UTAH ELEVATION

Gary L. Hickman[1]

ABSTRACT.— A Great Blue Heron (*Ardea herodias*) was found dead at the west end of the Utah Uinta Mountains at approximately 11,000 feet. Rain, fog, and very low cloud ceilings reducing visibility to almost zero causing directly or indirectly the heron's death was postulated.

On 5 September 1965 I found a dead Great Blue Heron (*Ardea herodias*) at the west end of the Utah Uinta Mountains on Utah Highway 150 just under the north side of the 11,000 foot Hayden Pass. The heron was found just after sunrise when visibility at ground level to an undetermined altitude was almost zero because of fog. Rains had fallen periodically throughout the night. The heron was stiff from rigor mortis and the exact cause of death was not determined, but it appeared the bird had either crashed into the road or landed on the road and was hit by a vehicle. The heron was not on the highway at 2200 hours the previous night when I traveled the road.

The Uinta Mountains form the only major east-west mountain range in the United States, extending approximately 131 miles. No Great Blue Herons were observed above 7000 feet in the Uinta Mountains during my two-year mule deer study or during a two-year study of waterfowl use of high mountain lakes conducted by Steven Peterson.

Numerous accounts of migrating birds colliding with man-made structures, including tall lighted buildings and radio and television towers, have been reported. Forty-six species of birds were picked up on the night of 19-20 September 1963 at the television towers at Eau Claire, Wisconsin. David W. Johnston, at the University of Florida, Gainesville, estimated that 50,000 birds died on the nights of 7 and 8 October 1954 at the ceilometer of the Warner Robins Air Force Base near Macon, Georgia. In all instances these mass collisions were associated with rain, fog, and very low cloud ceilings (John Vosburgh, 1966. *Birds in Our Lives.* Washington, D.C., United States Government Printing Office, p. 361-364).

This observation raises the questions: Do Great Blue Herons migrate over the Uinta Mountain range? During migrations over mountain ranges, under certain climatic conditions is there a mortality resulting from collisions with natural objects and of what magnitude?

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FIVE NEW VARIETIES OF *ERIOGONUM* (POLYGONACEAE)

James L. Reveal[1]

As the first volume of Intermountain Flora: The Vascular Plants of the Intermountain West, by A. Cronquist, A.H. Holmgren, N.H. Holmgren, and J.L. Reveal, nears completion, a number of minor nomenclatural changes are needed for the introductory material in the first volume. Here, five new varieties of *Eriogonum* (Polygonaceae) are proposed, described, and discussed.

Eriogonum brevicaule Nutt. var. *cottamii* (S. Stokes) Reveal, COMB. NOV., based on *E. tenellum* Torr. ssp. *cottamii* S. Stokes, Gen. Eriog. 70. 1936.

Plants 1-3.5 dm tall; *leaves* narrowly oblanceolate to narrowly elliptic, the leaf-blade 3-7 cm long, 3-5 mm wide, densely tomentose on both surfaces, the margin plane or with thickened edges, not revolute; *flowering stems* erect, 0.5-2 dm long, tomentose, the tomentum grayish when young, becoming tannish- to reddish-brown at maturity; *inflorescences* cymose, open, 3-7 cm long, tomentose; *peduncles* lacking; *involucres* turbinate, 2-3 mm long, 1.5-2 (2.5) mm wide, tomentose; *flowers* yellow, 3-4 mm long.

TYPE.— Canyons in bottoms of the slopes on West Mountain, Utah Co., Utah, at 4500 feet elevation, 20 August 1925 (misquoted as 1924 in the original description), *Cottam* 411. Holotype, BRY! Isotype, UT!

DISTRIBUTION.— Infrequent on dry gravelly limestone slopes and clay hills in central Utah from eastern Tooele and Juab cos. to western Utah Co. Flowering from June to September.

The var. *cottamii* is an easily distinguished entity in the Utah Buckwheat flora. It differs from var. *brevicaule* in having densely tomentose stems, and from var. *laxifolium* (Torr. & Gray) Reveal in having a cymose inflorescence instead of a capitate or subcapitate one. The southwestern Wyoming phase of the species, var. *micranthum* (Nutt.) Reveal perhaps is most closely related to var. *cottamii*, the two differing in the color of their tomentum, flower size, and distribution.

Eriogonum brevicaule Nutt. var. *wasatchense* (M. E. Jones) Reveal, COMB. NOV., based on *E. wasatchense* M. E. Jones, Contr. W. Bot. 11:11. 1903.

Plants 3-5 dm tall; *leaves* narrowly elliptic, 1.5-4 cm long, (3) 4-7 mm wide, densely white-tomentose below, floccose above, the margin crenulate in most; *flowering stems* erect, 1-3 dm long, glabrous; *inflorescences* cymose, (8) 10-15 cm long, glabrous; *peduncles* rarely present; *involucres* turbinate, 3-4 mm long, 2-2.5 mm wide, glabrous; flowers white, 2-2.5 mm long.

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Type.— American Fork Canyon, Utah Co., 27 July 1880, *M.E. Jones* 1877. Lectotype, POM! Duplicates of the lectotype, BM, CAS, GH, MICH, POM, US, UTC!

Distribution.— Infrequent on dry talus slopes and limestone outcrops along the western flank of the Wasatch Mountains from Davis Co. south to Utah Co., Utah. Flowering from June to September.

The var. *wasatchense* is perhaps the most distinct of the several variants within *Eriogonum brevicaule*. It is quickly recognized by its cymose, glabrous inflorescence, glabrous stems and crenulate leaves sheathing up the lower portions of the stems, and the white flowers.

Eriogonum shockleyi S. Wats. var. *longilobum* (M.E. Jones) Reveal, comb. nov., based on *E. longilobum* M.E. Jones, Proc. Calif. Acad. Sci. II, 5:720. 1895.

Low, pulvinate, matted herbaceous perenials forming a dense mat (1) 2-4 dm across; *leaves* in rather loose rosettes, the leaf-blade oblanceolate to spatulate, (3) 5-8 (12) mm long, (2) 3-6 mm wide; *flowering stems* up to 3 cm long, tomentose; *involucres* (3) 4-6 (7) mm long, the lobes (1) 2-3 (3.5) mm long; *flowers* white, 3-4 mm long; *achenes* mostly densely pubescent.

Type.— Near Price, Carbon Co., Utah, 4 July 1894, *M.E. Jones* 5590*j*. Holotype, POM! Isotype, US!

Distribution.— Dry clay flats and lower slopes in eastern Utah from Duchesne and Uintah cos. southward to northern Arizona in Coconino, Navajo and Apache cos., and in western Colorado from Moffatt and Mesa cos. south to San Juan Co., New Mexico. Flowering from May to July.

In the past, three forms within *Eriogonum shockleyi* have been maintained. However, as additional material has been collected and field studies made on the species since 1965, the distinction between var. *shockleyi* and the form named *candidum* by Stokes (1936) became less clear. It now appears impossible to maintain the yellow-flowered phase (*candidum*) as a separate entity from the white-flowered phase (*shockleyi*) due to a series of pale-yellow populations across central Nevada. The third element, var. *longilobum*, can still be recognized, based on the characteristics outlined below.

A. Leaves 2-5 (6) mm long, 2-4 mm wide; involucres 2-3.5 mm long, the lobes 0.5-1.8 (2) mm long; flowers white or yellow, 2.5-3.5 (4) mm long; Inyo Co., California, eastward across central Nevada to western Utah and southern Idaho .... var. *shockleyi*

AA. Leaves (4) 5-12 mm long, 2-6 mm wide; involures (3.5) 4-6 mm long, the lobes (1.5) 2-3 mm long; flowers white, 3-4 mm long; eastern Utah and western Colorado south to northeastern Arizona and extreme northwestern New Mexico .... var. *longilobum*

Eriogonum ovalifolium Nutt. var. *caelestinum* Reveal, VAR. NOV. A var. *nivali* (Canby in Cov.) M.E. Jones et var. *depressa* Blank. floribus flavis demum rubro-tinctis, involucris solitariis differt.

Low densely caespitose herbaceous perennials forming a mat 0.5-1 dm across; *leaves* in densely congested basal rosettes, the leaf-blade mostly elliptic, 2-5 mm long, 1.5-3 mm wide, thinly greenish-tomentose on both surfaces with a tannish margin, the petiole 1-3 mm long, thinly pubescent; *scapes* 1-6 cm long, thinly floccose; *involucres* solitary or very rarely in pairs, turbinate-campanulate, 2-2.5 mm long; *flowers* yellow, maturing red or reddish-tinged in most, 2.5-3 mm long.

TYPE.— South fork of Pine Creek on the upper ridges of the Toquima Range, Toiyabe National Forest, Nye Co., Nevada, from 10,900 to 11,800 feet elevation, 23 July 1964, *Reveal* 629. Holotype, US! Isotypes, ARIZ, BRY, CAS, DS, GH, MO, NY, OKL, RM, RSA, UC, UT, UTC, WTU! Distributed as *E. ovalifolium* Nutt. var. *nivale* (Canby in Cov.) M. E. Jones.

ADDITIONAL SPECIMENS EXAMINED.— Head of Pine Creek Canyon, Toquima Range, 11,000 feet elevation, 16 July 1945, *Maguire & Holmgren* 25805 (NY, US, UTC).

This lovely addition to *Eriogonum ovalifolium* has been known to me for several years, but its distinctiveness has not become obvious until the late 1960s. At first, the yellow flowers were considered to be a common feature of the Nevada populations of *E. ovalifolium* var. *nivale*, but the fact was that no other mountain ranges harbored the yellow-flowered phase. This realization came only after most of the high mountain ranges of central Nevada were carefully surveyed as part of the Intermountain Flora Project. Thus, the Toquima Range has another endemic species and can join *Astragalus toquimanus* Barneby, *Draba arida* C. L. Hitchc., *Smelowskia holmgrenii* Roll., and an as yet undescribed *Geranium*.

Eriogonum umbellatum Torr. var. *devestivum* Reveal, VAR. NOV. A var. *stellata* (Benth.) M. E. Jones foliis late ellipticus et omnibus glabris vel marginibus non nisi pubescentis differt.

Plants forming a large open mat up to 6 dm across; *leaves* in loose, ± basal rosettes, the leaf-blade broadly elliptic, 1.5-2 cm long, glabrous on both surfaces or with the margin slightly pubescent in some, on a long slender petiole; *flowering stems* erect, slender, 1.5-2 dm long, thinly floccose to glabrous; *inflorescences* compoundly umbellate, 5-15 cm long with foliaceous bracts at the base of each division, the branches thinly floccose or more commonly glabrous; *peduncles* slender, 0.5-2 cm long, essentially glabrous, *involucres* with tubes 2-3.5 mm long, the reflexed lobes 1-2.5 mm long, glabrous; *flowers* bright yellow, 4-7 mm long including the stipe.

TYPE.— On sagebrush covered hills 10 miles south of Council along U.S. Highway 95, Adams Co., Idaho, 21 June 1966, *Holmgren & Reveal* 2746. Holotype, US! Isotypes, BRY, CAS, NY, RSA, UTC, WTU!

Distribution.— Locally common and sporadic from Adams and Washington cos. eastward to Blaine Co., Idaho. Flowering from June to August.

The var. *devestivum* forms a similar aspect of the species expression as seen between var. *umbellatum* and var. *aureum* (Gand.) Reveal. The leaves are totally glabrous (the margins excepted in some cases). However, unlike the relationship between var. *umbellatum* and var. *aureum* in which the latter simply replaces the former at higher elevations throughout much of the range of var. *umbellatum*, there are a number of minor morphological differences between var. *stellatum* (Benth.) M. E. Jones and var. *devestivum*. The most obvious differences are the highly branched inflorescences of the new variety, the wider leaves, and the longer petioles. While the entire range of the new entity remains to be fully ascertained, it appears that var. *devestivum* occurs a bit to the east of the majority of the populations of var. *stellatum*, although its stills forms a pocket within the overall distribution of var. *stellatum*.

Acknowledgment

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PLANTS NEW TO THE UTAH FLORA

Larry C. Higgins[1]

ABSTRACT.— New additions to the Utah flora include *Cryptantha dumetorum* Greene, *C. elata* (Eastwood) Payson, *C. longiflora* (Nels.) Payson (*Boraginaceae*), *Hulsea heterochroma* A. Gray, *Parthenium incanum* H. B. K. (Compositae), *Arctostaphylos pringlei* C. C. Parry (Ericaceae), *Eremocarpus setigerus* (Hook.) Benth., *Euphorbia micromera* Boiss, *Tragia ramosa* (Euphorbiaceae), *Leptochloa filiformis* (Lam.) Beauv., *Schismus arabicus* Nees. (Gramineae), *Epilobium nevadense* Munz (Onagraceae), *Lomatium megarrhizum* (A. Nels.) Mathias (Umbelliferae), and *Aloysia wrightii* (Gray Heller) Verbenaceae.

Collections over the last six years provide the following additions to the Flora of Utah and Nevada (Ivar Tidestrom, 1925) and Common Utah Plants (Welsh, Treshow, and Moore, 1965). Voucher specimens are deposited in the herbaria of Brigham Young University (BRY) and West Texas State University (WTSU).

Boraginaceae

Cryptantha dumetorum Greene, Bush-loving cryptantha. Washington Co.: black stationary sand dunes just southwest of Ivins Reservoir; associated with *Coleogyne* and *Hymenoclea;* 17 May 1971. L. C. Higgins 4130 (BRY, WTSU).

Cryptantha elata (Eastwood) Payson, Tall cryptantha. Grand Co.: near milepost 39 along Utah hwy 128; clay soil; *Atriplex* community; 3 June 1968. L. C. Higgins 1479 (BRY, WTSU). *Atriplex* community; along hwy 124, ca. 3 miles south of U.S. hwy 50-6; on mancos shale; 2 May 1968. S. L. Welsh 6952 (BRY).

Cryptantha longiflora (Nels.) Payson, Long-flowered cryptantha. Grand Co.: near milepost 32 along Utah hwy 128; sand-loam soil; associated with *Populus* and *Atriplex;* 3 June 1968. L. C. Higgins 1478 (BRY, WTSU). Near Cisco, along U.S. hwy 6-50, clay soil; *Atriplex* community; 3 June 1970. L. C. Higgins 3314 (BRY, WTSU). Morrison formation; along Colorado River, ca. 32.5 miles from Moab along Utah hwy 128; 3 May 1968. S. L. Welsh 6989 (BRY).

Compositae

Hulsea heterochroma A. Gray, Various-colored hulsea. Washington Co.: summit of the Beaverdam Mountains, ca. 3 miles southeast of the television relay tower; limestone soil; pinyon-juniper community; 28 May 1968. L. C. Higgins and N. D. Atwood 1410 (BRY).

Parthenium incanum H.B.K., Mariola. Washington Co.: Beaverdam Mountains, at Castle Cliffs along U.S. hwy 91; rocky, south-

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facing limestone slope; associated with *Buddleja-Agave-Larrea-Psilostrophe;* 17 May 1971. L. C. Higgins 4162 (BRY, WTSU).

Ericaceae

Arctostaphylos pringlei C. C. Parry, Pringles manzanita. Washington Co.: near the television relay tower at the summit of the Beaverdam Mountains; associated with *Quercus-Pinus-Juniperus;* limestone soil; 27 May 1966. L. C. Higgins 665, 3414 (BRY).

Euphorbiaceae

Eremocarpus setigerus (Hook.) Benth. Turkey mullein. Washington Co.: Beaverdam Mountains, near the Utah-Arizona border along U.S. hwy 91; sandy soil; associated with *Hymenoclea-Franseria-Larrea;* 29 November 1968. L. C. Higgins 1809 (BRY).

Euphorbia micromera Boiss. Washington Co.: Beaverdam Mountains, near the Utah-Arizona border along U.S. hwy 91; sandy soil; associated with *Hymenoclea-Larrea-Franseria;* 29 November 1968. L. C. Higgins 1802 (BRY).

Tragia ramosa Muell. Arg. Noseburn. Washington Co.: Beaverdam Mountains, near summit along U.S. hwy 91; gravelly wash bottom; *Juniperus-Cercocarpus-Purshia* community; 15 May 1966. L. C. Higgins 602 (BRY).

Gramineae

Leptochloa filiformis (Lam.) Beauv. Sprangle-top. Washington Co.: Beaverdam Mountains, 1 mile west of U.S. hwy 91 along the Jackson road; sandy soil; *Larrea-Prosopis-Coleogyne* community; 19 August 1966. L. C. Higgins 823 (BRY).

Schismus arabicus Nees. Arabian schismus. Washington Co.: Beaverdam Mountains, near the Utah-Arizona border along U.S. hwy 91; gravelly soil; *Larrea-Franseria-Yucca* community; 8 April 1966. L. C. Higgins 331 (BRY).

Onagraceae

Epilobium nevadense Munz, Nevada willow herb. Washington Co.: summit of the Beaverdam Mountains near the television relay tower; westfacing, rocky, limestone hillside; pinyon-juniper-oak association; 9 July 1966. L. C. Higgins 778 (BRY).

Umbelliferae

Lomatium megarrhizum (A Nels.) Mathias, Large-rooted lomatium. Emery Co.: San Raphael Swell, about 1 mile south of the San Raphael River Bridge; clay hillside; desert scrub and *Bouteloua gracilis* community; 30 April 1968. L. C. Higgins and J. Reveal 1268 (BRY, WTSU).

Verbenaceae

Aloysia wrightii (Gray) Heller, Oreganillo. Washington Co.: Beaverdam Mountains, about 5 miles west of Castle Cliffs along the road to Terry's Ranch; rocky limestone cliffs; associated with *Ferocactus-Coleogyne-Larrea*; 26 May 1966. L. C. Higgins 615 (BRY). Rare, only 4 to 5 shrubs were seen in the entire area.

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NOTES ON NEVADA SOLPUGIDS

Dorald M. Allred[1]

Muma (1963, Brigham Young Univ. Sci. Bull., Biol. Ser. 3 (2); 1970, Florida Dept. Agr. Contr. No. 154) listed distribution records of solpugids for the Nevada Test Site and other parts of North America, Central America, and the West Indies. In a series of solpugids collected at the Nevada Test Site subsequent to his 1963 report are two specimens which represent records worthy of mention.

In his 1963 report Muma recorded a single male of *Hemerotrecha branchi* taken at the Nevada Test Site, collected in Area 1 in a *Grayia-Lycium* plant community, 28 June 1960. An additional specimen was taken at Cane Springs at the test site, 12 June 1965. According to Muma (1970) this species also occurs in Arizona, California, and New Mexico.

Muma (1970) listed *Hemerotrecha jacintoana* as known only from California. A specimen was taken in a *Coleogyne* plant community approximately 2400 m north of the Sedan project crater at the Nevada Test Site, 22 June 1964; this extends the known range of the species to Nevada.

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GREAT BASIN NATURALIST

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ON THE RODENT-INFESTING ANOPLURA OF PANAMA

Phyllis T. Johnson[1]

ABSTRACT.— The species of Anoplura found on indigenous Panamanian rodents belong to the genera *Hoplopleura* (8 species), *Fahrenholzia* (3 species), *Neohaematopinus* (1 species), and *Polyplax* (1 species). As is the case with the Panamanian rodents, the anopluran fauna contains both Nearctic and Neotropical elements. Two new species of *Hoplopleura* are described: *H. scotinomydis* from *Scotinomys xerampelinus*, and *H. mendezi* from *Oryzomys* sp. (probably *O. alfaroi* or *O. albigularis*). A host-parasite list is included.

Panama, the land bridge between North and South America, has an unusually rich fauna whose study is important to an understanding of the movements and distribution of the animals of both continents, as Fairchild (1966) pointed out in his introduction to *Ectoparasites of Panama*. As well as for its intrinsic value, a study of the Panamanian anopluran fauna can be a useful adjunct to the study of movements and relationships of their mammalian hosts.

A preliminary paper on the Anoplura of Panama was published in *Ectoparasites of Panama* (Wenzel and Johnson, 1966). Since 1966, I have had the opportunity to study the numerous specimens collected during the surveys mentioned in the above volume. The present paper is based on those studies. Species discussed by Wenzel and Johnson, for which there is no additional information, are merely enumerated in the "Host-Parasite List," which is based on the present survey as well as on the records of Wenzel and Johnson. Place names and the species names of mammals mentioned herein may be traced in Fairchild and Handley (1966) and Handley (1966), respectively. The species groups of *Hoplopleura* referred to in this paper are discussed by Johnson (in press).

The holotypes and allotypes of new species, and the majority of other specimens are deposited in the collections of the National Museum of Natural History, Smithsonian Institution, Washington, D.C.

Hoplopleura Enderlein

The *hesperomydis* group.

There are two, perhaps three, Panamanian representatives of this group. All the known species occur on mice of the New

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World tribe, Peromyscini. Characters held in common by members of the *hesperomydis* group are given below:

Adults.— Head lacking accessory dorsal seta (ADHS of Kim, 1965). All abdominal setae inserted on posterior margins of sternal and tergal plates; paratergal plates III-VI with two truncate apical lobes; plate III with two large apical setae; plates IV-VI with dorsal apical seta small to minute and ventral one longer, though seldom surpassing apices of apical lobes. Females with two apical lobes on plate VII; aberrant males of described species occasionally with ventral lobe missing or vestigial; this lobe always missing in males of a new species described below. Thoracic sternal plate elongate; posterior apex narrowed, usually acute.

Nymphs.— Lacking abdominal spiracles and paratergal or other abdominal plates. First instar with one terminal abdominal seta on each side; second and third instars with one pair plus one single long terminal seta on each side. All instars with accessory dorsal head seta absent; one of dorsolateral head setae often enlarged (outer sutural head setae of Kim, 1965).

Characters that are too variable to assist greatly in species identification within the *hesperomydis* group are as follows: shape of the male genitalia, which depends on position; placement of setae on the lateral postantennal head margins, which depends to some extent on the amount of flattening during mounting; and shape of the apical lobes and length of setae of the paratergal plates. Shape of the thoracic sternal plate and presence or absence of a definite mesal keel on its posterior apex may be good characters for determination of some species. According to the statistical analysis of Kim et al. (1966), relative length and breadth of the thoracic sternal plate and total body length of the male are reasonably good discriminatory characters for males of two species, *ferrisi* Cook and Beer, and *hesperomydis* (Osborn). However, if a male specimen is not completely extended, measurement of body length is useless, and the reproductive state of a female may make a considerable difference in total length. In most cases, as suggested by Cook and Beer (1959) and Kim (1965), nymphs will be necessary for a definitive study of the *hesperomydis* group.

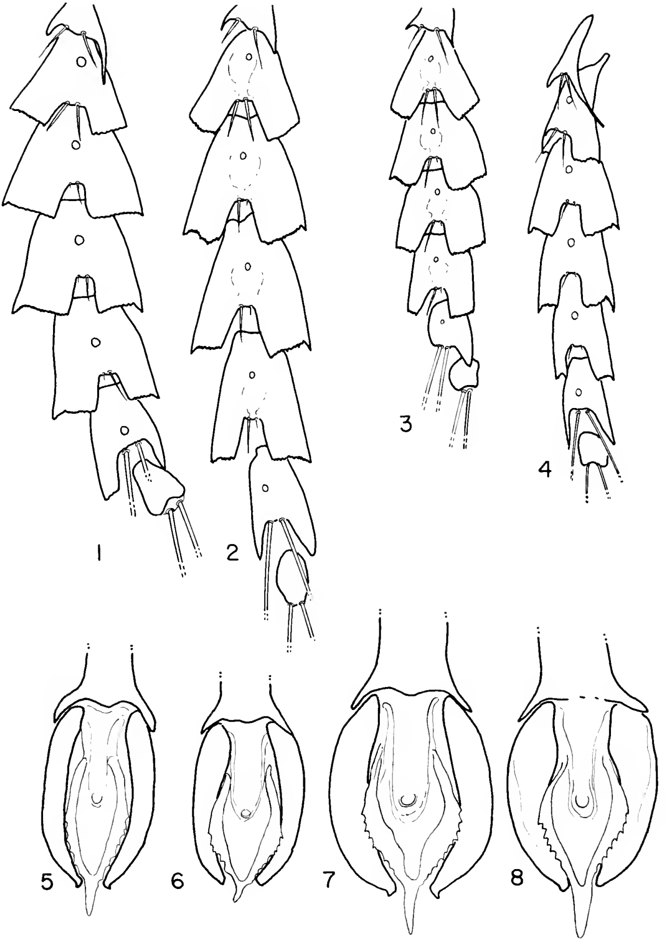
Hoplopleura emphereia Kim

Figs. 1, 7, 10, 14

Hoplopleura ferrisi emphereia Kim, 1965, J. Parasit. 51:882, figs. 37-42.

Hoplopleura hesperomydis: Wenzel and Johnson, 1966, Ectoparasites of Panama, p. 274 (err. det., records from *Peromyscus nudipes*, and probably that from *Reithrodontomys* sp.).

The female holotype, male allotype, 6 male and 20 female paratypes were taken from *Peromyscus nudipes*, El Hato, Province of Chiriqui, Panama, and 1 male and 2 female paratypes from *P. guatamalensis* and *P. mexicanus saxatilus*, Guatemala.



Figs. 1-8. *Hoplopleura hesperomydis*-group: 1, paratergal plates II-VIII, *H. emphereia Kim*, female ex *Peromyscus nudipes*, no. 10247; 2, same, *H. scotinomydis*, n. sp., female paratype ex no. 10245, same, male paratype ex no. 10155; 4, same, *H. hesperomydis* (Osborn), female ex *Peromyscus leucopus*, New Hampshire; 5, aedeagus, *H. hesperomydis* ex *Peromyscus maniculatus*, Washington; 6, same, *H. reithrodontomydis* Ferris (?) ex *Reithrodontomys megalotis*, California; 7, same, *H. emphereia* ex *Peromyscus nudipes*, Chiriqui, Panama; 8, same, *H. scotinomydis*, n. sp., holotype.

Panamanian specimens.—From *P. nudipes*, 145 males, 248 females, and 1 third instar nymph (female), in 52 collections; most from near or at the type locality. A few specimens were taken in the Province of Bocas del Toro.

Comparison of *emphereia* and *hesperomydis*.— The adult of *emphereia* differs as follows: thoracic sternal plate broader in proportion to length, slightly bulbous laterally, almost always lacking indication of mesal posteroapical keel (Figs. 12, 14). Usually larger (*hesperomydis*, 8 males and 16 females measured: male, 0.8 to 0.91 mm; female, 1.17 to 1.20 mm; *emphereia*, 20 males and 20 females measured: male, 0.95 to 1.10 mm; female, 1.15 to 1.25 mm). The dorsal apical lobe of paratergal plate VII is always subtruncate, with oblique, sometimes notched, apex (*hesperomydis* with this lobe usually evenly acute apically) (Figs. 1, 4). Aedeagus somewhat larger; often with parameres more convex laterally; pseudopenis more angulate laterally (Figs. 5, 7). Placement of small laterodorsal head setae and relative lengths of apical setae of paratergal plates variable in specimens examined.

Status of the name *emphereia* Kim.— The third-instar nymph from *P. nudipes* is unlike the nymph of *ferrisi* Cook and Beer, thus the name *emphereia* does not pertain to the latter species.

Kim (1965) resurrected the name *reithrodontomydis* Ferris, 1951, on the basis of a study of 8 nymphs collected from *Reithrodontomys* sp. in Chiriqui Province at El Hato, by Tipton. I have seen a female from *Reithrodontomys* sp. with collection data essentially as the nymphs studied by Kim, plus 13 males and 19 females in 14 collections from *Reithrodontomys creper*, and 3 males and 7 females from *R. mexicanus*, Chiriqui, 3 miles (5 km) W Cerro Punta, March, 1962. I did not find consistent differences between adults in the population from *Reithrodontomys* species, and that from *Peromyscus nudipes*. Further, my third instar nymph from *P. nudipes* (Fig. 10) appeared similar to Kim's (1965) drawings of a nymph from *Reithrodontomys* sp. except that the head capsule had been split and the mediodorsal portion, which would have contained the large dorsomedian seta figured by Kim, was missing. Because of the fully developed adult abdomen within, small ventral abdominal setae were not visible. One cannot, without further specimens, state unequivocally that *emphereia* from *P. nudipes* is conspecific with the form from Panamanian *Reithrodontomys* species, but it is highly probable and I make that assumption here.

As a further complication, I have seen a male and female of *Hoplopleura* from *Reithrodontomys megalotis*, California, that are smaller than the Panamanian specimens from *Reithrodontomys* species (male, 0.85 mm; female, 1.08 mm) and the thoracic sternal plate (Fig. 13) and aedeagus (Fig. 6) are more like those of true *hesperomydis* from North American *Peromyscus maniculatus* and *P. leucopus* than those of Panamanian species from *P. nudipes* and *Reithrodontomys* species.

If all the above specimens are of the same species and prove to be the same as the population from *Reithrodontomys chrysopsis* that was originally given the name *reithrodontomydis* Ferris, this name has priority over *emphereia* Kim.

Hoplopleura scotinomydis, n. sp.

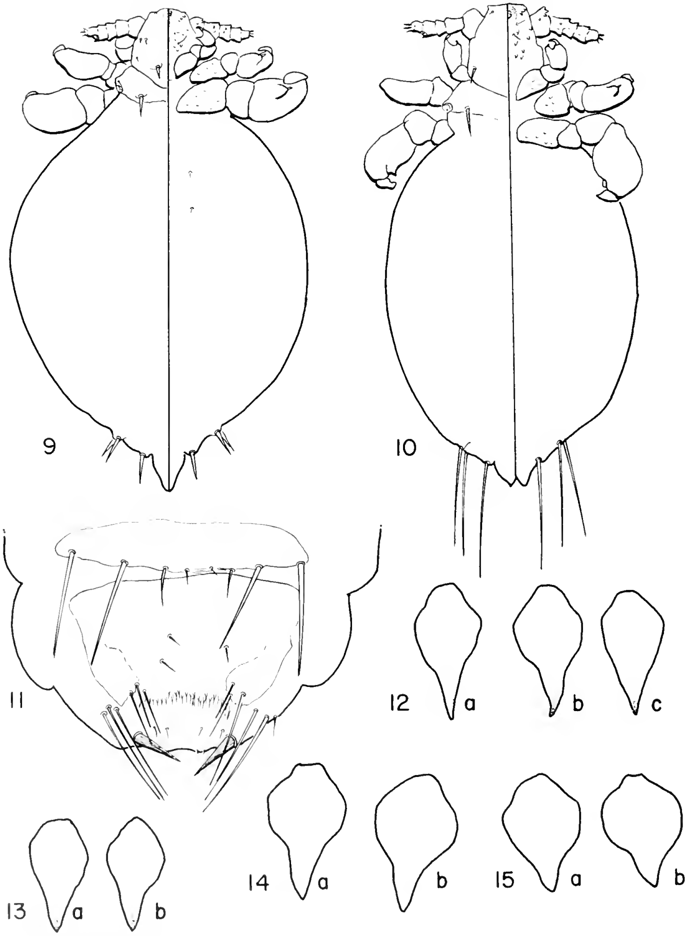
Figs. 2, 3, 8, 9, 11, 15-18

Type data.— Male holotype, female allotype, 1 male and 2 female paratypes ex *Scotinomys xerampelinus*, Panama: Province of Chiriqui, Boquete Trail, 3 miles (5 km) W Cerro Punta, 7700 ft (2700 m), 9-III-1962, PMMC 10275. Additional paratypes, all from *Scotinomys xerampelinus*, Province of Chiriqui, collected by the Preventive Medicine and Malaria Control Unit, U.S. Army, as follows: 1 female, Martinez Dairy, Cerro Punta, 6800 ft (2400 m), 8-I-1966, no. 6862. A series from Boquete Trail, 3 miles (5 km) W Cerro Punta, 6900 to 7800 ft (2400 to 2700 m), 7-14-III-1962, as follows: 3 males, 7 females, plus 1 third-stage nymph, no. 10155; 1 female, no. 10172; 1 male, 1 female, no. 10238; 4 females, no. 10245; 2 males, no. 10253; 1 male, plus 1 third-stage nymph, no. 10257; 1 female, plus 1 third-stage nymph, no. 10258; 1 female, no. 10260; 2 males, 1 female, no. 10276; 1 female, no. 10277; 1 male, 2 females, no. 10405; 1 male, 2 females, no. 10406; 1 female, no. 10424; 5 males, 5 females, no. 10454; 1 male, no. 10481; 2 females, no. 10492.

Diagnosis.— A member of the *hesperomydis* group. Separable by having apical lobes of paratergal plate II both short, not with ventral greatly prolonged (Fig. 2) and in lacking sword-shaped setae on abdomen. Female further separable by having genital seta rather short and blade-shaped (Fig. 11). Male further separable by having only one apical lobe on paratergal plate VII (Fig. 3) (occasional males of related species also lack the ventroapical lobe of this plate).

Lengths.— Male: holotype, 1.0 mm; paratype, 0.95 to 1.10 mm. Female: allotype, 1.45 mm; paratype, 1.30 to 1.45 mm.

Description.— *Male* (Fig. 16). *Head* (Fig. 17). First antennal segment not particularly enlarged, third segment not modified; postantennal margins slightly rounded, converging somewhat posteriorly; accessory dorsal seta missing. *Thorax*. Sternal plate (Fig. 15) broad, posterior apex bluntly rounded, short and broad, lacking a mesal keel; plate less than one and one-half times as long as broad. Dorsal mesothoracic seta long. *Abdomen*. All setae long, flexible, none sword-shaped; tergal and sternal plates well developed, all setae confined to their posterior margins; lacking tergal plate and setae on segment 1. Paratergal plates (Fig. 3) II with short acute apical lobes of similar length and two stout setae extending beyond apices of lobes; plates III-VI with equal, scaly, quadrate, apical lobes; plate VII with short triangular dorsal lobe; plate VIII lacking apical



Figs. 9-15. *Hoplopleura hesperomydis*-group: 9, *H. scotinomydis*, n. sp., third-stage nymph ex no. 10155; 10, *H. emphereia* Kim, third-stage nymph ex *Peromyscus nudipes*, Chiriqui, no. 10254. Note that the dorsomedian part of the head is missing; 11, *H. scotinomydis*, n. sp., female genitalia, allotype; 12, thoracic sternal plate, *H. hesperomydis* (Osborn) ex *Peromyscus maniculatus*: a, male, Washington; b, female, Washington; c, female, Utah; 13, same, *H. reithrodontomydis* Ferris (?), California ex *Reithrodontomys megalotis*: a, female; b, male; 14, same, *H. emphereia* Kim, Chiriqui ex *Peromyscus nudipes* no. 6814: a, male; b, female; 15, same, *H. scotinomydis*, n. sp.: a, holotype; b, allotype.

lobes; plate III with two stout apical setae extending about to apices of lobes; IV-VI with small to minute ventral apical seta and stout dorsoapical seta extending almost to apices of lobes. *Aedeagus.* (Fig. 8) with parameres somewhat broadened basally, lateral outlines convex; pseudopenis with elongate apex.

Female (Fig. 18). *Head* and *thorax* as in male. *Abdomen* as in male except for usual sexual dimorphism. Apical setae of paratergal plates (Fig. 2) often relatively shorter than in male; plate VII with two narrow apical lobes, the dorsal one the longer, obliquely truncate; ventral lobe acute. Genital seta shorter than in related species, blade-shaped (Fig. 11).

Nymph (Fig. 9). *Third instar.* Head, scaly dorsally, usual ventral tubercles; principal dorsal seta short, stout; other head setae minute. Dorsal mesothoracic seta about same size and shape as principal dorsal head seta. Four minute setae ventrally on abdomen. Terminal setae of abdomen consisting of a pair and single on each side, all these short, stout; anal lobe extended, short, bluntly rounded.

The *travassosi* group.

H. travassosi Werneck and allies are typical parasites of South American rodents. Species of this group are found throughout that continent. The northernmost representatives known are *H. angulata* Ferris, from Panama, and *H. similis* Kim, which is found in Panama and as far north as tropical Mexico.

Hoplopleura angulata Ferris

Hoplopleura angulata Ferris, 1921, Stanford Univ. Publ. Biol. Sci. 2:73, Figs. 40, 41A-C, E; Johnson, in press, Brigham Young Univ., Sci. Bull., Biol. Ser. 17(3), Figs. 58-69.

The type series was from *Rhipidomys venezuelae*, Venezuela. This louse species is common on several species of *Rhipidomys* in Venezuela, and also occurs on species of *Rhipidomys* in Peru, Colombia, and Trinidad.

PANAMANIAN SPECIMENS.— Two males from the rare *Nyctomys sumichrasti*, Province of Chiriqui, Cerro Punta. Occurrence of *angulata* on a mouse other than *Rhipidomys* is a surprising finding considering the rigid host specificity of this species in Venezuela.

Hoplopleura similis Kim

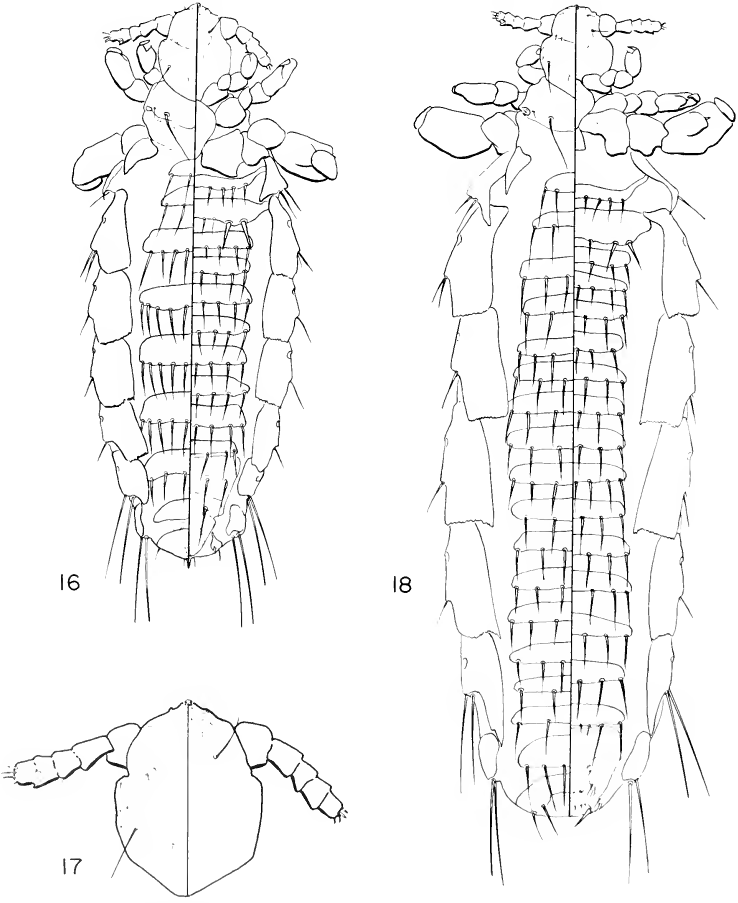
Figs. 19-21

Hoplopleura similis Kim, 1965, J. Parasit. 51:884, Figs. 47-53.

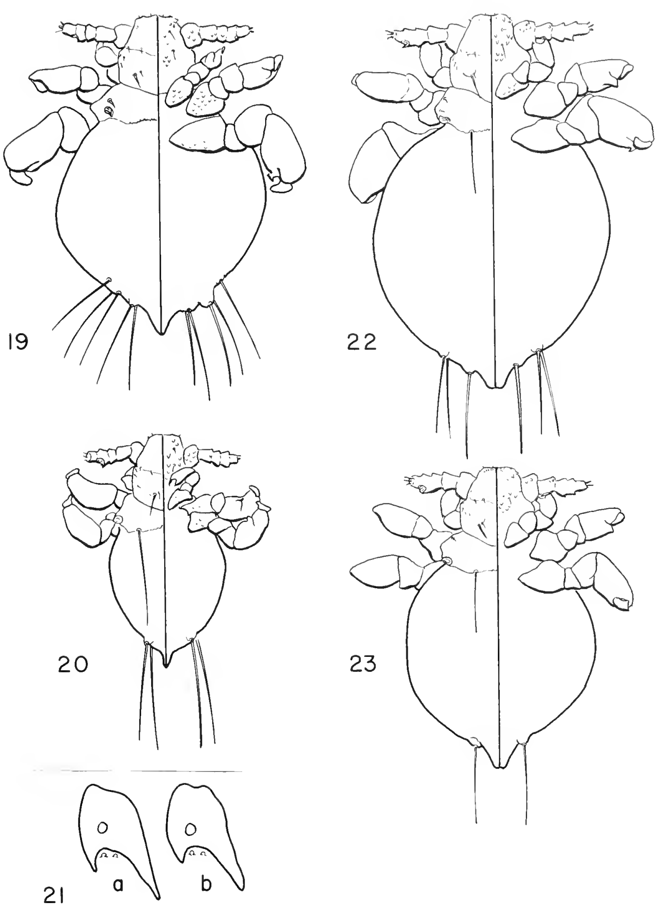
The female holotype and a series of female paratypes were from *Oryzomys fulvescens*, Veracruz, Mexico. The male allotype was from Bolivian *Oryzomys chaparensis*.

PANAMANIAN SPECIMENS.— From *Oryzomys fulvescens*: 1 female, Province of Bocas del Toro, Rancho Mojica, 500 ft (1700 m), 8-IX-

1961, no. PMMC 8017; 1 female, Province of Chiriqui, Boquete Trail, 3 miles (5 km) W Cerro Punta, 7750 ft (2700 m), 10-III-1962, no. PMMC 10314; 4 nymphs (first and third instar), Province of Chiriqui, 3 miles (5 km), W Cerro Punta, 7800 ft (2700 m), 7-III-1962, no. PMMC 10177.



Figs. 16-18. *Hoplopleura scotinomydis*, n. sp.: 16, holotype; 17, head, holotype; 18, allotype.



Figs. 19-23. *Hoplopleura* species: 19, *H. similis* Kim, third-stage nymph; 20, same, first-stage nymph; 21, same, paratergal plate VII, female: a, ex no. 8017; b, ex no. 10314; 22, *H. mendezi*, n. sp., third-stage nymph; 23, same, second-stage nymph.

The Panamanian females are like the holotype except the ventral apical lobe of paratergal plate VII is very short (Fig. 21). The nymph has not been described previously. It is very like that of *travassosi* except the dorsal head setae are less thornlike. The third instar lacks the dorsal mesothoracic seta. If the seta is missing, not broken off, this is a major difference between *travassosi* and *similis*.

DESCRIPTION.— *Nymph.* Abdomen of both first and third instar faintly reticulate; thoracic cuticle and anterior ventral abdominal cuticle spiculate. *First instar* (Fig. 20) with one pair of long terminal abdominal setae on each side; anal lobe somewhat extended; head with usual tubercles ventrally, principal dorsal head seta well developed, its accessory seta short, stout. Other dorsal setae of head small, not thornlike. Dorsal mesothoracic seta very long. *Third instar* (Fig. 19). Head much as in first instar but principal dorsal seta relatively shorter. Dorsal mesothoracic seta aparently not present. Two pairs and a single terminal abdominal seta on each side.

The *quadridentata* group.

As is true of the *travassosi* group, species of *Hoplopleura* related to *quadridentata* (Neumann) are typically Neotropical. However, distribution of known species of the group is generally more northern. In South America true *quadridentata*-group species apparently do not occur south of the tropical regions, while to the north one species, *oryzomydis* Pratt and Lane, is common on rice rats (*Oryzomys palustris*) in the southern United States. In Panama there are three representatives of the *quadridentata* group, one of them new.

Hoplopleura nesoryzomydis Ferris

Hoplopleura nesoryzomydis Ferris, 1921, Stanford Univ. Publ., Biol. Sci. 2:90, Fig. 53A; Wenzel and Johnson, 1966, Ectoparasites of Panama, p. 275.

PANAMANIAN SPECIMENS.— From *Zygodontomys microtinus*, 9 males, 11 females, 2 nymphs, taken in 13 collections, Canal Zone and Azuero Peninsula. Also present in 2 collections from *Oryzomys capito talamancae*, Canal Zone (4 males, 3 females, 15 nymphs) and Cerro Punta, Chiriqui (1 female, 1 nymph).

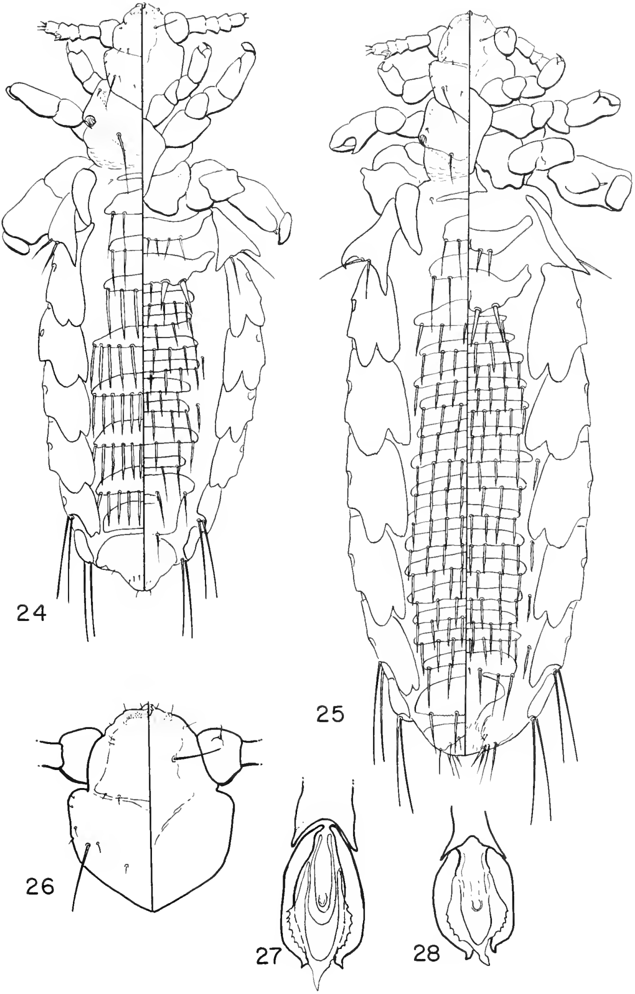
Hoplopleura oryzomydis Pratt and Lane

Figs. 27, 31-34

Hoplopleura oryzomydis Pratt and Lane, 1951, J. Parasit. 37:141, Figs. 1-3, 5; Wenzel and Johnson, 1966, Ectoparasites of Panama, p. 275. Johnson, in press, Brigham Young Univ. Sci. Bull., Biol. Ser. 17(3), Figs. 129-137.

The type series of *oryzomydis* was taken from *Oryzomys palustris*, Florida and South Carolina. Venezuelan specimens from *Nectomys squamipes* are similar to the North American form (Johnson, in press).

PANAMANIAN SPECIMENS.— One pair from *Oryzomys caliginosus*, El Valle; 1 pair from *Oryzomys capito*, Province of Darien, Santa Fe, no. OICS 2286.



Figs. 24-28. *Hoplopleura quadridentata*-group: 24, *H. mendezi*, n. sp., holotype; 25, same, female. Composite drawing of the allotype and paratype; 26, same, head, holotype; 27, *H. oryzomydis* Pratt & Lane, aedeagus, ex *Oryzomys capito*, Darien, Panama; 28, *H. mendezi*, aedeagus, holotype.

Morphological differences among the populations: paratergal plates of Panamanian specimens scalier than those of types. Thoracic sternal plate (Fig. 31) somewhat broader than in U.S. specimens; more like that of Venezuelan series. Aedeagus (Fig. 27) similar to types. Abdominal tergal and sternal plates narrower than in Venezuelan and U.S. specimens, approaching obsolescence. Penultimate tergal plate of female smaller than in U.S. specimens, but like them in having two rather than three or four apical setae (compare Figs. 32-34).

Hoplopleura mendezi, n. sp.

Figs. 22-26, 28-30

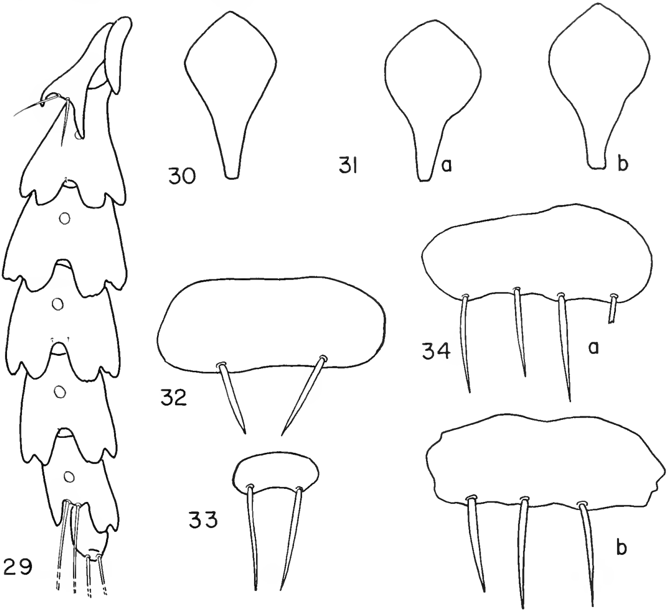
Type data.— Male holotype, female allotype, 2 male paratypes from *Oryzomys* sp., Province of Chiriqui, Bambito, El Hato, 15-I-1961, Keenan and Wislocki collectors, RML 40451. One female paratype as above but Chiriqui Viejo, Casa Shannon, 17-I-1961, Wislocki collector, RML 40450. Also examined: 2 males, 1 female, 3 nymphs (second and third instar), lacking data but possibly RML no. 40445.

According to Handley (1966) the type host could be either *Oryzomys alfaroi*, which is rare, or *Oryzomys albigularis*. Both these species are found at the type locality. A third species, *Oryzomys fulvescens*, occasionally occurs at high elevations like the type locality, in this area of Panama, but as it carries *Hoplopleura similis* Kim, there is less likelihood that it is the type host of *mendezi*.

Diagnosis.— A member of the *quadridentata* group. Adult separable by lacking long setae on paratergal plate III. Nymph differs (from others known) by having antennal segments 3 to 5 incompletely separated; and further from *nesoryzomydis* by having the small dorsolateral head setae minute.

Lengths.— Male: holotype, 1.0 mm; paratypes 0.95 to 1.05 mm. Female: 1.3 mm.

Description.— *Male* (Fig. 24). *Head* (Fig. 26). Postantennal angles well developed; antennae unmodified, first segment not particularly enlarged; accessory dorsal seta present. *Thorax.* Sternal plate (Fig. 30) elongate, squared apically. Dorsal mesothoracic seta long. *Abdomen.* Tergal and sternal plates arranged as usual; segment 1 with indistinct tergal plate and one minute seta to either side of the plate. Typical abdominal plates well developed, their posteroapical setae long, straight, slightly sword-shaped, some setae off plates dorsally and ventrally. Paratergal plates (Fig. 29, female) III-VI each with two deeply subdivided, rounded apical lobes; VII with truncate, divided dorsal lobe and lacking ventral lobe; VIII lacking apical lobes. Plate II with two long apical setae; plates III-VI with apical setae missing, extremely minute, or minute and removed from plate margin. *Aedeagus* (Fig. 28) with para-



Figs. 29-33. *Hoplopleura quadridentata*-group: 29, *H. mendezi*, n. sp., paratergal plates, female paratype; 30, same, thoracic sternal plate, allotype; 31, *H. oryzomydis* Pratt & Lane, thoracic sternal plate, ex *Oryzomys capito*, Darien, Panama: a, male; b, female; 32, *H. oryzomydis*, penultimate abdominal tergal plate, female, paratype; 33, same, ex *O. capito*, Darien; 34, same, ex *Nectomys squamipes*, Venezuela.

meres not noticeably convex laterally, pseudopenis flared and serrate laterally.

Female (Fig. 25). *Head*, *thorax* and *abdomen* as in male except for usual sexual dimorphism. Paratergal plate VII with long rounded-acute ventral apical lobe and truncate, apically divided dorsal lobe. Genital seta long, not blade-shaped.

Nymph. Second and third instar similar except for size and the fact that third instar (Fig. 22) has a pair plus a single terminal abdominal seta on each side while the second instar (Fig. 23) has only one terminal seta on each side. Anal segment slightly prolonged. Principal dorsal head seta well developed, its accessory seta short but not minute; other dorsal setae small to minute. Thorax with long mesothoracic seta; abdomen spiculate, lacking plates or spiracles.

This species is named for my friend and colleague Eustorgio Méndez, Gorgas Memorial Laboratory, Panama, in recognition of his contributions to the taxonomy of the Mallophaga and Siphonaptera of South and Central America.

Fahrenholzia Kellogg and Ferris

Fahrenholzia ferrisi Werneck

Fahrenholzia ferrisi Werneck, 1952, Rev. Bras. Biol. 12:73, Fig. 7; Johnson, 1962, Ann. Ent. Soc. Amer. 55:417, Figs. 10-13, 30, 37.

Fahrenholzia fairchildi: Wenzel and Johnson, 1966, Ectoparasites of Panama, p. 275 (*lapsus*, specimens from *Heteromys desmarestianus*, Cerro Punta).

The type series was from *Heteromys goldmani*, Veracruz, Mexico. This species also occurs on *Heteromys* sp., Guatemala.

PANAMANIAN SPECIMENS.— From *Heteromys desmarestianus*, 20 collections (43 males, 57 females, 39 nymphs). Seventeen collections were from Province of Chiriqui, near Cerro Punta; two from Boquete; one from Cerro Campana. Also examined: one nymph, probably this species, from *H. desmarestianus*, Piña, Canal Zone.

It seems evident that *F. ferrisi* is the normal anopluran parasite of *Heteromys desmarestianus* in Panama. See further comment below.

Fahrenholzia fairchildi Johnson

Fahrenholzia fairchildi Johnson, 1962, Ann. Ent. Soc. Amer. 55:419, Figs. 18-21, 32. 39. Wenzel and Johnson, 1966, Ectoparasites of Panama, p. 275.

The type series was supposedly from *Heteromys desmarestianus*, Santa Fe, Panama. Paratypes were from *Liomys adspersus*, Fort Kobbe and Summit Road, Canal Zone. These were all collected in 1955-57. In the 1961-63 surveys, this species was taken only from *Liomys adspersus*. There were 34 collections, including 29 males, 44 females, and 67 nymphs, Azuero Peninsula, Los Santos Province, and a collection of 1 male and 2 nymphs from Juan Mina, Canal Zone. The collection data of the type collection probably were erroneous, since *fairchildi* was found consistently on *Liomys* in the present series, while *Heteromys desmarestianus* carried only *F. ferrisi*. Thus the normal host of *fairchildi* is *Liomys adspersus*. Through a *lapsus*, specimens of *ferrisi* from *H. desmarestianus*, Cerro Punta, were reported as *fairchildi* by Wenzel and Johnson (1966).

Polyplax Enderlein

Polyplax auricularis Kellogg and Ferris

Polyplax auricularis Kellogg and Ferris, 1915, Stanford Univ. Publ., Univ. Ser., p. 13, Fig. 4; pl. 4, Fig. 8. Ferris, 1921, Stanford Univ. Publ., Biol. Sci. 2:206.

The type series was from *Peromyscus maniculatus*, California. This species is also found on other species of *Peromyscus* and from *Onychomys* sp. in North America. It has been reported from *Reithrodontomys mexicanus* and *Neotomodon* sp., Mexico.

PANAMANIAN SPECIMENS.— From *Reithrodontomys creper*, Province of Chiriqui, near Cerro Punta, 15 males, 19 females, 7 nymphs, in 10 collections. *P. auricularis* often occurred together with *Hoplopleura emphereia* Kim.

Panamanian specimens do not differ consistently from North American individuals taken from species of *Peromyscus*, *Neotoma*, and *Onychomys*. This aberrant species is the southernmost representative of the genus *Polyplax* in the New World. Although its northern populations apparently have a broad host range, in Panama—doubtless at the southernmost point of its range—*auricularis* is associated only with *Reithrodontomys creper*.

HOST-PARASITE LIST

Order Rodentia	
Family Sciuridae	
Sciurus granatensis	*Enderleinellus* sp. (longiceps group)
	Neohaematopinus semifasciatus F., s. lat.
Sciurus variegatoides	*Neohaematopinus semifasciatus* F., s. lat.
Family Heteromyidae	
Liomys adspersus	*Fahrenholzia fairchildi* J.
Heteromys desmarestianus	*Fahrenholzia ferrisi* W.
	Fahrenholzia hertigi J.
Family Cricetidae	
Oryzomys sp.	*Hoplopleura mendezi*, n. sp.
Oryzomys caliginosus	*Hoplopleura oryzomydis* P. & L.
Oryzomys capito	*Hoplopleura oryzomydis* P. & L.
	Hoplopleura nesoryzomydis F.
Oryzomys fulvescens	*Hoplopleura similis* K.
Nyctomys sumichrasti	*Hoplopleura angulata* F.
Reithrodontomys creper	*Hoplopleura emphereia* K.
	Polyplax auricularis K. & F.
Reithrodontomys mexicanus	*Hoplopleura emphereia* K.
Peromyscus nudipes	*Hoplopleura emphereia* K.
Zygodontomys microtinus	*Hoplopleura nesoryzomydis* F.
Scotinomys xerampelinus	*Hoplopleura scotinomydis*, n. sp.
Sigmodon hispidus	*Hoplopleura hirsuta* F.
Family Muridae	
Rattus rattus	*Polyplax spinulosa* (B.)
Family Echimyidae	
Hoplomys gymnurus	*Hoplopleura audax* F.

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NOTES CONCERNING MEXICAN SALDIDAE, INCLUDING THE DESCRIPTION OF TWO NEW SPECIES (HEMIPTERA)

John T. Polhemus[1]

ABSTRACT.— A complete description and discussion of the genus *Enalosalda* Polhemus is given, and the males of *E. mexicana* Van Duzee and *Saldula hispida* are described. *Saldula saxicola* and *Saldula durangoana* are described as new. *Saldula suttoni* Drake and Hussey is transferred to *Ioscytus* (n. comb.); *Salda hispida* Hodgden is considered a subspecies (n. comb.) of *Saldula sulcicollis* Champion.

The new taxa and nomenclatural changes proposed here have resulted from a comprehensive study of Mexican Saldidae. As the larger work may not be published for some time, it seems advisable to make this information available to other workers.

The work upon which this paper is based was supported in part by a grant from the University of Colorado Museum.

The specimens utilized are primarily from the Polhemus collection (JTP) and the University of Colorado Museum Collections (CU). A small amount of additional material was borrowed from Texas A & M University (TAM), the California Academy of Sciences (CAS), and the University of Michigan (UM); and I am indebted to J. C. Schaffner, P. H. Arnaud, and T. E. Moore respectively for their help in this regard.

The genus *Enalosalda* Polhemus was recently named in a paper by Polhemus and Evans (1969); however, a complete description and discussion were inappropriate in that paper and are given below.

Enalosalda Polhemus

Enalosalda Polhemus, 1969, *in* Polhemus and Evans, Pacific Insects 11:575.

Hemelytra with membrane not differentiated from corium except at inner margin; cell pattern variable, usually indistinct. Hind wings reduced to small, membranous strips. Female ovipositor short, broad, normally with six small teeth. Tube leading from spermatheca bulb with tapering walls, thinning toward apex, without flange. Larval organ absent. Ocelli, measured from center, equidistant from each other and inner margins of eyes.

All other generic characters typical of the Chiloxanthinae (Cobben, 1959), i.e., base of filum gonopori forming one closed ring, median sclerotized structure of aedeagus paired, apicolateral structure of aedeagus absent, posterior margin of female subgenital plate truncate with hind margin weakly indented, head without postclypeus. (The ductus ejaculatorius has not been studied.) This genus falls in the subfamily Chiloxanthinae.

Type species: *Orthophrys mexicanus* Van Duzee, 1923.

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DISCUSSION.— Van Duzee (1923) described *mexicanus* from a single female taken under kelp on Angel de la Guardia Island in the Gulf of California and placed it in the genus *Orthophrys*. Its generic position was considered by Drake and Hoberlandt (1950), who placed it in *Pentacora*, and later Drake and Hottes (1954) figured the type and published a note on it. Recently, Lattin and Cobben (1969) reexamined the type and tentatively assigned the species to *Pentacora*; however, the rediscovery of the species at Guaymas, Sonora, Mexico, has permitted the examination of a long series, and I concluded that the taxon represents a distinct genus, hence the name and a brief diagnosis were recently published (Polhemus and Evans, 1969). Table 1 gives a comparison between *Enalosalda* and the other genera in the Chiloxanthinae of which females were available. (Only a single male of *Pelachoris leucographa* [Rimes] was studied, but it and Drake's description [1962] indicate that *Pelachoris* is a fairly typical member of the subfamily.)

Enalosalda is divergent from other Chiloxanthinae, as it lacks some of the specialized structures of *Pentacora*, *Chiloxanthus*, and *Paralosalda*. The great reduction of flight (metathoracic) wings and lack of larval organs could be interpreted as an indicator of the age of split off of *Enalosalda* from the rest of the subfamily, which is a fairly homogeneous unit with the exception of the annectant *Paralosalda*. Flight wings are of high importance to many saldids, and only those species occupying stable ecological situations over a long time period are likely to lose the ability to fly. Even then, many brachypterous forms retain relatively well-developed posterior

Table 1. Comparison of the genera of Chiloxanthinae.

Enalosalda	*Paralosalda*	*Pentacora*, *Chiloxanthus*
Spermatheca tube leading from bulb having tapering walls. Ovipositor short, having six small teeth and no well-developed ridges.	Spermatheca tube leading from bulb having tapering walls. Ovipositor of moderate length, having 8 well-developed teeth. Ridges along ovipositor well developed.	Spermatheca tube with thickened structure (flange) at terminus. Ovipositor long, with 13-14 well-developed teeth. Ridges along ovipositor well developed.
Flight (metathoracic) wings vestigial, being reduced to small membranous strips.	Flight wings well developed.	Flight wings more or less well developed, nearly attaining apex of hemelytra in all species.
Female hemelytra with only slight modification to receive male coupling plate, the modification being a glabrous area with a few erect hairs on the underside of embolium.	Female hemelytra modified to receive male coupling plate.	Female hemelytra always modified to some degree to receive male coupling plate; at least a thickening of the embolar region.
Larval organ absent.	Larval organ present.	Larval organ present.
Intertidal.	Intertidal.	Littoral or inland.

wings, although a reduction in hind wing structure, similar to that in *Enalosalda*, is seen in some other saldids colonizing the ocean shore (i.e., *Orthophrys* and *Halosalda*), and in the intertidal *Omania* they are absent. The parallelism between *Enalosalda* and *Orthophrys* has been discussed at length in another paper (Lattin and Cobben, loc. cit.). The lack of a flange on the spermatheca is a character of unknown significance; however, in his studies of the female genitalia of the Heteroptera, Pendergrast (1957) stated that for the Saldidae a single deep pump flange exists. The species that he studied were *Saldula saltatoria* (L.) and *Salda littoralis* (L.). Concerning the Heteroptera as a whole, he states that the spermatheca may possibly be of use at the generic level of classification. The species studied by this author in the Chiloxanthinae, other than *Enalosalda*, all possess the flange.

The reduced ovipositor structure, tending toward the mesoveliid type, may have resulted from laying eggs in rock crevices or soft material rather than in plant stems. While the eggs have not been found, the habitat surrounding the intertidal rocks, in which these bugs were studied, provided no visible terrestrial plant life that could be used for egg deposition. Also, nymphs of almost all instars were found in the intertidal zone.

I am indebted to G. G. E. Scudder for studying the female genitalia in detail. His figures (1A and B) are reproduced here, and the nomenclature is that of Scudder (1959, 1961). His comments, in part, are: "It seems to me that this is a fairly typical saldid, both in external structure and detail. . . . The attachment of the gonoplacs is a little different to that I have studied in *Salda* and *Saldula*: The 'connecting piece' is quite free in your new genus and not in *Salda* and *Saldula*."

As the same condition of the "connecting piece" is found in *Pentacora signoreti* Guerin, it is possible that this character may be typical of the subfamily Chiloxanthinae; however, in *Paralosalda* it is not free. The figure by Drake and Hottes (1954) does not properly depict the antenna of *Enalosalda mexicana*, and as no male has been available until the present series came to hand, a redescription of the species follows. The type, a female, has been studied.

Enalosalda mexicana (Van Duzee)

Orthophrys mexicanus: Van Duzee, 1923, Proc. Calif. Acad. Sci. 12:165 (Type: Puerto Refugio, Angel de la Guardia Island, Gulf of California, Mex.; Calif. Acad. Sci. type no. 1045).

Pentacora mexicana: Drake and Hoberlandt, 1950, Acta Ent. Mus. Nat. Pragae 26:5.

Pentacora mexicana: Drake and Hottes, 1954, Occ. Papers Mus. Zool., Univ. Mich. 553:5.

Pentacora mexicana: Lattin and Cobben, 1968, Ent. Berichten. 28:130.

Enalosalda mexicana: Polhemus and Evans, 1969, Pacific Insects 11:575.

COLORATION.— Head, pronotum, scutellum, sutures of thoracic venter, hemelytral markings and veins, dorsal surface of antennal segment 1 and all of segments 3 and 4 brown to deep brown; small spot either side of vertex of head, elongate area along inner margin of each eye, medial spot on frons and apex of frons, rostrum, anteclypeus, labrum, broad areas along lateral pronotal margins, narrow area caudad from collar, two triangular pronotal spots adjacent to anterior femora, dorsal surface of middle and hind femora, apices of tibia, tarsi ochreous; hemelytral ground color flavous to ochreous; thoracic underparts leucine; legs, coxae, tibia luteous; antennal segment 2 luteous, becoming lighter distally; femora luteous, knees lighter.

Head.— Shining, frons and vertex rugulose. The elongate ochreous areas along eyes interrupted by a dark brown sulcus starting between ocelli and eye and extending anterolaterally almost to eye, deeper ahead of ocelli; rostrum reaching between hind coxae; ocelli equidistant from each other and eyes; with usual three pairs of tricobothria.

Thorax.— Pronotum shining, rugulose; anterior lobe scarcely raised, weakly differentiated from posterior lobe; with broad depression medially and a depression on each side of middle caudad of medial depression; lateral margins straight, angles rounded, anterior width slightly less than eyes, posterior width/anterior width, 60/43; posterior lobe/anterior lobe, 5/16; width/median length, 60/21; posterior margin slightly indented over scutellum. Scutellum width/length, 21/26.

Wings.— Hemelytra semi-brachypterous; broad, irregular spots along margin two-fifths and three-fifths of the distance from base to apex, a smaller spot four-fifths toward apex, irregular spots on inner corium one-third and two-thirds toward apex, and at apex, irregular, elongate brown areas along vestigial claval suture on both inner corium and clavus and along margin of scutellum on clavus; clavus fused to corium, vestigial suture ochreous; membrane largely wanting, existing narrowly from apex of claval commissure to apex of hemelytra, remainder of hemelytra rather uniformly coriaceous; cell structure indistinct, apparently with three cells; flight wings vestigial, consisting of short membranous strips (Fig. 2).

Extremities.— Antennal segments clothed with short, dark hairs and scattered longer hairs; proportions (60 units = 1 mm) I, 16; II, 32; III, 26; IV, 29. Tibiae and tarsi with usual scattered dark spines; all leg structures covered with semi-long light brown hairs.

Genital structures.— Parandria, paramere, sclerotized structures of aedeagus, filum gonopori, and coupling plate as shown in Fig. 1C, E, F, G, H, and I.

Size.— Length 2.7 mm, width 1.4 mm.

Female.— Similar to male, but slightly larger (see table); subgenital plate truncate (Fig. 1D). Hemelytra with polished area on underside of embolium about two-thirds toward apex from base, polished area having several short decumbent hairs directed caudad.

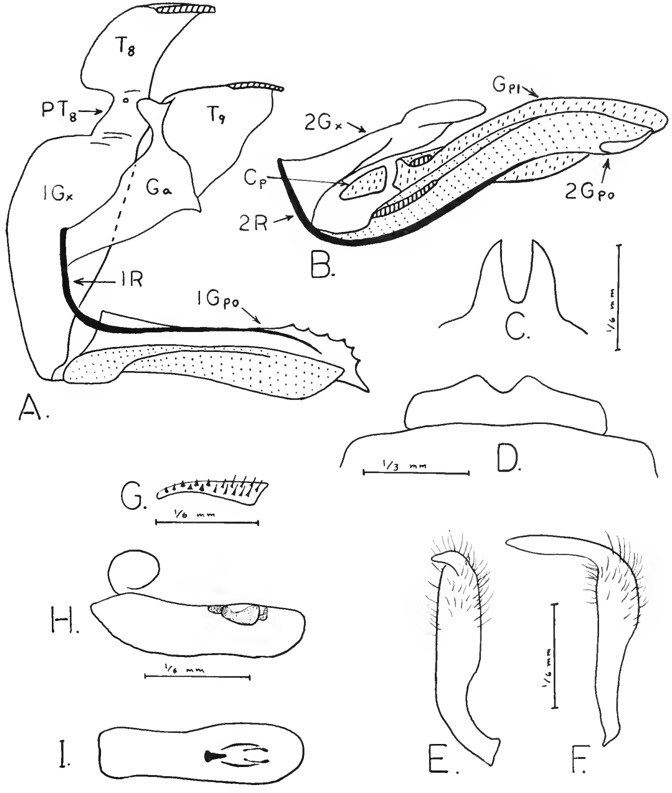

Fig. 1. *Enalosalda mexicana* (Van Duzee): (A) Female genitalia: T_8, tergite 8; T_9, tergite 9; PT_8, paratergite 8; Ga, gonangulum; 1 Gx, first gonocoxa; 1R, first ramus; 1 Gpo, first gonopophysis. (B) Female genitalia: Gpl, gonoplac; 2 Gx, second gonocoxa; 2R, second ramus; 2 Gpo, second gonopophysis; Cp, connecting piece. (C) Parandria. (D) Female subgenital plate. (E & F) Left male paramere, two views. (G) Male coupling plate. (H) Aedeagus, lateral view. (I.) Aedeagus, dorsal view.

Ovipositor short, broad, with six small teeth (Fig. 1A, 1 Gpo). Antennal proportions, I, 18; II, 40; III, 30; IV, 30.

Mean length of 10♂♂: 2.68mm (max 2.7; min 2.6)
Mean width of 10♂♂: 1.36mm (max 1.4; min 1.3)
Mean length of 10♀♀: 3.06mm (max 3.1; min 2.9)

Mean width of 10♀♀: 1.59mm (max 1.7; min 1.5)

Material examined.— 104♂♂, 66♀♀, 15 nymphs, San Carlos Bay, Guaymas, Sonora, Mexico, CL1202, 28-V-1966 to 5-VI-1966 (JTP); 9♂♂, 2♀♀, 3 nymphs, Ensenado Lalo, Sonora, Mexico, 27 56' 15" N x 111 17' 30" W, 29-X-1966, W. G. Evans. On high mid-tide rocks (JTP); 1♀, Angel de la Guardia Island, Gulf of Lower California, 29-VI-1921, E. P. Van Duzee (Holotype, CAS); 1♂, Pelican Point, Sonora, Mexico, 31 20' N, 113 38' W, on reef, water's edge, 27-III-1969, V. Roth (JTP).

The Ensenado Lalo and Pelican Point series were kindly furnished by the collectors, and I am indebted for the opportunity to study this material.

Variation.— The Ensenado Lalo series exhibits a greater variation in eunomy than the San Carlos series, with the brownish areas often less extensive but much darker where they occur, almost piceous. A very dark male has head markings darker, in the same pattern as the described male, but has the pronotum only narrowly margined with ochreous, the light area along the collar interrupted medially, and the remainder piceous; the scutellum is concolorous; the hemelytra are largely deep brownish black, with scattered light areas and broad elongate light area on the basal three-fourths of the outer corium interrupted medially by a weakly shining deep brown wedge; other markings similar to the described male, but the brown is darker.

In a female from the same series, the brown markings are deep as in the male, and the pattern is similar to the described male except the hemelytra, which are largely leucine to ochreous, with deep brown markings as follows: lightly shining spot on embolium and adjacent irregular contiguous spots on outer and inner corium one-fifth of the distance from base to apex; slight markings along claval commissure, and a tiny spot on clavus near apex of scutellum.

The veins delineating the cells of the membrane have a rather random pattern, creating from three to five irregularly shaped cells on each hemelytra (Fig. 2). This is true throughout all series.

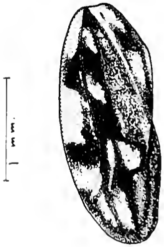

Fig. 2. *Enalosalda mexicana* (Van Duzee), left hemelytron.

HABITAT.— *Enalosalda mexicana* (Van Duzee) was found at San Carlos Bay in the intertidal zone on porous volcanic rock. The rock abounded with tiny pockets and crevices where the bugs hid when disturbed. None were observed feeding; however, it is presumed they utilize the abundant sea life clinging to the rocks. In June of 1966 the saldids made their appearance on the rocks as soon as the tide receded sufficiently for the surfaces to start drying, and were most abundant on dry rock. None were found where substantial spray was evident. The habitat seems restricted to the mid-tidal zone, where the full tide covers the rocks with several feet of water and low tide leaves several feet of rock exposed. All suitable areas along the rocky headland south of the trailer park near the Yacht Club at San Carlos Bay had abundant populations of the bugs, but a few miles distant in areas that appeared suitable none could be found. The rocky headland where the colonies are found is protected by a nearby island, which could be important since it protects the area from heavy seas.

When the low tide occurs at night, it will be interesting to determine whether or not the saldids feed, as most saldids are positively phototropic.

(In March of 1967 the habitat described above and another harboring this species on nearby Deer Island were examined. At this time of year the tide has little variation and is very low, so the saldids followed a pattern consisting of activity in sunlight and retreating to the rock crevices during darkness, the normal pattern of activity followed by littoral saldids.)

Ioscytus suttoni (Drake and Hussey), n. comb.

Saldula suttoni: Drake and Hussey, 1951, Occ. Papers Mus. Zool. Univ. Mich. 536:1-3 (Type: Michoacan, Mexico; Museum of Zoology, Univ. Mich.).

I have examined the type *Saldula suttoni* and find that it must be transferred to the genus *Ioscytus* because of the nature of the antennae, dorsal hairiness, pronotum, and general facies. The left hemelytron is shown in Fig. 5.

MATERIAL.— Mexico: 1♂ (Holotype), Michoacan, 26 km S Patzcuaro, under stones, 10,000 ft 2-III-1949. G. M. Sutton (UM).

Saldula saxicola, n. sp.

Of moderate size, quite slender, general color black, macropterous. (For all measurements 60 units = 1 mm.)

COLORATION.— Hemelytra dull black, barely shining; head, scutellum, thorax, and venter of abdomen deep brown to piceous, with golden pubescence on dorsum and fine silver pubescence on venter; spot on each side of vertex of head extending from hind margins of ocelli to eye, anteriorly diverging bands on each side of frons, outer corium anteriorly, spots on clavus and hemelytra yellowish; lateral pronotal margins whitish yellow, sharply becoming black anteriorly and posteriorly; embolium whitish yellow, becoming leucine posteriorly, there expanding to a large concolorous spot adjacent to membrane; clypeus and labrum ochroleucus; anterior and middle coxae margined with subhyaline; hind coxae acetabula, ventral segments of abdomen brown margined; outer corium yellowish anteriorly; inner corium with yellowish spot mediolaterally, two yellowish spots between the apex of the clavus and the membrane along hemelytral commissure. Narrow whitish yellow band or spot at apex of inner corium along anterior margin of membrane. Clavus with basal portion brownish yellow, and a yellowish spot near the apex. Legs hyaline to leucine, anterior femora brownish on apical four-fifths, middle and hind femora brownish on apical one-third, all femora light at apex; knees dark, middle and hind tibiae slightly embrowned over apical half, becoming lighter before apex which is brown.

Head.— Vertex raised medially in ocellar region; frons with median sulcus, and a cavity between the posterior portion and eye; a pair of conspicuous long black hairs on vertex, another pair on frons; rostrum brownish, extending between hind coxae.

Thorax.— Shining, faintly rugose, clothed with conspicuous golden pubescence; lateral margins straight, narrowing moderately anteriorly; callus strongly raised, with circular deep impression on each side; posterior lobe shorter than anterior lobe, midline ratio 8:13.

Scutellum about as wide as long (W, 51; L, 47).

Wings.— Hemelytra fully developed, covered with scattered golden pubescence, the longest subequal to width of the hind tibia; membrane long, with four cells, clouded with ochreous to brown, veins darker. For the eunomy, see Figs. 3F, G, and H.

Extremities.— Antennae long, slender; segment 1 stoutest, testaceous; segments 2, 3, and 4 deep brown; all segments clothed with short, inconspicuous hairs; antennal proportions:

♂: I, 19; II, 44; III, 29; IV, 27.
♀: I, 20; II, 47; III, 31; IV, 30.

Tibiae with a few scattered dark spines.

Genital structures.— Ovipositor of female with very stout, well-separated teeth on saw. Male paramere (Figs. 4C and D) clothed with fine hairs, filum gonopori coiled one and one-half times; coupling plate and parandria of male. (Figs. 4I and J.)

Holotype (♂): length 3.5 mm, width 1.4 mm.
Allotype (♀): length 3.7 mm, width 1.6 mm.
Mean length of 10 ♂♂: 3.28 mm (max 3.5; min 3.1)
Mean width of 10 ♂♂: 1.31 mm (max 1.4; min 1.3)
Mean length of 10 ♀♀: 3.76 mm (max 3.9; min 3.4)
Mean width of 10 ♀♀: 1.59 mm (max 1.7; min 1.5)

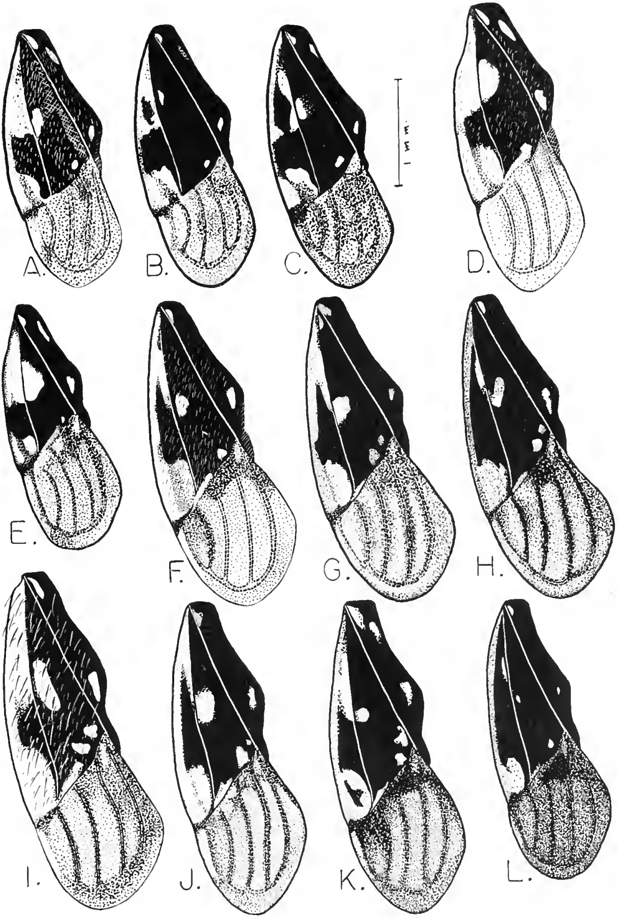

Fig. 3. *Saldula dewsi* group, hemelytra: (A, B, C) *Saldula abdominalis* (Champion). (D, E) *Saldula ventralis* (Stal). (F, G, H) *Saldula saxicola* n. sp. (I, J, K, L) *Saldula dewsi* (Hodgden).

Material examined.— Holotype ♂, allotype ♀, and paratypes 9 ♂ ♂ and 4 ♀ ♀, 5 miles (8 km) NE Castle Hot Springs, Arizona, CL 312, 7-X-1964 (JTP); 12 ♂ ♂, 16 ♀ ♀, 2 nymphs, Cuchajaqui Arroyo,

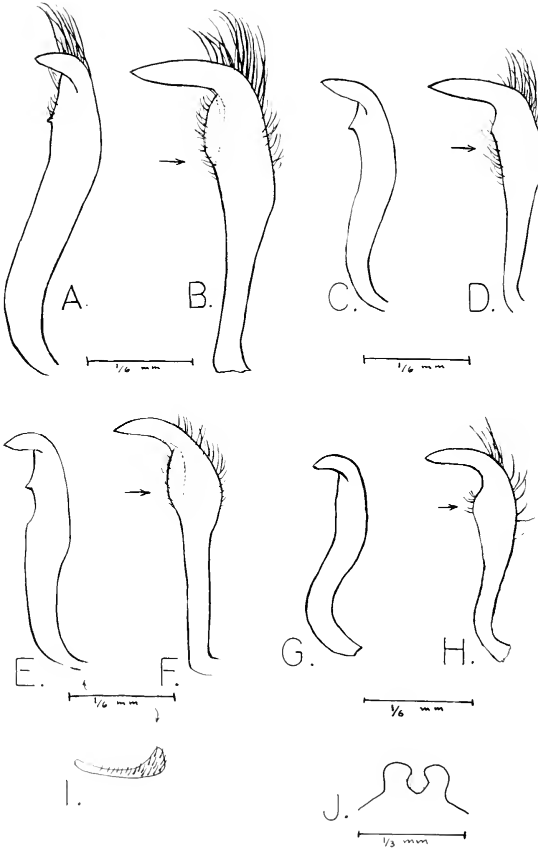

Fig. 4. *Saldula dewsi* group, genitalia: (A, B) *Saldula dewsi* (Hodgden), left male paramere, two views. (C, D) *Saldula saxicola* n. sp., left male paramere, two views. (E, F) *Saldula abdominalis* (Champion), left male paramere, two views. (G, H) *Saldula ventralis* (Stal), left male paramere, two views. (I, J) *Saldula saxicola* n. sp., male coupling plate (I) and parandria (J).

near Alamos, Sonora, Mexico, CL 1215, 21-III-1967, J. T. Polhemus (JTP); 6♂♂, 3♀♀, Cuchajaqui Arroyo, near Alamos, Sonora, Mexico, CL 1264, 29-V-1966, J. T. Polhemus (JTP); 4♂♂, 2♀♀, 1 mile (2 km) SW Ixhuatan, Chiapas, Mexico, CL 1098, 5-V-1964, J. T. and M. S. Polhemus (CU); 8♂♂, 2♀♀, 2 miles (3 km)

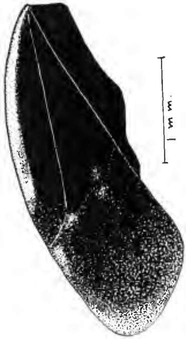

Fig. 5. Hemelytra: *Ioscytus suttoni* (Drake and Hussey), type.

NE Ixhuatan, Chiapas, Mexico, CL 1099, 5-V-1964, J. T. and M. S. Polhemus (CU); 6♂♂, 2♀♀, Santa Fe, Chiapas, Mexico, CL 1101, 5-V-1964, J. T. and M. S. Polhemus (CU); 3♂♂, 3♀♀, 3 miles (5 km) W El Naranjo, 1200 ft (367 m), San Luis Potosi, Mexico, 5-VI-1965, Burke, Meyer, and Schaffner (TAM); 1♂, Rio Quezalapan, 2 miles (3 km), E Lago Catemaco, Veracruz, Mexico, 21-VI to 5-VII-1964, J. R. Meyer (TAM); 1♂, Ciudad Victoria, Mexico, 14-VII-1950, Drake and Hottes (JTP); 1♀, Cola de Caballo, 3000 ft (917 m), Nuevo Leon, Mexico, 6-VII-1959, R. B. Selander and J. C. Schaffner (JTP); 1♂, Real de Arriba, Temescaltepec, Mexico, 4-VI-1933; H. E. Hinton and R. L. Usinger (JTP); 1 ♂, 22 miles W Ptazcuaro, Michoacan, Mexico, CL 1033, 23-IV-1964, J. T. and M. S. Polhemus (CU). Holotype, allotype, and paratypes in the University of Colorado Museum collection; paratypes will be deposited in the collections of Texas A & M University, California Academy of Sciences, and the author.

COMPARATIVE NOTES.— The most obvious external character separating *Saldula saxicola* from *S. dewsi* (Hodgden) is the long, hairy dorsal vestiture of *dewsi*. The male parameres are helpful in diagnosing the group, those of *dewsi* usually being larger, having a tuft of heavier black hairs (Figs. 4A and B), and a shape different from either *saxicola* or *Saldula abdominalis* (Champion).

Saldula saxicola was first recognized in the Arizona material and later additional specimens were found in the Mexican material being held under *abdominalis*. While the second antennal segment in some of the southern Mexico forms occasionally overlaps the proportions found in *abdominalis*, the eunomy will help to separate the two. The hemelytral markings in *abdominalis* (Figs. 3A, B, and C) tend to form an eye-shaped spot arising from the embolium at the forepart of the wing, whereas the tendency in *saxicola* is to form a solid fascia arising from the embolium, and in darker specimens the light area draws away from the embolium and degenerates into a line parallel with it. Rarely is *saxicola* found without a line or thin spot of white in the inner corium along the anterior margin of the membrane, whereas this is lacking in *abdominalis;* and two white spots are often found close to the hemelytral commissure in *saxicola*, whereas never more than one is present in *abdominalis*. Also the fascia at the apex of the corium along the embolium is usually solid white in *saxicola*, and if darkening occurs it is in the center. In *abdominalis* this spot is usually U-shaped, open at the rear; as the eunomic series progresses, the lighter colored specimens have the U filled in with white, and the eye-shaped spot well developed.

In the northern populations (Arizona, Sonora, Tamaulipas) of *S. saxicola*, the ratio of the length of the second antennal segment to the width of the head through the eyes will easily separate them from *abdominalis*, as the ratio is .80 or more in *saxicola* and a maximum of .60 in *abdominalis*. In the southern specimens, however, the ratio varies widely even within a given series, and an occasional overlap is found. Of the 51 specimens of *saxicola* examined for this character, only 4 had ratios of .60 or less, the lowest being .57. Of the 21 specimens of *abdominalis* studied, only 4 had ratios of .57 or greater, the highest being .60. Of the 8 specimens in the overlap zone, none presented a great problem in separation because of the long series available to work out the eunomy of each species.

HABITAT.— In Arizona, *S. saxicola* was found on exposed sloping sandstone in a streambed. The water was seeping from the base of an abandoned dam, wetting the roughly sculptured rock surfaces and forming pools where *Trepobates becki* Drake and Harris was abundant. On the more steeply sloping damp surfaces, *S. saxicola* was collected, along with *Saldula pexa* Drake.

At Cuchajaqui Arroyo, Mexico, the specimens were found in a similar habitat, on vertical stone surfaces beside a stream flowing into a large vertical-walled, sandstone basin and on a large log in the stream. Other locations in Mexico produced *saxicola* from similar situations, the specimens almost always being found on vertical or steeply sloping damp stone surfaces.

DISTRIBUTION.— In the *Saldula dewsi* species group, *S. abdominalis*, *S. dewsi*, *S. saxicola*, and *Saldula ventralis* (Champion) are found in Mexico. *S. ventralis* is the southernmost component of these and is not easily confused with the others. *S. dewsi* is found in Arizona, Mexico, and Central and South America, roughly paralleled in distribution by *S. abdominalis;* but the latter has not been found north of Central Mexico. *S. saxicola* apparently has its distributional center in Mexico and ranges into Arizona.

Saldula durangoana, n. sp.

Moderately large, robust; general color black and light brown, macropterous. (All measurements: 60 units = 1 mm.)

COLORATION.— Hemelytra dull black, not shining; head, scutellum, thorax, and venter of abdomen black, covered with fine decumbent golden pubescence on dorsum and thick silver pubescence on venter; clypeus, labrum, rostrum testaceous to brownish; anterior and middle acetabulae, coxae, ventral abdominal segments posteriorly margined with subhyaline; base of embolium, corium next to clavus, two medial elongate spots between corium and embolium, and small spot at apex of embolium deep brown to black; remainder of corium and embolium luteous, inner corium lighter at median corial suture, outer corium subhyaline. Clavus black, with fine golden pubescence, apex with faint brownish area. Legs testaceous to ochreous, anterior and middle femora blackish beneath on apical three-fourths, posterior femora blackish beneath on apical half, femora ochreous basally, with brownish spots on sides.

HEAD.— Shining with scattered long hairs on vertex and frons. Vertex with usual small yellow spot between ocelli and eye on each side, faintly rugose; ocelli large, seperated by approximately the width of an ocellus. Rostrum extending between hind coxae.

THORAX.— Pronotum moderately shining, faintly rugose, clothed with long, erect, black hairs that are not obvious unless viewed from the side, except a few along the anterior lateral margins; lateral margins curved, slightly explanate, narrowing moderately anteriorly. Callus moderately raised with a deep circular median impression; posterior lobe shorter than anterior lobe (not including collar), midline ratio 12:14, length to width ratio 30:103. Anterior and middle acetabula, coxae margined with subhyaline. Scutellum as wide as long (70:70).

WINGS.— Hemelytra fully developed, dull, not shining, with scattered golden pubescence, a little thicker at the base of the embolium, entire dorsum except membrane clothed with long, erect, black hairs. Membrane faintly brownish, subhyaline, veins slightly darker; long, with four cells (Fig. 6).

EXTREMITIES.— Antennae moderately long, moderately stout; segment 1 stoutest, testaceous, dark brown beneath on apical three-fourths; segment 2 longest, dark brownish yellow, lighter on apical third, apex dark; segments 3 and 4 black, somewhat thicker than segment 2; thicker than hind tibia; all segments clothed with semi-short pubescence, longer on segments 1 and 2, scattered longer stiff hairs on segments 3 and 4; antennal proportions:

♂: I, 18; II, 34; III, 24; IV, 30
♀: I, 18; II, 43; III, 26; IV, 30

Tibia covered with short, depressed hairs, none obviously longer than diameter of tibia, and usual dark spines; femora with longer, thin hyaline hairs beneath.

GENITAL STRUCTURES.— Male paramere (Figs. 7A and B) stout, clothed with long, fine hairs. Parandria as shown in Fig. 7C.

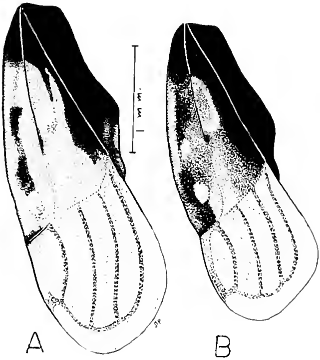

Fig. 6. *Saldula durangoana* n. sp.: (A, B) hemelytra.

Holotype (♀): length 4.5 mm; width 2.1 mm.
Allotype (♂): length 3.8 mm; width 1.7 mm.
Paratype (♀): length 4.2 mm; width 2.0 mm.

Allotype.— The allotype (male) darker than holotype; outer corium mostly brown to dark brown with a white spot medially at the apical four-fifths.

Material examined.— Holotype (♀) and paratype (♀), 39 miles W Durango, Durango, Mexico, CL 1013, 20-IV-1964, J. T.

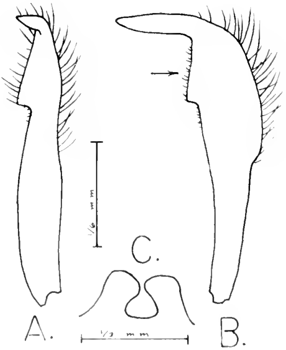

Fig. 7. *Saldula durangoana* n. sp.: (A, B) Left male paramere, two views. (C) Parandria.

and M. S. Polhemus. Allotype (♂), 61 miles W (99 km) W Durango, Durango, Mexico, CL 1014, 20-IV-1964, J. T. and M. S. Polhemus. (The holotype and allotype are in the University of Colorado Museum, and the paratype in the Polhemus collection.)

COMPARATIVE NOTES.—The species most closely resembles *Saldula luctuosa* (Stål) but *luctuosa* has a faintly shining to shining hemelytra, while *durangoana* is dull. This species bears a slight resemblance to *Saldula andrei* Drake; however, *andrei* is a narrower species with polished shining scutellum and pronotum, straight lateral pronotal margins, and a tendency for the apical spot on the clavus to form a fascia.

HABITAT.—Taken from amongst the grasses at two locations, one a grazing meadow, the other a margin of a farm pond. At both locations the ground was very wet. The elevation here is approximately 2000 m (6500 ft).

Saldula sulcicollis hispida (Hodgden), n. comb.

Salda hispida Hodgden, 1949, J. Kansas Ent. Soc. 22(4):115-156 (Type: Temescaltepec, Mexico; Calif. Acad. Sci.)

The comparison of the type of *Saldula hispida* (Hodgden) with a long series of *Saldula sulcicollis* (Champion) from various locations ranging from Arizona to Costa Rica has revealed that *hispida* cannot be considered more than a subspecies of *sulcicollis*. Specimens from the high mountains of Northern Chiapas in Mexico agree well with the type of *hispida*, and a male has been designated as typical of the subspecies and is described below.

In the series of *sulcicollis* from San Cristobal las Casas, Chiapas, specimens vary from the typical form almost to the *hispida* form in antennal dilation and coloration, which are the only reliable characteristics which will separate the two. In the typical form of *sulcicollis*, the last two antennal segments are slightly swollen and the apical half of the fourth segment is light colored, whereas in the *hispida* form the antennal segments are more slender and the last segment concolorous. The male genitalia of the two forms agree perfectly, and the other characters used by Hodgden for separation are too variable to be reliable.

As the type of *hispida* is from Real de Arriba (about 7000 ft) and the Chiapas material of *hispida* is from about the same altitude, it seems that this subspecies is restricted to the higher elevations, while the typical subspecies inhabits the valleys and plains from about 3000 to 5000 ft (900 to 1500 m) elevation. Very recent collections in Guatemala also support this view.

DESCRIPTION OF MALE.— Of moderate size, general color deep brown to black, macropterous, entire dorsum (except membrane) covered with long, erect setae, and semilong sparse golden pubescence. (For all measurements, 60 units = 1 mm.) Length 4.5 mm, width 1.8 mm.

Coloration.— Hemelytra black to deep chocolate brown with pruinose and leucine markings; head, scutellum, thorax, and venter of abdomen black; small spot between ocelli and each eye, clypeus, anteclypeus, labrum ochreous; rostum flavous to ochreous; clavus velvety black, with bluish pruinose areas at base, middle and near apex, narrow area at suture shining; inner corium pruinose black basally, pruinose area terminating in whitish grey at basal one-fourth; small whitish spot medially, whitish pruinose area next to membrane at middle; remainder shining black; outer corium blackish brown basally, becoming translucent deep chocolate brown apically, with leucine spot at apical fourth on embolium; legs ochreous to leucine; femora medially darkened, lighter at base and apex, with usual brown spots; tibia dark at knees, apex and broad medial area darkest on anterior legs, leucine elsewhere; tarsi with first segment largely leucine, second segment darker; coxae leucine, dark basally.

Head.— Shining, frons and vertex rugulose. Rostrum reaching between hind coxae; frons slightly depressed longitudinally at middle; ocelli approximate, slightly elevated. Eyes large, extending laterally half their width beyond anterior pronotal margins, with scattered setae.

Thorax.— Pronotum rugulose, shining callus strongly raised, with deep medial depression and a tiny, shallow depression on each side of the medial pit, marked off from collar and posterior lobe by deep, pitted sulci; collar wide (5); anterior lobe longer than posterior lobe (17/11); lateral margins slightly concave; humeral angles

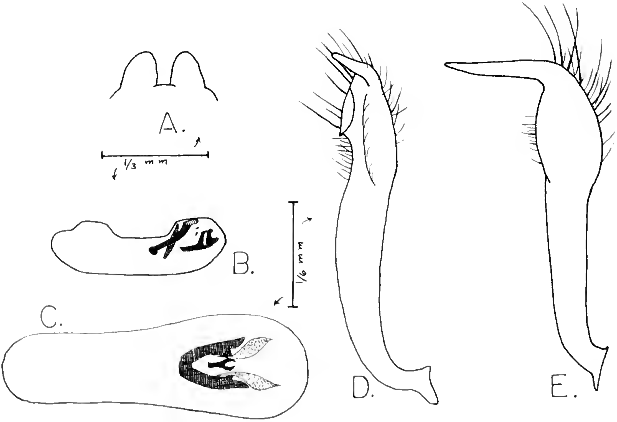

Fig. 8. *Saldula sulcicollis* (Champion), male genitalia: (A) Parandria. (B, C) Aedeagus, lateral view (B) and dorsal view (C). (D, E) Left male paramere, two views

sharply rounded; posterior margin broadly convex; posterior width/anterior width, 88/45. Scutellum rugulose, shining; width/length, 58/62.

WINGS.— Hemelytra fully developed; membrane fumose, with whitish mottling, veins dark, outer margin shining brown basally and apically, leucine medially, with four cells.

EXTREMITIES.— Antennal segment 1 ochreous, with small brownish anterior spot; segment 2 ochreous, brown at apex, slender; segments 3 and 4 dark brown, subequal in diameter to segment 1; segments 1 and 2 clothed with semilong hairs and scattered long hairs, segments 3 and 4 clothed with short pubescence and scattered longer hairs; proportions, I, 23; II, 54; III, 36; IV, 41. All leg structures covered with short, fine, light-colored pubescence; femora with long hairs beneath.

GENITAL STRUCTURES.— Parandria, paramere, and median sclerotized structure of aedeagus as shown in Fig. 8; filum gonopori coiled two and one-half times.

MATERIAL EXAMINED.— 7♂♂, 2♀♀, Mexico, Chiapas, 5 miles (8 km) S Tapiula, CL 1095, 4-V-1964, J. T. and M. S. Polhemus (CU); 1♂, 1♀, Chiapas, 12 miles (19 km) N Bochil, CL 1091, J. T. and M. S. Polhemus (CU).

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SCORPIONS OF UTAH

John D. Johnson[1] and Dorald M. Allred[2]

Abstract.— The 736 scorpions representing nine species collected in Utah, listed in order of greatest to least abundance, are *Vaejovis boreus*, *V. utahensis*, *Anuroctonus phaeodoctylus*, *V. confusus*, *Hadrurus spadix*, *V. becki*, *V. wupatkiensis*, *H. arizonensis* and *Centruroides sculpturatus*. *Centruroides sculpturatus*, *H. arizonensis*, *V. becki*, *V. confusus* and *V. wupatkiensis* are reported from Utah for the first time. *Vaejovis boreus* is the most widely distributed of the Utah scorpions. *Vaejovis boreus* and *V. confusus* occur in both the Great Basin and the Colorado River Basin. *Centruroides sculpturatus*, *Hadrurus arizonensis*, *H. spadix*, *V. wupatkiensis*, and *V. utahensis* occur only in the Colorado River Basin, whereas *Anuroctonus phaeodactylus* and *V. becki* are confined to the Great Basin. *Anuroctonus phaeodactylus*, *V. boreus* and *V. confusus* occur from the southern to the northern border of the state.

Both males and females were taken from May through October, with greatest numbers in May, June, and July. Females were taken in greater numbers than males. This may be related to their mating habits during the collecting periods, and does not necessarily indicate other than a 1:1 ratio in normal populations.

Morphological variations associated with distribution were distinguishable in two of the species collected—*Anuroctonus phaeodactylus* and *Vaejovis boreus*. The mean and standard error computed for the carapace, preabdomen, postabdomen, and telson on these two species indicate a significant morphological variation in the size of the preabdomen between the northern and southern populations.

Scorpions first collected from Utah were taken by Stansbury during the late 1840's, but none were named until 1854 (Ewing, 1928). Nothing more was published on scorpions of this region until Banks (1900) listed several species. However, most of Bank's records were of specimens from the Marx collection (now in the U.S. National Museum), which were incorrectly labelled and misidentified (Gertsch and Soleglad, 1966). Although more interest was shown in scorpions since the turn of the century, little published information and pertinent collecting data for Utah are existent. Studies by Stahnke (1950) and Williams (1966) dealt with scorpions of the western United States, but only those by Gertsch and Soleglad (1966) and Gertsch and Allred (1965) refer to Utah taxa.

Although scorpions are occasionally seen in desert areas of the western United States, few systematic studies have been made. Most specimens collected heretofore in Utah have been used for exhibit and teaching in high schools and universities, and their collection data is not existent or available. Specimens from Brigham Young University, supplemented by collections made by the senior author, constitute the basis for this listing of species from Utah, their geographic distribution, seasonal occurrence, and sex ratio, and notes on some morphological variations associated with distribution. Specimens from other institutions, if existent, were not obtainable.

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Dr. Stanley C. Williams, San Francisco State College, verified and/or identified some specimens. Financial assistance was provided, in part, by a Karl G. Maeser Research Award given to Drs. D Elden Beck and Dorald M. Allred by the Alumni Association of Brigham Young University, shortly before Dr. Beck's untimely death in August, 1967. The Department of Zoology, Brigham Young University, supplied laboratory space, equipment, supplies, and some transportation.

Procedures

Scorpions were collected from the eastern part of the Great Basin and western area of the Colorado River Basin within the political boundaries of Utah. The ecology and topography of these basins were described by Durrant (1952), Hayward, Beck, and Tanner (1958), Allred, Beck, and Jorgensen (1963), and Allred (1968) as high, inland plateaus separated by mountain ranges. These mountains begin at the northwest corner of Wyoming and extend southward approximately two-thirds the length of Utah, then westward to the southwest corner of the state. They are among the highest in Utah with elevations from 9,000 to 12,000 ft. Within each of the two basins are lower mountain ranges oriented in north-south directions.

Scorpions already existent in collections had been taken by their collectors principally during daylight hours under rocks and other ground cover. Most of the ones being reported herein were captured at night by use of the ultraviolet light technique described by Honetschlager (1965).

Measurements for comparison and identification were taken in the following manner. The total length is from the anterior tip of the carapace to the posterior tip of the cauda, excluding the telson. The length of the cauda is from the anterior margin of the first caudal segment to the posterior margin of the fifth segment, excluding the telson. The length of the pedipalp is from the proximal end of the femur to the distal end of the fixed finger, excluding the coxa and trochanter. The length of the chela includes the palm and fixed finger as a single unit.

Adult scorpions were identified by use of keys by Ewing (1928), Comstock (1948), Gertsch and Allred (1965), Gertsch and Soleglad (1966), and Williams and Hadley (1967). Specific keys are not available for the identification of immature specimens, but morphological characteristics of most young are so similar to those of the adults that they can be assigned to species.

The mean and standard error (x, s) were computed to determine statistical significance in variation (95 percent level) between different populations.

Collectors of the scorpions reported in this study are indicated by their initials as follows:

BB	B. Bradley	CC	C. Cottam
BM	B. McMorris	CH	C. L. Hayward, et al.
BL	B. R. Lemora	DA	D. M. Allred
BW	B. Weston	DB	D E. Beck

DU	D. Usher
EC	E. Cottam
FC	F. Camenzind
FH	F. Harmston
GH	G. M. Harmston
GK	G. F. Knowlton
HV	H. E. Vokes
JF	J. Finley
JJ	J. D. Johnson
JR	J. A. Rowe and C. F. Smith
LH	L. Hook
MD	M. Dumas
MK	M. Killpack
PH	P. Hastings
SD	S. C. Daines
SO	S. Oliver
VT	V. M. Tanner
WG	W. J. Gertsch
WR	W. Robertson

Key to Scorpions of Utah and Southern Nevada

1. Middle lamellae of pectine consists of five or fewer irregularly-shaped, rectangular segments (Fig. 1) 2

Middle lamellae of pectine consists of six or more regularly-shaped, oval segments (Fig. 2) 3

2. Ridges on fingers of pedipalps black; telson abruptly constricted near base of aculeus (Fig. 3); medioventral margin of moveable finger of chelicera with conspicuous brush of hair on basal part .... *Anuroctonus phaeodactylus*

Ridges on fingers of pedipalps same color as rest of finger; telson not abruptly constricted (Fig. 4); medioventral margin of moveable finger of chelicera with light fringe of hair .... *Superstitionia donensis*

3. Medioventral margin of moveable finger of chelicera with one or two large, conspicuous, dark teeth (Fig. 5) 4

Medioventral margin of moveable finger of chelicera lacks large teeth, but often finely serrate or irregular (Fig. 6) .. 6

4. Medioventral margin of moveable finger of chelicera with two large teeth; telson with subaculear spine (Fig. 7) .... *Centruroides sculpturatus*

Medioventral margin of moveable finger of chelicera with one large tooth; telson lacks subaculear spine (Fig. 4) 5

5. Interocular area of carapace pale, much lighter than dark color of rest of carapace .... *Hadrurus arizonensis*

Interocular area of carapace dark brown or black, same color as rest of carapace .... *Hadrurus spadix*

6. Palm of pedipalp has prominent, granulose keels; inner margin of fixed finger of pedipalp strongly crenulate (Fig. 8) 7

Palm of pedipalp essentially smooth, keels not prominent; inner margin of fixed finger of pedipalp straight or only slightly crenulate (Fig. 9) 8

7. Palm of pedipalp approximately twice as long as wide;

telson smooth; fixed finger of pedipalp about same length as palm (Fig. 10) .... *Vaejovis becki*

Palm of pedipalp less than one and one-half times as long as wide; telson lightly granulate, especially near base; fixed finger of pedipalp shorter than length of palm .... *Vaejovis boreus*

8. Venter of telson densely covered with long hairs (Fig. 11) .... *Vaejovis hirsuticauda*

Telson with only a few long hairs (Fig. 4) 9

9. Palm of pedipalp not over one and one-half times as long as wide .... *Vaejovis utahensis*

Palm of pedipalp twice as long as wide 10

10. Venter of telson conspicuously granulate over most of area (Fig. 12) .... *Vaejovis confusus*

Venter of telson granulate essentially only at base, and then only lightly so (Fig. 13) .... *Vaejovis wupatkiensis*

Anuroctonus phaeodactylus (Wood)

Centrurus phaeodactylus Wood, 1863, Proc. Acad. Nat. Sci. Philadelphia, p. 111; 1863, J. Acad. Nat. Sci. Philadelphia (2)5:372.

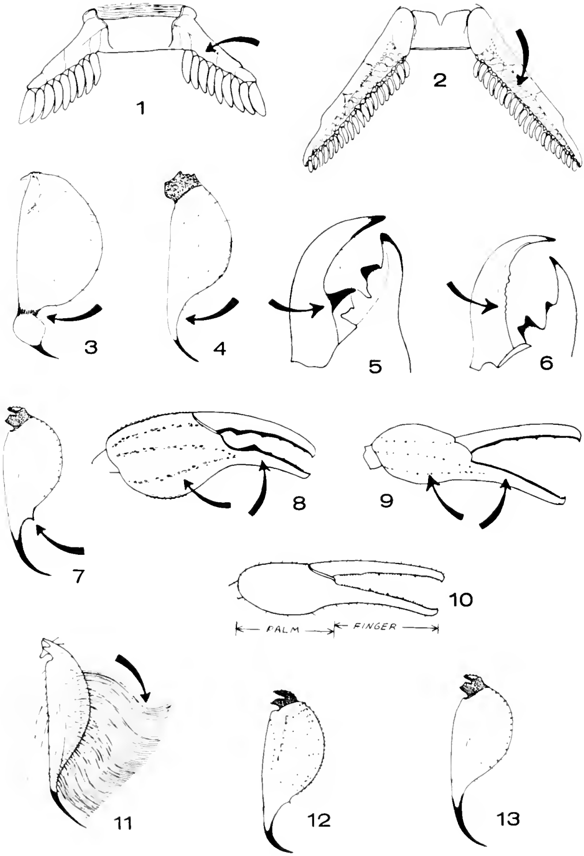
Anuroctonus phaeodactylus Pocock, 1902, Biol. Centrali-Americana, Arachnida, Scorpions, Pedipalpi and Solfugae, p. 14.

In Utah, scorpions of this species occur over the entire length, but not the width, of the state. Forty-seven specimens were collected from the Great Basin, but none were found in the Colorado River Basin (Fig. 14, Table 1). Six times as many males as females were collected, mainly because females were seen only at the entrance of their burrows, and their quick movements made capture difficult. This species is also known from California, Colorado, Nevada, Virginia, Baja California, and Guatemala (Pocock, 1902; Gertsch and Allred, 1965).

This species in Utah is surpassed in length only by *Hadrurus arizonensis* and *H. spadix*. It may be distinguished from other species in Utah by its relatively stout appearance, heavy pedipalps bearing short, black fingers, and by a bulbous swelling posterior to the vesicle on the telson in males. On some small males the sting is extended as an evenly-curved spine, and resembles that of the female.

These scorpions typically are burrowing animals that exhibit a high degree of aggregation; they are not randomly distributed as individuals, but occur in scattered colonies in relatively large numbers (Williams, 1966).

The mean and standard error were computed for morphological variations of the carapace, preabdomen, postabdomen and telson for specimens of two groups—those from northern Utah and those from



Figs. 1-13. (1) Pectines with rectangular, middle lamellae; (2) pectines with oval, middle lamellae; (3) telson of *Anuroctonus phaeodactylus;* (4) telson which lacks aculear constriction; (5) ventral view of chelicera with large tooth on moveable finger; (6) ventral view of chelicera with serration in place of large tooth on moveable finger; (7) telson with ventral spine at base of aculeus; (8) pedipalp with crenulated, fixed finger; (9) pedipalp with non-crenulated, fixed finger; (10) pedipalp with designated limitations of palm and fixed finger; (11) telson of *Vaejovis hirsuticauda;* (12) telson with conspicuous granulation; (13) telson which essentially lacks conspicuous granulation.

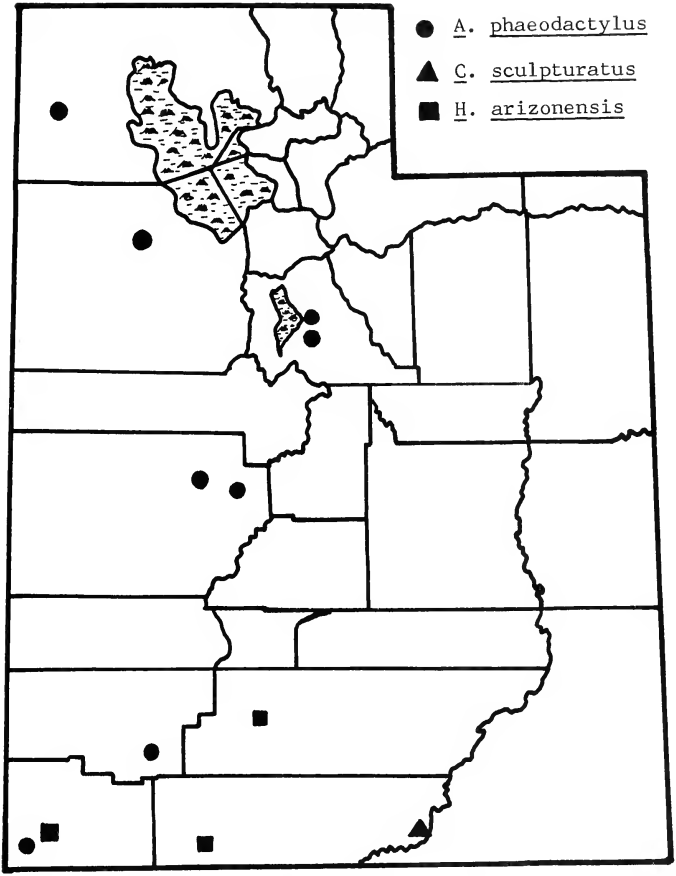


Fig. 14. Distribution of *Anuroctonus phaeodactylus*, *Centruroides sculpturatus* and *Hadrurus arizonensis* in Utah.

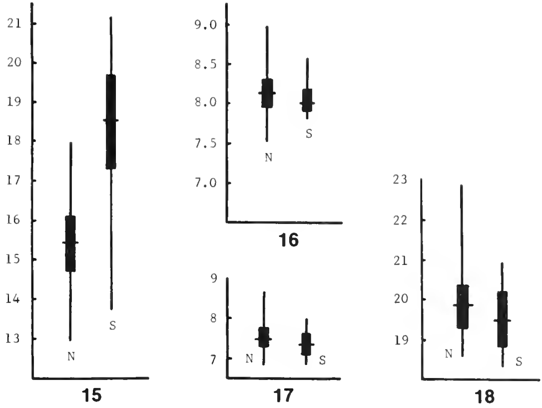
southern Utah (Figs. 15-18, Table 2). No significant differences occurred in the lengths of the carapace, postabdomen or telson at the 95 percent level of confidence, but a significant difference in the length of the preabdomen (1.24 mm) was evident between the two populations.

Table 1. Collection data for *Anuroctonus phaeodactylus* in Utah.

County and location	Date	No. and sex	Collector
Box Elder, Lucin	7-VII-68	16 m, 1 f	JJ
Iron, Cedar City	4-VI-68	5 m	JJ
Millard, Holden	1-VI-68	1 m	JJ
Clear Lake	3-VI-68	14 m, 3f	JJ
Tooele, Knolls	5-VII-68	1 m	JJ
Utah, Provo	VII-58	1 m	DB
	VIII-58	1 m	DB
	X-67	1 m	GH
Spanish Fork	V-28	1 f	DB
Springville	unknown	1 m	JF
Washington, 10 mi S. Shivwits Indian Res. on U.S. Hwy 91	6-VI-68	1 m	JJ

Table 2. Length of the carapace, preabdomen, postabdomen, and telson of 20 *Anuroctonus phaeodactylus* from northern Utah and 20 from southern Utah, with computation of the mean and standard error.

	Northern Utah				Southern Utah			
	Car.	Preab.	Postab.	Tel.	Car.	Preab.	Postab.	Tel.
	8.0	16.7	19.3	7.8	8.2	18.8	20.0	8.0
	8.0	15.7	19.9	7.4	8.9	13.7	20.7	7.8
	8.2	16.2	20.0	7.5	8.4	19.9	20.6	7.8
	7.9	17.7	18.6	7.0	8.1	20.7	20.9	8.0
	7.9	13.8	19.5	7.5	7.8	13.9	19.2	7.4
	8.1	15.9	18.8	7.0	7.8	21.2	19.7	6.9
	7.8	15.4	18.8	7.5	7.8	18.6	18.3	7.0
	7.7	15.4	19.1	7.3	8.3	20.9	20.0	7.8
	8.2	17.6	19.2	7.6	7.9	19.7	19.0	7.4
	7.8	13.9	18.6	7.3	8.0	21.1	19.4	7.2
	8.2	14.2	19.2	7.1	7.8	20.8	18.7	7.0
	8.1	16.4	19.3	7.5	8.2	20.6	19.2	7.3
	7.9	18.0	20.0	7.6	8.3	19.8	19.2	6.8
	7.8	15.1	19.0	7.1	8.4	16.0	20.8	7.6
	7.5	14.9	18.7	6.8	7.7	18.7	19.7	7.0
	8.9	17.0	21.4	8.3	7.8	17.8	18.4	6.9
	8.5	13.0	21.7	7.7	8.0	18.5	19.0	7.3
	8.8	13.0	21.7	7.8	8.0	17.0	19.1	7.2
	8.5	12.9	22.9	8.7	7.9	14.0	19.8	7.6
	9.0	14.3	21.0	7.9				
Mean	8.14	15.38	19.81	7.52	8.10	18.51	19.53	7.37
SE	±.19	±.72	±.55	±.21	±.13	±1.17	±.68	±.23



Figs. 15-18. The mean, standard deviation and range of length (in mm) of the (1) preabdomen; (2) carapace; (3) telson; (4) postabdomen of *Anuroctonus phaeodactylus* from northern and southern Utah.

Centruroides sculpturatus Ewing

Centruroides sculpturatus Ewing, 1928, Proc. U.S. Nat. Mus. 73(2730):20-21

Members of the species *Centruroides sculpturatus* occur abundantly throughout southern Arizona (Ewing, 1928), and recent records have noted their occurrence in Puerto Penasco, Sonora, Mexico (Williams and Hadley, 1967). In Utah, two females were collected by D E. Beck from Hole-in-the-Rock, Kane County, May, 1953 (Fig. 14). This is the only known record of this species in Utah.

These are medium-sized scorpions, comparable in length to those of *Vaejovis boreus*. The base color is yellow to orange-brown, without markings on the body. In general appearance they resemble *V. wupatkiensis*, but are much longer and have a wider preabdomen. The fingers of the chelae are long, but not as narrow and slender as in *V. wupatkiensis*. Members of this species may be distinguished from others in Utah by their relatively long postabdomen and distinct tooth at the base of the vesicle on the telson.

Hadrurus arizonensis Ewing

Hadrurus hirsutus arizonensis Ewing, 1928, Proc. U.S. Nat. Mus. 73:8.
Hadrurus arizonensis Stahnke, 1945, Amer. Mus. Novitates, no. 1298, p. 6.

Scorpions of this species are known from Arizona, southern Nevada, southern California, and southward into Sonora, Mexico (Gertsch and Allred, 1965). This is the first time they have been reported from Utah. Three specimens were collected from the Colorado River Basin area of Utah; none were taken from the Great Basin (Fig. 14, Table 3).

The genus *Hadrurus* contains the largest Utah scorpions. The two species which occur in Utah, *H. arizonensis* and *H. spadix*, are similar in length (up to 100 mm in the adult), and both are covered with red bristles. Specimens of *H. arizonensis* may be distinguished from those of *H. spadix* by their overall lighter coloring and the presence of a yellow interocular space extending from the median eyes to the anterior edge of the carapace.

Hadrurus spadix Stahnke

Hadrurus spadix Stahnke, 1940, Iowa State College J. Sci. 15:102; 1945, Amer. Mus. Novitates, no. 1298, p. 4.

These animals are known from Nevada, California, and eastern Oregon (Gertsch and Allred, 1965). Eighteen adults and immatures were collected in the Colorado River Basin of Utah. Males and females were taken in a ratio of 1:1 (Fig. 19, Table 4).

Scorpions of this species are structurally similar to those of *H. arizonensis*, and color is the only distinguishing characteristic. Members of *H. spadix* are dark brown, almost black, and lack the yellow interocular space described for those referrable to *H. arizonensis*.

TABLE 3. Collection data for *Hadrurus arizonensis* in Utah.

County and location	Date	No. and sex	Collector
Garfield, Calf Creek	X-46	1 f	BL
Kane, Kanab	6-V-66	1 m	SD
Washington, St. George	1920	1 m	VT

TABLE 4. Collection data for *Hadrurus spadix* in Utah.

County and location	Date	No. and sex	Collector
Garfield, North Wash	V-55	2 m	MD
Grand, Arches Nat. Mon.	VIII-50	1 f	DA
Moab	20-VI-68	2 m	JJ
Kane, Hole-in-the-Rock	16-V-53	1 m	DB
San Juan, Navajo Mt. Trading Post	2-V-55	1 m, 4 f	DB, CH
Glen Canyon	17-V-68	2 f	BM
Canyonlands Nat. Park (Needles campground)	21-VI-68	1 m, 2 f	JJ
Washington, Zion Nat. Park	7-VII-28	1 f	VT

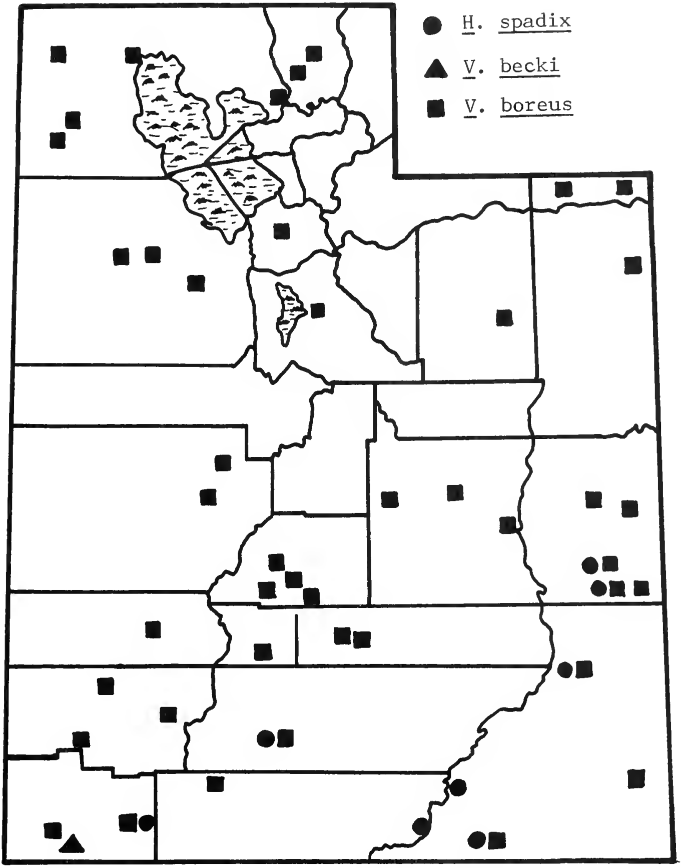


Fig. 19. Distribution of *Hadrurus spadix*, *Vaejovis becki* and *V. boreus* in Utah.

Vaejovis becki Gertsch and Allred

Vaejovis Koch, 1836; Williams, 1971, Pan-Pacif. Entomol. 47(1):78-79.
Vaejovis becki Gertsch and Allred, 1965, Brigham Young Univ. Sci. Bull., Biol. Ser. 5(4):9-11.

Members of this species are known from southern Nevada and adjacent California (Gertsch and Allred, 1965). In Utah, six males and seven females were taken at St. George, Washington County, 5-VI-1968 (Fig. 19). This is the first time *V. becki* has been reported in Utah.

Vaejovis becki closely resembles *V. boreus*, but lacks the characteristic markings and robust, heavily granulated hands of *V. boreus*. The base color is yellow to orange-brown. They may be distinguished from other species in Utah by the presence of a dusky patch enclosing the median eyes, which radiates forward almost to the anterior edge of the carapace. No other markings are present on the body.

Vaejovis boreus (Girard)

Scorpio (*Telegonus*) *boreus* Girard, 1854, *in* Marcy, Exploration of the Red River of Louisiana in the year 1852, p. 257.

Vaejovis boreus Ewing, 1928, Proc. U.S. Nat. Mus. 73(9):12.

Vaejovis boreus is known from California, Arizona, Colorado, Wyoming, Idaho, Oregon, Washington, Montana, and North Dakota in the United States, and British Columbia, and Alberta, in Canada (Gertsch and Soleglad, 1966). It is the most common and most widely distributed of all scorpions in Utah. It occurs in both the Great Basin and the Colorado River Basin. In Utah it occurs from the southern to the northern border of the state. Four hundred and one specimens were taken in Utah. Males and females were collected in a ratio of 1:1.9 (Fig. 19, Table 5).

This species is medium-sized, comparable in length to *V. confusus*. It is the fourth largest species in Utah, surpassed in length only by *Hadrurus arizonensis*, *H. spadix*, and *Anuroctonus phaeodactylus*. It may be distinguished from other species in Utah by the characteristic markings on the carapace and preabdomen, and the robust,

Table 5. Collection data for *Vaejovis boreus in* Utah.

County and location	Date	No. and sex	Collector
Beaver, Milford	20-IV-30	1 f	VT
Box Elder, Brigham City	VIII-28	2 f	WR
Grouse Creek foothills	VI-28	1 f	VT
Lucin	19-VI-52	2 f	DB
Locomotive Springs	19-VI-52	1 m	DB
Utah Hwy 70, on Grouse Creek Road	7-VI-68	2 m, 4 f	JJ
Cache, Blacksmith Fork Canyon	9-VII-35	1 f	JR, CS
Logan	26-VIII-36	1 f	FH
Daggett, Sheep Creek	VI-26	1 f	EC
Flaming Gorge	28-VI-26	1 f	EC
Duchesne, Roosevelt	5-VII-68	11 m, 12 f	JJ
Emery, Ferron	IX-28	2 f	WR
Buckhorn Canyon	6-IX-53	4 f	VT

Table 5. (continued)

Green River	7-IV-46	2 f	GK
	7-V-46	1 f	GK
	6-IX-46	1 m, 5 f	HV
	18-VI-68	11 m, 13 f	JJ
Garfield, North Wash	V-55	3 f	MD
Grand, Arches Nat. Mon.	12-V-48	1 f	DB
	3-V-68	10 m, 70 f	JJ
	20-VI-68	2 m, 20 f	JJ
Moab	10-VII-67	1 f	DU
Cisco	18-VI-68	6 m, 7 f	JJ
Castle Valley	19-VI-68	11 m, 14 f	JJ
Sego	28-IV-68	1 f	BW
Iron, Parowan	31-VIII-29	1 m	VT
Newcastle	5-VI-68	4 m, 5 f	JJ
Lund	5-VI-68	4 m, 5 f	JJ
Kane, Johnson Canyon	30-VIII-53	4 f	VT
Millard, Delta	2-VI-68	2 m, 9 f	JJ
14 mi S Deseret	4-VI-68	3 m, 10 f	JJ
Piute, Kingston	25-VI-52	1 m, 1 f	DB
Salt Lake, Salt Lake	22-VI-30	1 m, 2 f	JR
San Juan, Navajo Mt. Trading Post	5-V-55	1 m, 1 f	CH
Canyonlands Nat. Park (Needles campground)	22-VI-68	3 m, 18 f	JJ
Hatch Trading Post	23-VI-68	1 f	JJ
Sevier, Richfield	19-VI-47	1 f	DB
	15-V-40	1 m, 5 f	WG
Sevier Canyon	19-VII-40	1 f	WG
2 mi E Glenwood	30-VI-40	1 f	WG, LH
Fishlake	22-VI-30	1 m	WG
Paradise Valley	10-VIII-52	1 f	MK
Tooele, Skull Valley	19-IV-39	1 f	GK
Desert Range Exp. Sta.	9-XI-50	2 f	DB
Knolls	5-VII-68	1 m, 9 f	JJ
Delle	5-VII-68	6 m, 9 f	JJ
Uinta, Dinosaur Nat. Mon. (Quarry)	21-V-50	2 f	VT
	6-VII-68	19 m, 26 f	JJ
Utah, Provo	XI-28	1 m	VT
Washington, St. George	19-III-31	1 m, 1 f	VT
	29-III-31	2 f	VT
Zion Nat. Park	9-VI-68	3 f	JJ
Wayne, Fruita	17-VII-31	2 f	WG
Torrey	17-VI-38	3 f	DB, VT
	7-VIII-52	1 f	MK

TABLE 6. Length of the carapace, preabdomen, postabdomen, and telson of 20 *Vaejovis boreus* from northern and 20 from southern Utah, with computation of the mean and standard error.

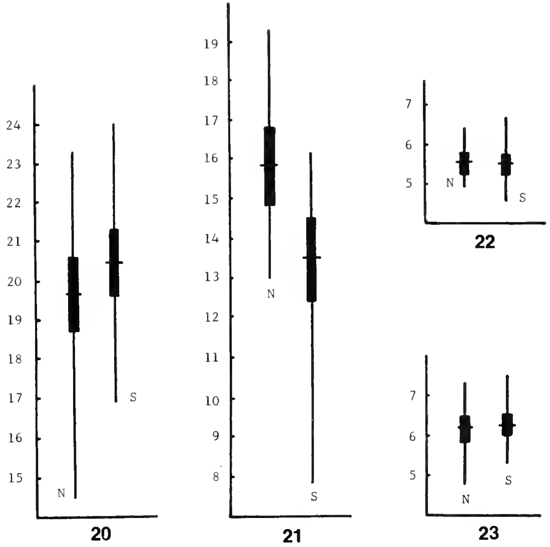
	Northern Utah				Southern Utah			
	Car.	Preab.	Postab.	Tel.	Car.	Preab.	Postab.	Tel.
	4.9	16.4	18.0	6.0	5.0	15.1	19.2	6.0
	4.9	14.5	16.9	5.6	5.3	16.2	19.7	6.0
	6.0	17.0	23.3	7.0	5.7	11.3	21.2	6.2
	4.6	13.9	14.5	4.7	5.6	12.9	20.0	6.9
	5.5	17.7	20.0	6.1	5.6	7.8	19.0	6.1
	6.0	19.1	21.9	6.9	6.4	12.7	24.0	7.5
	6.4	19.4	21.4	6.8	5.9	10.6	22.5	6.7
	5.5	13.8	19.0	6.0	5.3	13.8	21.5	6.3
	5.8	15.5	21.3	6.0	5.7	15.3	21.8	6.3
	5.8	13.0	19.5	6.1	5.7	13.2	22.8	6.7
	5.8	15.2	20.6	6.4	5.2	13.0	19.2	6.0
	5.7	19.0	20.5	6.0	5.2	13.0	19.4	5.9
	4.9	13.8	18.2	5.7	4.5	11.2	17.8	5.2
	5.3	13.5	19.9	6.4	5.3	15.0	21.4	6.3
	5.4	15.0	19.0	5.8	4.9	14.6	19.0	5.7
	6.0	15.6	21.0	6.9	4.9	12.3	13.5	5.7
	5.7	17.9	19.3	6.2	4.8	14.5	16.9	5.2
	5.0	12.0	16.9	5.3	6.7	18.9	22.8	6.9
	5.6	16.8	19.3	6.2	6.7	12.6	22.6	6.6
	6.4	17.7	23.0	7.3	5.8	15.9	20.0	6.1
Mean	5.53	15.84	19.68	6.17	5.51	13.50	20.47	6.22
SE	±.26	±.99	±.97	±.28	±.27	±1.08	±.87	±.26

coarsely granulated pedipalps. The base color is pale yellow. Specimens from northern Utah, when compared with those from southern Utah, were not significantly different at the 95 percent level (Figs. 20-23, Table 6) in the length of the carapace, postabdomen, and telson. However, a significant difference of 0.27 mm in the length of the preabdomen was present between populations.

Vaejovis confusus Stahnke

Vaejovis confusus Stahnke, 1940, Iowa State College J. Sci. 15:101.

This species is known from southern Nevada (Gertsch and Allred, 1965) and southern California (Williams and Hadley, 1967). This is the first time *V. confusus* has been reported from Utah. Twenty-three specimens representing adults and immatures were collected from localities in the Great Basin and the Colorado River Basin. Males and females were taken in a ratio of 1:3.6. This species occurs along the entire length of the state (Fig. 24, Table 7).



Figs. 20-23. The mean, standard deviation and range of length (in mm) of the (1) postabdomen; (2) preabdomen; (3) carapace; (4) telson of the *Vaejovis boreus* from northern and southern Utah.

TABLE 7. Collection data for *Vaejovis confusus* in Utah.

County and location	Date	No. and sex	Collector
Box Elder, Lucin	7-VII-68	2 f	JJ
Grand, Arches Nat. Mon.	20-VI-68	1 m	Unknown
Millard, Holden	1-VI-68	4-f	JJ
Clear Lake	3-VI-68	3 m, 5 f	JJ
San Juan, Canyonlands Nat. Park (Tower Ruins)	22-VI-68	1 m, 4 f	JJ
Monument Valley	24-VI-68	1-f	JJ
Utah, Orem	20-V-68	1 f	SO
Washington, St. George	5-VI-68	1 f	JJ

Vaejovis confusus closely resembles *V. wupatkiensis* in general appearance, but *V. confusus* is slightly larger and lighter in color. It may be distinguished from other species in Utah by the lack of definite markings on the body, a relatively thick, fifth caudal segment, relatively long pincers on the pedipalps, and a coarsely-granulated, robust telson bearing a short sting.

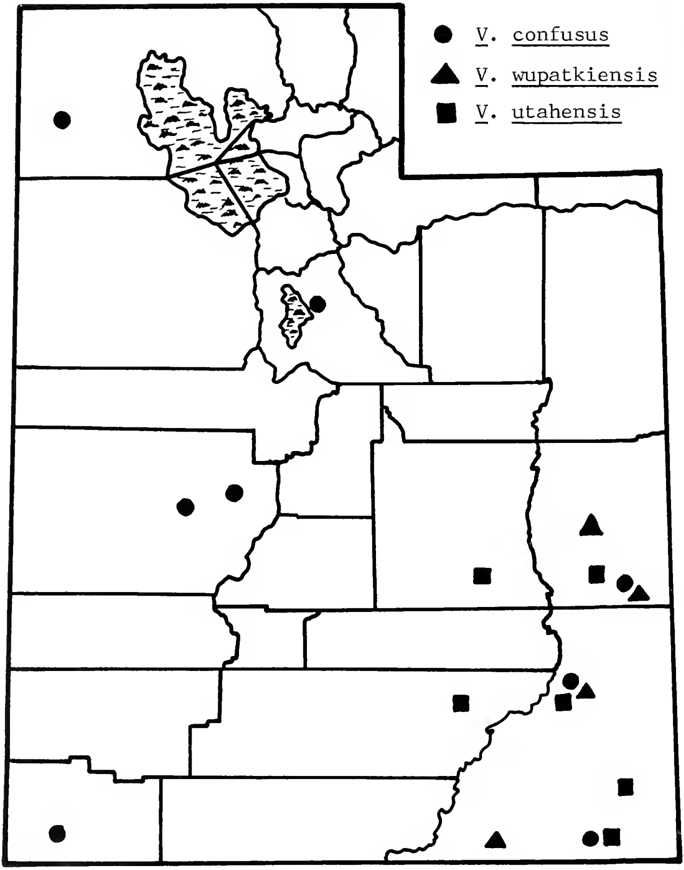


Fig. 24. Distribution of *Vaejovis confusus, V. wupatkiensis* and *V. utahensis* in Utah.

Vaejovis wupatkiensis Stahnke

Vaejovis wupatkiensis Stahnke, 1940, Iowa State College J. Sci. 15:101.

This species is known from northern Arizona, and westward into Nevada and adjacent California (Gertsch and Allred, 1965). This is the first time it has been reported in Utah. The eleven females were taken only from the Colorado River Basin in Utah (Fig. 24, Table 8).

Vaejovis wupatkiensis is a slender scorpion, similar to but smaller than *V. confusus*. It lacks the coarse granulation of the cauda and telson common to *V. confusus*. It may be distinguished from other species in Utah by its uniform yellow to orange-brown color, absence of any markings on the body, long fingers on the pedipalps, and a tubercle or tooth beneath the base of the vesicle on the telson.

TABLE 8. Collection data for *Vaejovis wupatkiensis* in Utah.

County and location	Date	No. and sex	Collector
Grand, Moab	VI-23	2-f	CC
	V-55	5-f	CH
Thompson	3-V-68	1 f	FC
San Juan, Navajo Mt. Trading Post	2-V-55	2 f	DB
Canyonlands Nat. Park (Tower Ruins)	VI-67	1 f	PH

Vaejovis utahensis Williams

Vaejovis utahensis Williams, 1968, Pan-Pacif. Entomol. 44(4):313-321.

This species was heretofore known only from Bluff, San Juan County, Utah (Williams, 1968). An additional 218 specimens representing adults and immatures were taken from the Colorado River Basin in Utah (Fig. 24, Table 9).

TABLE 9. Collection data for *Vaejovis utahensis* in Utah.

County and location	Date	No. and sex	Collector
Garfield, 35 mi W Dirty Devil River on Utah Hwy 95	25-VI-68	5 f	JJ
Grand, Dead Horse Pt. Road	19-VI-68	25 f	JJ
Emery, 30 mi N Hanksville on Utah Hwy 24	25-VI-68	2 f	JJ
San Juan, Monument Valley	24-VI-68	56 f	JJ
Bluff	23-VI-68	26 f	JJ
Canyonlands Nat. Park (Needles campground)	20-VI-68	50 f	JJ
	10-VI-68	54 f	BB

This species closely resembles *V. boreus*, but may be distinguished from it by the absence of the dusky, transverse bands on the segments of the preabdomen, and the longer, less robust hands of the pedipalps.

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RELICT STANDS OF PINYON HYBRIDS IN NORTHERN UTAH[1,2]

Ronald M. Lanner[3] and Earl R. Hutchison[3]

ABSTRACT.— Relict stands of *Pinus edulis* and *P. monophylla*, and of natural hybrids of these species have been found in Cache and Rich counties. The stands and their sites are described. The *P. edulis* stand in Rich County extends the range of this species northward. Possible means of seed dissemination are discussed and it is speculated that both species formerly migrated into and out of this area during periods of differing climates.

Two pinyon pine species are native to Utah: pinyon (*Pinus edulis* Engelm.) and singleleaf pinyon. (*P. monophylla* Torr. & Frém.). Pinyon is typically a species of the Colorado Plateau, while singleleaf pinyon is characteristic of the Great Basin. Cole[4] postulated that the two species hybridize along an ecotone running north and south through central Utah. Recent field studies have confirmed that these pines hybridize along the eastern edge of the Great Basin and in other areas where their ranges overlap (Lanner, 1971).

Hybrid segregates have also been discovered in Cache and Rich counties, in a series of relict stands previously thought to be well outside the range of *P. edulis* (Critchfield & Little, 1966). The evidence for hybridization will be fully covered in a later paper. Major criteria are number of needles per fascicle (*P. edulis* = 2; *P. monophylla* = 1; hybrids have fascicles of both types) and number of resin canals per needle (*P. edulis* = 2; *P. monophylla* = 2 - 10; hybrid means are intermediate). The aims of this paper are to describe the northern relicts and to explain their supposed origin.

THE POPULATIONS

Four of the relict stands are in Cache County, and one is in the Crawford Mountains of Rich County.

1. *Mt. Logan.* Eleven trees on a spur between Logan and Dry canyons, in Sec. 31 and 32, TI2N, R2E, Cache National Forest. Of 10 trees examined, 8 appear to be pure *P. monophylla*, but the others have 11-35 percent of their foliage in fascicles of two.

2. *Logan Canyon.* Two trees located 2 miles NE of the above population, in Sec. 29, T12N, R2E, Cache National Forest. Both appear to be pure *P. monophylla*. Reported presence of additional trees is unverified.

3. *Blacksmith Fork.* Many trees scattered in drainage of Mollen's

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[2] An abstract of this paper was presented at the Utah Academy of Sciences, Arts, and Letters meeting at Logan in September 1971.

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[4] Cole, Franklin R. The pharmacognosy of Utah pinyon pines. Doctoral dissertation, University of Utah, 1965.

Hollow, Sec. 27, 28, 29, 32, 33, 34, T10N, R4E, Cache National Forest. Most are pure *P. monophylla*, but some have up to 68 percent of their foliage in fascicles of two.

4. *Porcupine.* At least 29 trees, N of Porcupine Reservoir in Sec. 10 and 11, T9N, R2E. Trees range from pure *P. monophylla* to individuals with 90 percent of their foliage in fascicles of two.

5. *Crawford Mountains.* Eleven trees were sampled 4 miles E of Randolph in a box canyon on the western scarp of Rex Peak in Sec. 30, T11N, R8E. Trees range from pure *P. monophylla* to pure *P. edulis*, with individuals of intermediate character.

Unlike the other populations, this is mainly a *P. edulis* stand and represents the northernmost limit of the species.

Locations are given in reference to the Salt Lake Meridian. They fit within a rectangle 34 miles long (E - W) and 15 miles wide (N - S), the NW corner of which lies at 41°45'30"N and 111°45'30"W; and the SE corner at 41°31'30"N and 111°05'30"W.

Growth Habits

The relict stands consist of small groups of relatively slow-growing trees. They are usually on south-facing slopes within a narrow elevational range and associated with tree species that characterize the transition from relatively xeric to subhumid conditions (Table 1). The pinyon pines seem unable to compete with lush north-slope tree and brush cover and are mainly restricted to drier aspects where plants are widely spaced between large areas of bare ground. The limited area of these stands and their age distribution suggests a precarious balance between survival and extinction. Though regeneration is sporadic, some trees are long-lived and have many opportunities to reproduce (Table 1). It is possible that the *P. edulis* trees, growing at the northern limit of their range, may be reproductively impaired by pollen that is rendered inviable by low temperatures at critical times in its development (Chira, 1967). In very small populations, the high incidence of self-pollination may result in the production of inviable seed or nonvigorous seedlings.

Origins

The nearest station of *P. monophylla* is in the Black Pine Mountains of southern Idaho, about 70 miles WNW of Logan.[5] The nearest *P. edulis* stands are about 100 miles S of Randolph, in the Uinta Basin. The disjunct stands are either old relicts, left behind by widespread extinction, or they represent new invasions.

Invasion seems unlikely. Pinyon pine seeds are wingless, heavy, and ballistically unadapted to wind dissemination. Experiments in this laboratory by R. Warnick indicate that a wind of 100 mph is required to carry *P. monophylla* seeds 30 ft downwind from the

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[5] Critchfield and Little (1966) show *P. monophylla* extensively distributed in the northern Wasatch, straddling the Utah-Idaho state line, but this report appears to be in error.

TABLE 1. Some characteristics of relict pinyon pine stands in northern Utah.

Location	Elev. (ft)	Aspect	Tree Associates	Range of Estimated Tree Ages[1] (years)	Maximum Heights (ft)	Maximum Stem Diam. (in)[2]	Date of Anthesis 1969
Mt. Logan	6500	S	*Juniperus osteosperma* *Pseudotsuga menziesii* *Cercocarpus ledifolius*	92-262	35	20	20 June
Logan Canyon[3]	6500	S		90-143	35	15	-
Blacksmith Fk.	6000-7300	S,E,W	*J. osteosperma* *J. scopulorum* *P. menziesii* *C. ledifolius* *Pinus flexilis* *Populus tremuloides* *Acer sp.*	-	-	-	27 June
Porcupine	6000-6500	S,SE	*J. scopulorum* *P. menziesii* *C. ledifolius* *P. flexilis*	67-314	35	48	20 June
Crawford Mts.	6800-7300	N,S,W	*J. osteosperma* *J. scopulorum* *P. menziesii* *C. ledifolius*	120-426	25	22	20 June

[1] Rings at breast height plus 50 years; at several locations there were younger trees too small to bore.
[2] Diameter at 4.5' above ground.
[3] Data supplied by C. M. Johnson.

top of a 30-ft tree. Long distance dispersion by birds or mammals, though a possibility, seems unlikely to account for two tree species on sites far removed from both present distribution areas, one to the west, the other to the south.

The movement of seeds by man is a possibility worth consideration. Wright[6] concluded that a disjunct *P. edulis* stand in Owl Canyon, near Fort Collins, Colorado, resulted from "accidental or intentional planting that took place approximately 400 years ago" along an ancient Indian trail. Acceptance of this interpretation has led Weber (1961, 1965) to explain other trees subsequently found nearby in the Rockies as having originated from seed transported there, by birds, from the Owl Canyon grove. It seems equally logical to consider all the northeast Colorado pinyon locations as relicts of a once-continuous distribution from the south, but the evidence on this point is by its very nature inconclusive.

In the present case, man seems an unlikely agent. The Paiute and Shoshoni of the Great Basin often set up their temporary winter villages in pinyon pine areas, in order to take advantage of the pine-nut crop (pers. comm. Prof. Julian H. Steward, Univ. of Illinois). Thus, the Indians went to the trees, rather than attempting to plant them. The pinyon stands at Mt. Logan and Logan Canyon are on steep ridges, unsuitable as travel routes or campsites where caches might be established. And, again, the coincidence of establishing two species on the same sites seems farfetched.

We lean toward an explanation based on paleoclimates. There is a rough parallel here with the situation described by Cottam et al. (1959). According to their analysis, hybrid clones of *Quercus gambelii* Nutt. and *Q. turbinella* Greene originated early in the latest postglacial period, when warmer climates in the north permitted *Q. turbinella* to persist well outside its present range. Using a similar line of reasoning, we propose the following sequence of events to account for the pinyon pine relicts of northern Utah:

(a) *P. monophylla* migrated into the northern Wasatch and Crawford mountains at a time when it was cooler and moister than now. At this time, *P. monophylla* may have been continuous along the north rim of the Great Basin from the Raft River Mountains, across the low hills on the north shore of Lake Bonneville, to the Wasatch.

(b) *P. edulis* migrated north on the Wasatch from the Uinta Basin when it was warmer than now. The species interbred. It is interesting in this connection that an outpost of Gambel oak has been found several miles east of the Porcupine location where there are trees appearing to be nearly pure *P. edulis*. In the Uinta Basin these species are sometimes associated with each other.

(c) Later changes caused the following to occur:

i. *P. monophylla* became extinct at lower elevations, leaving

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[6] Wright, C. W. An ecological description of an isolated pinon pine grove. Master's thesis, University of Colorado, 1952.

populations that have survived to become its major stands on the Great Basin ranges, and relicts on the Wasatch.

ii. *P. edulis* retreated southward, persisting in a few suitable areas where competition was less severe. Thus, both species are present only as relicts. The species have an overlapping range of tolerance to environmental conditions, as attested by their frequent sympatry, so it is not surprising they should share common refugia. Admittedly, this interpretation of these relict stands is speculative, but other interpretations require assumptions that are equally speculative.

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NEARCTIC DESERT DECTICIDAE (ORTHOPTERA)
PART I. A NEW GENUS FROM CALIFORNIA

Ernest R. Tinkham[1]

Petropedes, new genus

This genus appears to have closest relationships to *Inyodectes* Rentz and Burchim from which it differs by much larger size, strongly excavate inferior margin of the lateral lobes of the pronotum, the enormous tympanum, the different cerci, bispinose genicular lobes of the pro- and meso-femora, the unispined external genicular lobe of the caudal femora as well as other features; from *Eremopedes* Cockerell by the differently shaped pronotum and the emargination of the inferior margin of the lateral lobes of the pronotum, by the much larger tympanum, by the bispinose and not unispinose genicular lobes of the pro-femora, by the less prominent emargination of the ultimate notite of the abdomen with less forcipate arms, by the cerci and subgenital plate and by the ovipositor; from *Oreopedes* Rehn and Hebard by size, pronotum, tympanum, spination of the genicular lobes of all femora and many other features; and from other eremicolous genera by even more striking dissimilarities.

Diagnosis:— Size, medium large; antennae, at least three times body length. Pronotum, about twice as long as broad, rounding into rather deep lateral lobes having inferior margin strongly excavate to expose enormous tympanum. Tegmina exposed for a length equal to that of metazona, its base pale, its apical portion jet black, and diagnostic. Ultimate notite of abdomen with median, moderately deep-shaped notch formed by moderate forcipate divaricating arms, much shorter than those of *Eremopedes*. Cerci moderately slender with one internal triangular, almost central, projection bearing a piceous, thin plate with 6-8 fine serrate teeth directed anteriorad. Subgenital plate subtriangular in male, with rounded ventro-lateral ridges and a shallow median posterior notch. Pro- and meso-femora with bispinose genicular lobes. Ovipositor, about length of body, strong and slightly recurved in apical half. Subgenital plate in female with a very shallow median posterior emargination.

Description:— Head slightly broader than deep (at clypeal suture); eyes roundly oval and subglobose; antennae at least three times body length. Pronotum with barrel long, rounding into lateral lobes, about twice as long as broad; anterior and posterior margins squarely truncate. Prozonal sulcus a very broad v-shaped shallow groove running to near fore margin of lateral lobes, thence continuing as a very broad shallow groove submarginally to almost posterior margin. Prozonal-metazonal juncture, dorsally, with a slight horseshoe-shaped depression. True tympanum very large, roundly oval, fore margin slightly irregular due to prothoracic spiracle; its margin devoid of hairs. Tegmina exposed for a length equal to metazonal length. Abdomen with ultimate notite having divaricating forcipate arms forming a moderately deep v-shaped emargination. Cerci, diagnostic, relatively slender, with internal, almost median, triangular

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prominence bearing a dark sclerotized thin plate with 6-8 serrate, fine, teeth. Titillator arm straight, ventral keel very slightly curved apically, dorsal keel with row of retrorse teeth. Subgenital plate narrowly triangular with round ventro-lateral ridges and a shallow u-shaped emargination posteriorly.

Leg spination: Forelegs with strong procoxal spine; fore femora with 3 strongly appressed aciculate teeth on central portion of external and internal ventral keels plus bispinose geniculae; fore tibiae with six pairs of long acuminate spines on the ventral keels and three dorsal external spines (one on so-called tympanum of authors, one median and one apical). Tarsi 3-segmented with ungues segment. Meso-femora with four pairs of ventral spines in apical two-thirds plus bispinose geniculae; mesotibiae ventrally as in protibiae, dorsally with 2 anterior and 4 posterior dorsal spines (leg in back position). Caudal femora with 6-8 external and 6-7 internal spines on ventral keels all in apical half. Caudal tibiae with 25-26 external and 23-25 internal teeth on ventral keels and 7 external and 3-5 internal dorsal apical teeth. Leg spination: forelegs with strong procoxal spine; fore femora with 3 strongly appressed aciculate spines on central portion of internal inferior keel plus bispinose geniculae; fore tibiae with six pairs long acuminate spines on ventral keels and three dorsal external spines, one on so-called tympanum of authors, one median and one apical. Tarsi 3-segmented plus ungues segment. Meso-femora with four pairs ventral spines on the apical two-thirds plus bispinose geniculae; mesotibiae ventrally as in protibiae; dorsally with two external and four internal spines (leg in back position). Caudal femora with 6-8 external and 6-7 internal teeth on ventral keel all in apical half. Caudal tibiae with 25-26 external and 23-24 internal ventral teeth and 7 external and 3-5 internal dorsal teeth.

TYPE SPECIES.— *Petropedes santarosae* Tinkham.

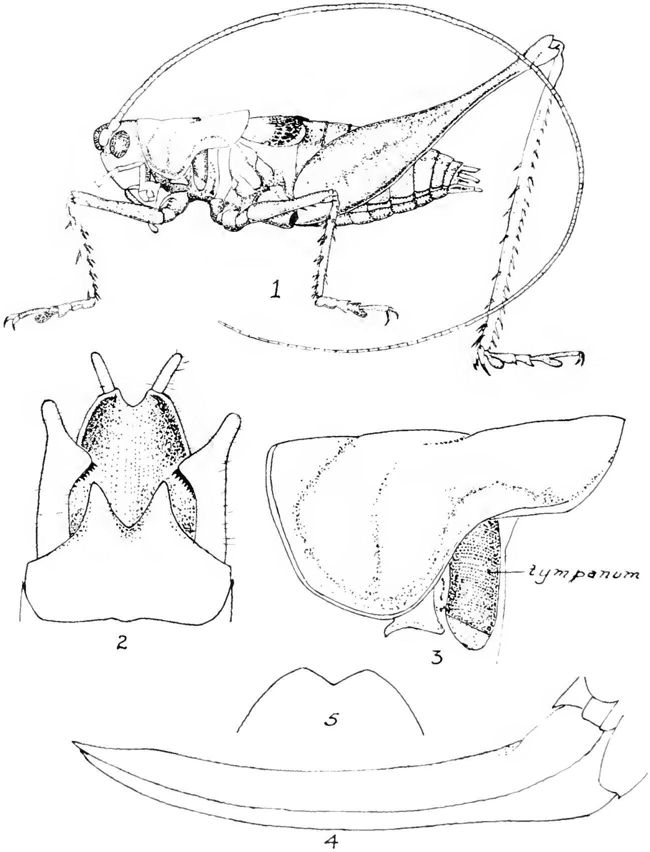
Petropedes santarosae, n. sp.

Coloration generally tawny or pale reddish brown, profusely mottled on abdominal notites with dark gray flecking, especially along posterior marginal area. Internal musculature of legs indicated by fine grayish infuscation. Tegmina pale with black infuscation in apical third, leaving posterior marginal area pale buff.

MALE HOLOTYPE:— Santa Rosa Mountains, Palms to Pines Hiway, 2000 feet elevation, 9-VIII-70; E. R. Tinkham; crossing pavement at night. Calipered measurements in mm: body length 24.8; head 5.0 x 6.8 at clypeal suture; pronotum 8.6 x 6.8; caudal femora 26.6; antennae approx 77.0. Type deposited in the Tinkham Eremological Collection.

FEMALE DESCRIPTION:— Size slightly larger than holotype; ovipositor as described. Subgenital plate rounding without ventrolateral ridges as in male; posterior margin circularly rounded with very shallow v-shaped emargination.

FEMALE ALLOTYPE:— Same data as holotype but collected 5-VII-69. Calipered measurements in mm: body length 29.9. length to ovipositor 46.8;



Figs. 1-5. *Petropedes santarosae* Tinkham: 1, male holotype; 2, genitalia of male holotype showing ultimate notite, cerci, and subgenital plate; 3, lateral aspect of pronotum and tympanum of male holotype; 4, lateral aspect of ovipositor of female allotype; 5, posterior portion of subgenital plate of female allotype.

ovipositor 20.2; pronotum 8.2 x 7.2 in maximum breadth at inferior marginal flange. Allotype in the Tinkham Eremological Collection.

Male paratypes: Same data as holotype except: 3, 26-VI-66; 4, 26-VII-66; 3, 9-VII-70; 2, 10-VII-70. All male paratypes very closely similar to holotype in every respect. Calipered range measurements in mm as follows: body length 23.8-25.0; pronotum 8.1 x 5.9 to 9.2 x 7.0 breadth; caudal femora 25.8-29.9, antennae approx. 86.8. Paratypes to be exchanged with major Orthopterological museums.

FEMALE PARATYPES:— Closely similar to allotype except: 2, 26-VI-66; 1, 3-VII-67; 2, 9-VII-70; 1, 4-VII-70 (after light rain). Calipered range measurements in mm: Body length 25.0-30.0; length to apex of ovipositor 41.0-46.8; ovipositor 23.0-18.8; pronotum 9.5 x 7.5 to 9.1 x 7.3; caudal femora 31.1-28.8. Deposition as noted above.

HABITAT:—*Petropedes* inhabits the steep, rocky, northern slopes of the Santa Rosa Mountains in a rather narrowly defined altitudinal zone ranging from 1900 to 2200 feet elevation; the optimum being about 2000 feet. This belt, although within the areal limits of the Colorado Desert, is, due to its considerable elevation, more accurately Gila Desert because of the presence of the indicative Mohave yucca (*Yucca schidigera*). Other dominants and codominants include: desert agave (*Agave deserti*); cheese bush (*Hymenoclea salsola*); desert sweet (*Bebbia juncea*); desert sunflower (*Vigueria deltoides*) and other rarer plants that occupy their niches in and among the boulders and rocks of this habitat. Even more preferred are the rocky road cuts of this highway for *Petropedes* is truly a rock-inhabiting decticid.

BIOLOGY:—Little is known about their life history at present, as the creature was only found crossing the pavement at night. Its saltatorial powers are considerable. Its song is very weak which may explain the enormous tympanum. The eggs probably hatch during the winter rains. In 1971, a drought year, collecting failed to reveal any specimens in the optimum zone of habitation. In a xeric environment the Orthopteran associates included: *Ateloplus notatus*, *Capnobotes fuliginosus*, *Poecilotettix sanguineus*, *Oedomerus* sp., *Melanoplus* sp., and *Stagmomantis californicus*.

Petropedes spinosa (Hebard), n. comb.

Eremopedes spinosa Hebard, 1923, Proc. California Acad. Sci. 12(15):337 figs. 10-13.

For many years the identity of this Mexican decticid described from Mejia Island in the Gulf of California has been a mystery. There is now no question that it is a member of the genus *Petropedes* Tinkham but at present nothing is known about its biology and little about its habitat.

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AQUATIC PHYCOMYCETES OF LILY LAKE, UTAH[1]

Hugh M. Rooney[2] and Kent H. McKnight[3]

Abstract.— During the ice-free period from May to November on two successive summers water molds were collected on 14 different substrata placed in Lily Lake, a subalpine bog lake in the Uinta Mountains of Utah. Twenty-five collections yielded thirty-four species in 20 genera, 11 families, and 6 orders of aquatic Phycomycetes. Correlation of frequency presence of the species reported with physical and chemical characteristics of the lake showed that the number of species collected increased with an increase in water temperature and a decrease in oxygen content during June to August, reaching a peak in late July. *Rhipidium americanum Thaxter* (100 percent frequency) and *Sapromyces androgynus* Thaxter (72 percent frequency) were the most common species and the species found on more different substrata than any others. Also in the "very abundant" group were *Saprolegnia ferax* (Gruith.) Thurent and *Achlya* sp., both with 64 percent frequency.

Lily Lake, a subalpine lake in the Wasatch National Forest of the Uinta Mountain region, Utah, is located about one-half mile west of Trial Lake at an elevation of 10,000 feet (T. 3, R. 9 E., sec. 31). This lake, which is one of the acidic, cold, lentic bogs characteristic of the area, is the site of a taxonomic-distribution study of aquatic Phycomycetes. This study is a beginning to our understanding of the role of fungi in Lily Lake, and it supplies the first information on record of the water molds of this area. Fungi found on 14 different substrata are identified and correlated with pH, dissolved oxygen, and temperature of the lake.

Christensen and Harrison (1961) have described the psysiography and possible plant succession around Lily Lake. Stutz (1951) studied the hydrarch succession as well as physical and chemical properties of water and soil at Moss Lake, a similar subalpine lake in the Granddaddy Lake Basin nearby. Tanner (1931) reported on the algae of the Mirror Lake region in the Uinta Mountains.

Little is known about the fungi in subalpine lakes. However, Tiesihausen (1912) and Rutter (1937) reported on the alpine water molds of the Swiss Alps. Koob (1966) reported *Rhizophidium plank-*

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[1] This paper includes a portion of a thesis presented in partial fulfillment of the requirements for a Master of Science degree, Brigham Young University.

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tonicum Canter on *Asterionella formosa* Hauss. in subalpine lakes of Colorado. Studies by Chapman (1965), Coker (1923), Jewell and Brown (1929), and Willoughby (1961) report fungi in bogs, and there are a few papers showing seasonal distribution of aquatic Phycomycetes: Coker (1923), Suzuki (1960, 1961), and Willoughby (1962).

Water molds are given little consideration in general treatments of aquatic ecology (Welsh, 1945; Weston, 1941). However, representatives of these fungi have been found in all types of inland waters that have been studied for them (Crooks, 1938; Graff, 1928; Johnson, 1956; Koob, 1966; Sparrow, 1960; Suzuki, 1960a, 1961a; Suzuki and Nimura, 1960, 1961). As saprophytes and parasites on aquatic plants and animals, they are important in biological interactions in lakes.

METHODS AND MATERIALS

At approximately weekly intervals during the study period, water molds were collected and environmental data of the water were recorded. Baits were placed in the lake during the ice-free period from May 1965, to November 1965, and from May 1966, to June 1966. The 14 substrata used for bait may be classified in four major groups as follows: (i) twigs (river birch, weeping white birch, poplar, hackberry, pine); (ii) fruits (apples, rose hips); (iii) chitinous and keratinous materials (human hair, snake skin, insect exuviae); and (iv) miscellaneous materials (cellophane, *Ulothrix*, pine pollen, pine needles). Of these, the twigs and fruits were collected in the autumn preceding their use and stored at 5 C until needed.

A wire basket containing the baits was placed 1½ feet below the surface of the lake each week and removed four weeks later. When removed from the lake the basket was transferred to a glass jar and brought to the laboratory, where the baits were rinsed with tap water and examined for aquatic Phycomycetes. Both temporary water mounts and permanent mounts were prepared for microscopic examination of the fungi. After this initial examination the baits were cultured in large plastic dishes, using water collected that week from the lake. Such additional substrata as human hair, pine pollen, and insect exuviae were added to the cultures, which were then covered with a glass plate and cultured at 5 C. These cultures were examined three to seven days later for chytrids and other microscopic species.

For any one collection, species of Phycomycetes were listed simply as present or absent, and no attempt was made to estimate the number of thalli; therefore, a record of presence may refer to a single thallus or a great number of thalli. The term *frequency*, as used in this study, refers to the number of times the species occurred in 25 collections and is expressed as a percentage. For example, *Rhipidium thaxteri* Minden occurred seven times in 25 collections and has a frequency of 28%.

Water temperature, pH, and dissolved oxygen were measured on each visit to the lake. The pH was measured in the field with a Beckman pH meter, Model G, except on July 29 and August 8, 1965.

when it was measured with a Beckman Model K pH meter in the laboratory. Dissolved oxygen was measured with a Yellow Spring Instrument Model 51 oxygen meter.[1]

Results

Thirty-four species representing 20 genera, 11 families, and 6 orders of aquatic Phycomycetes were obtained from the 25 collections made from Lily Lake during the course of this study. On the basis of frequency, each species is placed in one of four groups as follows (Table 1): (i) very abundant (frequency 64-100%)—4 species; (ii) moderately abundant (frequency 20-36%)—10 species; (iii) occasional (frequency 12-20%)—5 species; and (iv) scarce (occurred only once or twice)—15 species.

Table 2 shows the number of species in each order and the substrata on which each species occurred. Identification of the 11 species of Saprolegniales made this order the most widely represented among the orders studied. However, they were not the most abundantly occurring species on substrata of categories (i) twigs, (ii) fruits, or (iii) chitin-keratin. Seven species of Leptomitales were found on twigs, fruits, pine needles, and insect exuviae. The Chytridiales had six species occurring on keratin, chitin, cellophane, *Ulothrix*, and pine pollen. Four species of Blastocladiales, four species of Monoblepharidales, and two species of Peronsporales were found on twigs and fruits.

The pH of the lake remained acidic throughout the study, with an average pH of 6 and a range of 5.4 to 6.5; dissolved oxygen content had an average of 7.2 ppm and a range of 5.5 to 9.2; and water temperature ranged from 0 C to 18 C for the 1965 season (Figure 1).

Discussion

The 34 species found in this study indicate that many fungi can grow under the environmental conditions of this subalpine lake, and their abundance indicates that they may be important in the biological degradation of substrata in these areas.

Since a record of species presence in this report might refer to a single thallus or, in other cases, to a great many thalli, erroneous conclusions could result. However, although no counts were made showing the number of individuals present, we noticed that species for which a high frequency was recorded were generally very abundant whenever found. The species for which a low frequency was recorded were often represented by few individuals at the time of collection. These species grew very sparsely on the bait, and there was a considerable likelihood that some were overlooked. They were seen on only a few occasions in a large number of collections.

The species in the "very abundant" and "moderately abundant" groups were saprophytes and parasites on a wide range of substrata.

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[1] Mention of a trademark name or a proprietary product does not constitute a guarantee or warranty of the product by the USDA and does not imply its approval to the exclusion of other products that may also be suitable.

Table 1. Species found in relation to date of collection and abundance.

		Date of Collection																								
		1965																					1966			
		M. June			July					August				September				October					M. June			
Species	Frequency	18	10	24	1	8	15	22	29	6	13	20	27	3	10	17	24	1	8	18	22	29	5	12	19	27
Very Abundant Species																										
Rhipidium americanum	100	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Sapromyces androgynus	72		x		x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x					x
Achlya sp.	64				x	x	x	x	x	x	x	x	x	x	x	x	x	x		x		x				
Saprolegnia ferax	64				x	x	x	x	x	x	x	x	x	x	x		x	x		x	x					x
Moderately Abundant Species																										
Rhipidium interruptum	36						x	x	x	x		x				x	x		x				x			
Blastocladia pringsheimii	32			x		x			x		x	x			x				x						x	
Saprolegnia delica	28						x		x	x	x	x					x				x					
Gonapodya polymorpha	24				x								x					x						x	x	x
Pythiopsis cymosa	24				x				x	x			x	x						x						
Pythium sp.	24						x			x		x						x						x		x
Saprolegnia hypogyna	24							x		x	x			x			x		x							
Phytophthora sp.	20							x	x			x					x	x								
Rhipidium thaxteri	20					x	x					x	x				x									
Sapromyces elongatus	20							x		x			x				x	x								
Occasional Species																										
Blastocladia ramosa	16			x															x						x	x
Achlya americana	12										x					x	x									
Achlya oblongata	12								x	x			x													
Chytridium acuminatum	12													x			x	x								
Gonapodya prolifera	12			x			x		x																	

Table 1. (Continued).

Scarce Species																										
Achlya klebsiana	8									x	x															
Blastocladia sp.	8																								x	x
Leptolegniella keratinophilum	8			x																			x			
Leptolegneilla sp.	8					x																		x		
Leptomitus lacteus	8							x	x																	
Monoblepharis polymorpha	8																						x	x		
Apodachlya brachynema	4																				x					
Blastocladia angusta	4																								x	
Megachytrium westonii	4										x															
Monoblepharis insignis	4																								x	
Nowakowskiella ramosa	4																							x		
Olpidium endogenum	4						x																			
Olpidium pendulum	4								x																	
Protoachlya paradoxa	4							x																		
Rhizophlyctis rosea	4											x														
Number of species collected per week		1	2	5	6	7	10	10	13	12	10	11	9	7	5	5	12	9	5	5	5	2	4	6	7	7

TABLE 2. Water molds of Lily Lake and the substrata on which they occurred.

Species	Substrata
Chytridiales	
Olpidiaceae	
Olpidium endogenum (Braun) Schroeter	insect exuviae, pine pollen
Olpidium pendulum Zopf	algae
Rhizidiaceae	
Rhizophlyctis rosea (de Bary and Woronin) Fischer	cellophane
Chytridiaceae	
Chytridium acuminatum Braun	cellophane, *Ulothrix*, baby hair, pine pollen
Megachytriaceae	
Nowakowskiella ramosa E. J. Butler	cellophane
Megachytrium westonii Sparrow	*Ulothrix*
Blastocladiales	
Blastocladiaceae	
Blastocladia sp.	apples
Blastocladia ramosa Thaxter	weeping white birch twigs, apples
Blastocladia angusta Lund	weeping white birch twigs, rose hips
Blastocladia pringsheimii Reinisch	apples, rose hips, twigs of river birch and poplar
Monoblepharidales	
Gonapodyaceae	
Gonapodya polymorpha Thaxter	hackberry twigs, rose hips
Gonapodya prolifera (Cornu) Fischer	apples
Monoblepharidaceae	
Monoblepharis insignis var. *insignis* Thaxter	poplar twigs, apples
Monoblepharis polymorpha Corne	poplar twigs
Saprolegniales	
Saprolegniaceae	
Phythiopsis cymosa	apples, pine needles, twigs of river birch, poplar and hackberry
Saprolegnia delica Coker	apples, rose hips, insect exuviae, twigs of river birch, poplar, and hackberry
Saprolegnia ferax (Gruith.) Thurent	hackberry twigs, apples
Saprolegnia hypogyna Pringsheim	twigs of river birch and hackberry
Leptolegniella sp.	river birch twigs
Leptolegniella keratinophilum Huneycutt	river birch twigs
Protoachlya paradoxa Coker	poplar twigs
Achlya sp.	apples, insect exuviae, twigs of river birch, poplar, and hackberry
Achlya klebsiana Pieters	twigs of river birch, poplar, and hackberry
Achlya oblongata de Bary	twigs of river birch and poplar
Achlya americana Humphrey	poplar twigs
Leptomitales	
Leptomitaceae	
Leptomitus lacteus (Roth) Agardh	hackberry twigs, apples, insect exuviae
Apodachlya brachynema (Hildeb.) Pringsh.	river birch twigs

Table 2. Continued

Rhipidiaceae	
Rhipidium americanum Thaxter	apples, rose hips, pine needles, twigs of river birch, weeping white birch, poplar, hackberry, and pine
Rhipidium interruptum Cornu	poplar twigs, apples
Rhipidium thaxteri Minden	pine twigs, apples, pine needles
Sapromyces androgynus Thaxter	apples, twigs of river birch, weeping white birch, poplar, hackberry, and pine
Sapromyces elongatus (Cornu) Coker	rose hips, pine needles, twigs of poplar and pine
Peronosporales	
Pythiaceae	
Pythium sp.	apples, twigs of river birch, poplar, hackberry, and pine
Phythophthora sp.	apples, rose hips

By comparison, the "occasional" and "scarce" groups were usually specific saprophytes and parasites on a limited range of substrata. The greater numbers of species present during the peak periods might be a function of abundance and quality of substrata as well as physical factors of the lake. Thus, abundance of such naturally occurring substrata as lily pads, algae, and pine pollen available in June, July, and August could account for the presence of some species which were not found in May, September, and October, when the substrata were limited or absent.

The number of species collected increased with an increase in water temperature and a decrease in oxygen content during June to August, as illustrated in Figure 1. The number of different species collected was highest in the month of July 1965, and lowest in May of 1965.

Aspects of the physical environment measured may account in part for seasonal population fluctuations, but other factors may also influence them. For example, these fungi seem to infect substrata with rough surfaces or with broken or decomposed protective outer layers. Thus *Rhipidium americanum* Thaxter infected pine needles only after the cuticle of the pine needle was decomposed or cracked, calling to mind Emerson's report (1951) that in 9-11 days *Blastocladia* infected apples that were wiped with ether but took several weeks to infect untreated apples.

The two families of Leptomitales both have representatives occurring in Lily Lake. However, the species of Leptomitaceae found in this study were in group iv (scarce) as opposed to species of Rhipidiaceae, which were all in groups i and ii (abundantly to very abundantly occurring). Five species in the Rhipidiaceae had a higher percentage of occurrence than those of any other family reported in this study (Table 1). *Rhipidium americanum* was the most common species, being found in every week of the study period, and *Sapromyces androgynus* Thaxter was the second most common.

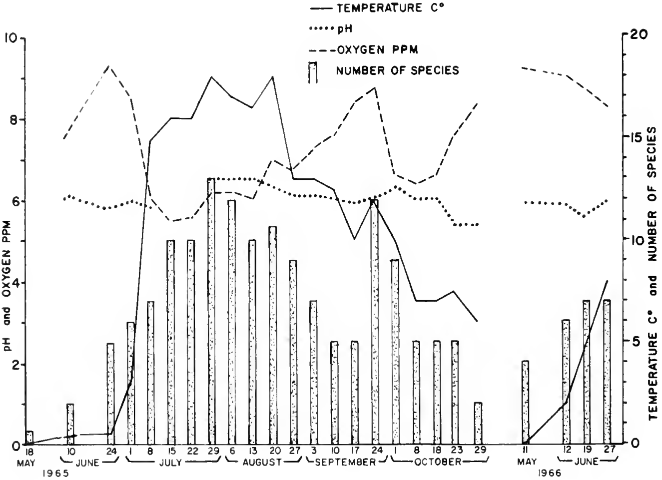

Fig. 1. Weekly comparisons of water temperature, pH, and dissolved oxygen in relation to numbers of species.

These two species were found on more different substrata than any of the others. The other two species in the "very abundant" group are *Saprolegnia ferax* (Gruith.) Thurent and *Achlya* sp., both of the Saprolegniaceae. The same two families dominate the "moderately abundant" group. There were two species of the Pythiaceae, namely, *Pythium* sp. and *Phytophthora* sp., while the Blastocladioceae is represented by *Blastocladia pringsheimii* Reinsch and the Gonapodyaceae is represented by *Gonapodya polymorpha* Thaxter. Six species of Chytridiales were collected from the lake, all in the "scarce" and "occasional" groups. However, our choice of baits and sampling techniques very likely selected against the detection of many chytrid species. Six species were found on substrata not mentioned by Sparrow (1960). These are: *Megachytrium westonii* Sparrow, parasitic on *Ulothrix; Rhizophlyctis rosea* (deB. and Wor.) Fischer, on cellophane and *Oedogonium* sp.; *Chytridium acuminatum* Braun, parasitic on pine pollen; *Monoblepharis insignis* Thaxter, saprophytic on poplar twigs and apples; and *Rhipidium americanum* and *Rhipidium thaxteri*, saprophytic on pine needles.

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NEW SYNONYMY IN AMERICAN BARK BEETLES (SCOLYTIDAE: COLEOPTERA), PART II[1]

Stephen L. Wood[2]

Abstract.— New synonymy involving American Scolytidae includes: *Acanthotomicus* Blandford (= *Mimips* Eggers), *Dendroterus* Blandford (= *Xylochilus* Schedl), *Chramesus dentatus* Schaeffer (= *Ch. barbatus* Eggers), *Cnemonyx atratus* (Blandford) (= *C. nitens* Wood), *C. errans* (Blandford) (= *Ceratolepsis brasiliensis* Schedl), *C. exiguus* (Blandford) (= *Loganius pumilus* Eggers), *C. minusculus* (Blandford) (= *Loganius vismiae* Eggers), *Cnesinus porcatus* Blandford (= *Cn. bicostatus* Schedl), *Cryptocarenus seriatus* Eggers (= *Cr. adustus* Eggers), *Dendroterus luteolus* (Schedl) (= *D. mundus* Wood), *D. mexicanus* Blandford (= *D. confinis* Wood), *D. sallaei* Blandford (= *Xylochilus insularis* Schedl), *D. striatus* (LeConte) (= *Plesiophthorus californicus* Schedl), *Hylastes gracilis* LeConte (= *H. longus* LeConte), *Hylocurus elegans* Eichhoff (= Hy. *minor* Wood), *Hy. retusipennis* Blandford (= *Hy. bidentatus* Schedl), *Hy. rudis* (LeConte) (= *Micracis biorbis* Blackman), *Xyleborus asper* Eggers (= *X. amoenus* Schedl), *X capucinus* Eichhoff (= *X. capucinoides* Eggers), *X. caraibicus* Eggers (= *X. trinidadensis* Schedl), *X. declivis* Eichhoff (= *X. pseudoprocer* Schedl), *X. deplanatus* Eggers (= *X. longideclivis* Wood), *X. discretus* Eggers (= *X. usticus* Wood), *X. gilvipes* Blandford (= *X. mexicanus* Eggers), *X. godmani* Blandford (= *X. caelebs* Blandford), *X. guatemalensis* (Hopkins) (= *X. anisandrus* Schedl), *X. intrusus* Blandford (= *X. howardi* Hopkins, *X. scopulorum* Hopkins), *X. lecontei* (Hopkins) (= *X. gundlachi* Eggers), *X. sparsipilosus* Eggers (= *X. inconveniens* Schedl), *X. spathipennis* Eichhoff (= *X. coronatus* Eichhoff, *Boroxylon burgdorfi* Hopkins, *X. curtus* Eggers, *X. femoratus* Eggers), *X. tumucensis* Hagedorn (= *X. guayanensis* Eggers), *X. vespatorius* Schedl (= *X. corniculatus* Schedl, *X. corniculatulus* Schedl), and *X. volvulus* (Fabricius) (= *X. grenadensis* Hopkins, *X. vagabundus* Schedl). *Microborus bicolor* Eggers is removed from synonymy, and the new name *Acanthotomicus bidentis* is proposed for the preoccupied name *Mimips bidens* Wood.

While reviewing the Scolytidae of North and Central America in the preparation of a taxonomic monograph of the family for this area, the types of numerous species have been examined to confirm the identity of the various taxa. This has resulted in the discovery of several new synonyms. Since the monograph will not be published for several years, the new synonymy is presented below in order that names might be used in identifications and other work. The genera and then the species treated are presented in alphabetical order.

An item of special significance is noted here for the first time. Two species described by Blandford (1895-1905, Biol. Centr. Amer., Coleopt. 4, part 6) from Mexican tobacco refuse intercepted at Paris, *Cnemonyx atratus* (Blandford) and *Hylocurus retusipennis* Blandford, have never been found in North or Central America, but both are reported here as species native to southern Brazil. It is suggested that all Blandford species described from Mexican tobacco refuse actually came from Brazil, since none of them have ever been taken from North or Central America.

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Acanthotomicus Blandford

Acanthotomicus Blandford, 1894, Trans. Ent. Soc. London 1894:89 (Type-species: *Acanthotomicus spinosus* Blandford, monobasic).

Mimips Eggers, 1932, Rev. Zool. Bot. Afr. 22:33 (Type-species: *Ips pilosus* Eggers, original designation). *New synonymy.*

In species assigned to the genera *Acanthotomicus* Blandford, 1894, and *Mimips* Eggers, 1932, the strongly flattened antennal club varies from minutely pubescent and entirely devoid of sutures to clearly marked, strongly procurved sutures in both groups. The elytral declivity is broadly excavated, with the margins armed by one to six pairs of denticles in species assigned to both groups. In view of the diversity of the groups and the intergradation between species assigned to each name, and in the absence of characters that might support continued separation, I place *Mimips* in synonymy under the much older name *Acanthotomicus.*

Schedl (1964, Reichenbachia 2:218) placed *Acanthotomicus* and several other genera (*Orthotomides* Wood, *Pityokteines* Fuchs, and *Orthotomicus* Ferrari) in synonymy under *Ips.* Although there is some justification for his action, I do not feel it is in the interest of taxonomy or of forestry to support his action. The characters employed and the justification for my restoration of these genera will appear in another work.

Dendroterus Blandford

Dendroterus Blandford, 1904, Biol. Centr. Amer., Coleotp. 4(6):233 (Two species); Hopkins, 1914, Proc. U.S. Nat. Mus. 48:120 (Type-species: *Dendroterus mexicanus* Blandford, subsequent designation).

Xylochilus Schedl, 1956, Pan-Pacif. Ent. 32:31 (Type-species: *Xylochilus insularis* Schedl = *Dendroterus sallaei* Blandford, original designation). *New synonymy.*

The type-species of *Xylochilus* Schedl, *X. insularis* Schedl, is identical to *Dendroterus sallaei* Blandford (see below), a species clearly conspecific with *D. mexicanus* Blandford, the type-species of *Dendroterus* Blandford. For this reason *Xylochilus* must be placed in synonymy.

Acanthotomicus bidentis, n. n.

Mimips bidens Wood, 1971 (nec Schedl, 1967), Brigham Young Univ. Sci. Bull., Biol. Ser. 15(3):41. *Preoccupied.*

When *Mimips bidens* Wood was published, the use of the same name for an African species by Schedl (1967, Opusc. Zool. Budapest 7:229) was overlooked. In view of the above synonymy involving the name *Mimips* and the homonymy, the new name *Acanthotomicus bidentis* is proposed as a replacement name for *Mimips bidens* Wood.

Chramesus dentatus Schaeffer

Chramesus dentatus Schaeffer, 1908, Jour. New York Ent. Soc. 16:221 (Lectotype, female; Huachuca Mts., Arizona; U.S. Nat. Mus.).

Chramesus barbatus Eggers, 1931, Ent. Blätt. 26:169 (Holotype, male; Valle de Mexico; Berlin Zool. Mus.). *New synonymy.*

A pair of specimens bearing identical data to the lectotype of *dentatus* Schaeffer and also compared to it, and the holotype of *barbatus* Eggers were compared directly to one another. The males are identical in every respect. The name *barbatus*, therefore, is here placed in synonymy.

Cnemonyx atratus (Blandford)

Loganius atratus Blandford, 1896, Biol. Centr. Amer., Coleopt. 4(6):129 (Lectotype, female; Bugaba, Chiriqui, Panama; British Mus. Nat. Hist., present designation).

Cnemonyx nitens Wood, 1969, Brigham Young Univ. Sci. Bull., Biol. Ser. 10(2):9 (Holotype, male; Puerto Viejo, Heredia, Costa Rica; Wood Coll.). *New synonymy.*

Blandford named *Loganius atratus* from three syntypes taken at Bugaba, Panama. Of these three, two are females and the third specimen is missing from its pin. Because the specimens of *Cnemonyx nitens* Wood taken to the British Museum in 1964 were all males and Blandford's *atratus* was represented only by females, the synonymy was not detected until later when a lectotype was selected. I here designate the first syntype from Bugaba, Panama, in Blandford's series as the lectotype of *Loganius atratus*. This specimen was labeled "Type" many years ago and since then has been regarded as the type, although it has never officially been so designated.

Cnemonyx errans (Blandford)

Ceratolepsis errans Blandford, 1896, Biol. Centr. Amer., Coleopt. 4(6):127 (Lectotype, male; intercepted at Paris in "Mexican" tobacco refuse; British Mus. Nat. Hist., present designation).

Ceratolepsis brasiliensis Schedl, 1936, Archiv. Inst. Biol. Veg. Rio de Janeiro 3:104 (Syntypes; Rio Grande do Sul, Brazil; Schedl Coll. and Vienna Mus.). *New synonymy.*

Blandford named *Ceratolepsis errans* from a syntypic series of several specimens intercepted at Paris in tobacco refuse that supposedly came from Mexico. Four of those syntypes are in the British Museum (Natural History) where the first specimen, a male, was labeled "Type" and has generally been regarded as the type, although it has never officially been so designated. I here designate that male syntype as the lectotype of *Ceratolepsis errans* Blandford. This lectotype and two male paralectotypes were compared to three males and two females of *Ceratolepsis brasiliensis* Schedl in my collection identified by Schedl, labeled "Brasilian, Nova Teutonia, XII-1940, F. Plaumann," and were found to be identical. It is noted that in the original description of *brasiliensis* the sexes were reversed.

This species has been reported from southern Brazil and northern Argentina. There are no records or other reasons for believing it occurs in Mexico as was indicated by Blandford.

Cnemonyx exiguus (Blandford)

Loganius exiguus Blandford, 1896, Biol. Centr. Amer., Coleopt. 4(6):130 (Lectotype, male; Bugaba, Chiriqui, Panama; British Mus. Nat. Hist., present designation).

Loganius pumilus Eggers, 1929, Wiener Ent. Zeit. 46:65 (Holotype, male; Turrialba, Costa Rica; U.S. Nat. Mus.). *New synonymy.*

Loganius exiguus Blandford was named from two male and one female syntypes from Bugaba, Panama. The first male syntype is here designated as the lectotype of *Loganius exiguus* Blandford. This specimen was labeled "Type" many years ago, but has never officially been so designated. This lectotype and the male holotype of *Loganius pumilus* Eggers were both compared to the same male homotypes in my collection. Since all belong to the same species, Eggers's name is here placed in synonymy under the senior name *exiguus* Blandford.

Cnemonyx minusculus (Blandford)

Loganius minusculus Blandford, 1896, Biol. Centr. Amer., Coleopt. 4(6):130 (Holotype, male; Volcan de Chiriqui, Chiriqui, Panama; British Mus. Nat. Hist.).

Loganius vismiae Eggers. 1929, Wiener Ent. Zeit. 46:63 (Holotype, male; La Caja, 8 km W San José, San José, Costa Rica; Deutschen Ent. Mus.). *New synonymy.*

The male holotype of *minusculus* (Blandford) was compared directly to a male cotype and a male topotype of *vismiae* (Eggers). They are identical in all respects. An additional specimen from San Juan, Alta Verapaz, Guatemala, was also examined.

Cnesinus porcatus Blandford

Cnesinus porcatus Blandford, 1896, Biol. Centr. Amer., Coleopt. 4(6):137 (Six syntypes; Cerro Zunil, Guatemala, and Volcan de Chiriqui, Panama; British Mus. Nat. Hist.).

Cnesinus bicostatus Schedl, 1936, Arch. Inst. Biol. Veget. 3:106 (Holotype, male; Turrialba, Cartago, Costa Rica; Schedl Coll.). *New synonymy.*

Following a year of collecting in Costa Rica, including several days at various seasons at Turrialba, only two *Cnesinus* species could be found that even remotely resemble *bicostatus* Schedl. These were *porcatus* Blandford (2.8-3.1 mm) and *costulatus* Blandford (2.0-2.3 mm) of which 43 and 32 specimens respectively were examined. Based entirely upon the original description and field experience in the area of its type locality, it was concluded that *bicostatus* Schedl (2.7 mm), known only from the unique male holotype which is not available for loan, must be a male of *porcatus*. This proposed synonymy must be considered tentative until the type of *bicostatus* is available for study.

Cryptocarenus seriatus Eggers

Cryptocarenus seriatus Eggers, 1933, Mem. Trav. Lab. d'Ent. Mus. Nat. d'Hist. Nat. 1(1):10 (Holotype, female; Nouveau Chantier, Guyane Francaise; Paris Mus.).

Cryptocarenus adustus Eggers, 1933, Mem. Trav. Lab. d'Ent. Mus. Nat. 1(1):11 (Holotype, female; St. Jean du Maroni. Guyane Francaise; Paris Mus.). *New synonymy.*

The female holotypes of *seriatus* Eggers and *adustus* Eggers were examined and compared to more than 80 specimens from Florida to Brazil. This material is easily associated with the type of *seriatus*, which is 2.0 mm in length. The abraded condition of the type of *adustus*, its shorter declivital setae on the elytra, and the concealed frons led Eggers to regard it as a different species. The size was reported as being 2.5 mm; however, if one compensates for the slightly crushed condition of the type it actually is 2.3 mm in length, well within the size range of *seriatus*. The removal of a small piece of the mounting card exposed the previously concealed frons which is of the typical *seriatus* sculpture. The short declivital setae of the type of *adustus* occurs commonly in specimens from Venezuela. For these reasons the name *adustus* Eggers must be placed in synonymy under *seriatus* Eggers because of page priority and the option available to the first revisor.

Dendroterus luteolus (Schedl)

Plesiophthorus luteolus Schedl. 1951, Dusenia 2:111 (Holotype, male; Mexico; Schedl Coll.).

Dendroterus mundus Wood, 1959, Great Basin Nat. 19:3 (Holotype, male; Tehuitzingo, Puebla, Mexico; Snow Ent. Mus., Univ. Kansas). *New synonymy.*

The holotypes of both *luteolus* Schedl and *mundus* Wood were examined. Prior to the description of *mundus* all identified specimens (by Schedl) of *luteolus* known to me were from Baja California and actually were of *striatus* (LeConte). However, the holotype of *luteolus* has the evenly convex frons and coarser elytral vestiture of *mundus*. Although the exact type locality of *luteolus* in Mexico is unknown, the characters are sufficiently clear that the name *mundus* should be placed in synonymy.

Dendroterus mexicanus Blandford

Dendroterus mexicanus Blandford, 1904, Biol. Centr. Amer., Coleopt. 4(6):233 (Holotype, female; Tehuantepec, Oaxaca, Mexico; British Mus. Nat. Hist.).

Dendroterus confinis Wood, 1959, Great Basin Nat. 19:6 (Holotype, male; Magdalena, Jalisco, Mexico; Snow Ent. Mus., Univ. Kansas). *New synonymy.*

The larger average size of this species and the coarser sculpture of the elytra and frons found in the northwestern part of its range suggested the existence of a very different species from that described by Blandford. However, the examination of 119 specimens from six widely separated localities in Mexico indicates that these characters vary within a series and between series to such an extent that only one species can be recognized. The holotypes of both *mexicanus* Blandford and *confinis* Wood were examined.

Dendroterus sallaei Blandford

Dendroterus sallaei Blandford, 1904, Biol. Centr. Amer., Coleopt. 4(6):233 (Holotype, female; Veracruz, Veracruz, Mexico; British Mus. Nat. Hist.).

Xylochilus insularis Schedl, 1956, Pan-Pacif. Ent. 31:31 (Holotype, male; Arroyo Hondo, María Madre, Tres Marías Islands, Gulf of California; California Acad. Sci.). *New synonymy.*

The holotype of *Dendroterus sallaei* Blandford, the holotype and several paratypes of *Xylochilus insularis*, and 82 other specimens were examined. Only one species is represented by this material. The specimen labeled "female holotype" in the Schedl collection has status only as a paratype of his species.

Dendroterus striatus (LeConte)

Hypothenemus striatus LeConte, 1868, Trans. Amer. Ent. Soc. 2:156 (Syntypes; Cape San Lucas, Baja California; Mus. Comp. Zool.).

Plesiophthorus californicus Schedl, 1952, Pan-Pacif. Ent. 23:123 (Holotype, female; Angeles Bay, Gulf of California, Baja California; California Acad. Sci.). *New synonymy.*

The syntypic series of *striatus* LeConte, the holotype and several paratypes of *californicus* Schedl, and 13 other specimens of this species were examined. Only one species is represented. It is very closely related to *luteolus* Schedl and eventually may be found to represent only a geographical race of that species.

Hylastes gracilis LeConte

Hylastes gracilis LeConte, 1868, Trans. Amer. Ent. Soc. 2:174 (Two syntypes; Tahoe Valley, California; Mus. Comp. Zool.).

Hylastes longus LeConte, 1876, Proc. Amer. Philos. Soc. 15:388 (Holotype, female; Colorado; Mus. Comp. Zool.). *New synonymy.*

Both LeConte syntypes of *gracilis* and the holotype of *longus* LeConte, and 126 other specimens of this species were examined. Except for the brighter luster of the holotype of *longus* and of other specimens from the southeastern part of the range, there is little variation in this material. The name *longus* is here placed in synonymy under the senior name *gracilis* LeConte.

Hylocurus elegans (Eichhoff)

Hylocurus elegans Eichhoff, 1871, Berliner Ent. Zeitschr. 15:134 (Holotype, male; Teapa, Tabasco, Mexico; Inst. Roy. Sci. Nat., Brussels).

Hylocurus minor Wood, 1961, Great Basin Nat. 21:4 (Holotype, female; Finca Alto Bonito, Caicedonia, Valle de Cauca, Colombia; Wood Coll.). *New synonymy.*

The holotypes of *elegans* Eichhoff and *minor* Wood and 230 other specimens were examined. Because of the large size and the lack of clarity in the original descriptions of *elegans*, this name could not be associated with *minor*. An examination of the types, however, leaves no doubt as to the synonymy.

Hylocurus retusipennis Blandford

Hylocurus retusipennis Blandford, 1898, Biol. Centr. Amer., Coleopt. 4(6):223 (Holotype, male; "Mexican" tobacco refuse; British Mus. Nat. Hist.).

Hylocurus bidentatus Schedl, 1950, Dusenia 1:149 (Syntypes; Nova Teutonia, Santa Catarina, Brazil; Schedl and Plaumann Collections). *Probable synonymy.*

The holotype of *retusipennis* Blandford that was presumed to have come from Mexico, was compared to a series of *bidentatus* Schedl, identified by Schedl, received from Plaumann from Santa Catarina. The males are identical in every respect. Since the types of *bidentatus* are not available for loan, the confirmation of the suspected synonymy must be delayed.

Hylocurus rudis (LeConte)

Micracis rudis LeConte, 1876, Proc. Amer. Philos. Soc. 15:369 (Holotype, female?; Detroit, Michigan; Mus. Comp. Zool.).

Micracis biorbis Blackman, 1920, Mississippi Agric. Expt. Sta. Tech. Bull. 9:22 (Holotype, male; Syracuse, New York; U.S. Nat. Mus.). *New synonymy.*

Due to an error in identification, Blackman named *biorbis* from specimens that are identical to the holotype of *rudis* LeConte. Blackman associated the name *rudis* with a southern species that is now known as *Hylocurus torosus* Wood. The holotypes of both *rudis* and *biorbis* were examined.

Microborus bicolor Eggers

Microborus bicolor Eggers, 1933, Mem. Trav. Lab. d'Ent. Mus. Nat. d'Hist. Nat. 1(1):19 Holotype, sex?; Bas Carsevenne, Guyane Francaise; Paris Mus.).

This species was placed in synonymy under *aberrans* Wichmann by Schedl (1962, Mitt. Münchn. Ent. Ges. 52:86). However, the types of *aberrans* and *setulosus* Eggers were examined and were found to represent different sexes of the same species; the type of *bicolor* is larger and should be placed near *ambitus* Wood in a different species group from *aberrans*.

Xyleborus asper Eggers

Xyleborus asper Eggers, 1933, Mem. Trav. Lab. d'Ent. Mus. Nat. d'Hist. Nat. 1(1):30 (Holotype, female; Nouveau Chantier, Guyane Francaise; Paris Mus..)

Xyleborus amoenus Schedl, 1949, Rev. Brasil. Biol. 9:282 (Holotype, female; Hamburgfarm on Rio Reventazon, Limon, Costa Rica; Schedl Coll.). *New synonymy.*

The holotypes of both *asper* Eggers and *amoenus* Schedl were examined and compared directly to my specimens from Costa Rica, Panama, Colombia, Venezuela, and French Guiana. Only one easily recognized species is represented by this material. The junior name, *amoenus*, is here placed in synonymy.

Xyleborus capucinus Eichhoff

Xyleborus capucinus Eichhoff, 1868 (1869), Berliner Ent. Zeitschr. 12:281 (Holotype, female; Guadeloupe Island; Inst. Roy. Sci. Nat., Brussels).

Xyleborus capucinoides Eggers, 1941, Arb. Morph. Taxon. Ent. Berlin-Dahlem 8:104 (Holotype, female; Gourbeyre, Guadeloupe Island; U.S. Nat. Mus.). *New synonymy.*

The holotypes of both *capucinus* Eichhoff and *capucinoides* Eggers and 102 other specimens were examined. Although the holotype of *capucinus* is callow and slightly crushed, it clearly is of the same species as *capucinoides*. Eggers's name must be placed in synonymy.

Xyleborus caraibicus Eggers

Xyleborus caraibicus Eggers, 1941, Arb. Morph. Taxon. Ent. Berlin-Dahlem 8:103 (Holotype, female; Guadeloupe; U.S. Nat. Mus.).

Xyleborus trinidadensis Schedl, 1961, Ann. Mag. Nat. Hist. (13)3:530 (Holotype, female; River Estate, Trinidad; British Mus. Nat. Hist.). *New synonymy.*

The holotypes of *caraibicus* Eggers and *trinidadensis* Schedl and 24 other specimens were examined and compared to my material. Only one species is represented by this material. The junior name *trinidadensis* is here placed in synonymy.

Xyleborus declivis Eichhoff

Xyleborus declivis Eichhoff, 1868 (1869), Berliner Ent. Zeitschr. 12:280 (Holotype, female; Teapa, Tabasco, Mexico; presumably lost with Hamburg Mus.).

Xyleborus pseudoprocer Schedl, 1949, Rev. Brasil. Biol. 9:279 (Holotype, female; Guatemala; Schedl Coll.). *New synonymy.*

My three specimens of this species from Costa Rica and Mexico were compared to Blandford's series from Guatemala and to the holotype of *pseudoprocer* Schedl; all clearly represent the same species. This material completely fits the description of *declivis* Eichhoff, the type of which evidently is lost. Since it is the only species of this size (4.0-4.4 mm) from Mexico and Central America in this species group, since it fits the original description, and because it agrees with material identified by specialists who studied the Eichhoff collection, it is reasonable to assume that this species is *declivis* Eichhoff. If this is correct, the name *pseudoprocer* Schedl must be treated as a junior synonym.

Xyleborus deplanatus Eggers

Xyleborus discretus Eggers, 1933, Mem. Trav. Lab. d'Ent. Mus. Nat. d'Hist. Nat., Paris 1(1):32 (Holotype, female; Charvein, Guyane Francaise; Paris Mus.).

Xyleborus longideclivis Wood, 1968, Great Basin Nat. 28:1 (Holotype, female; Bartica Triangle, British Guiana; British Mus. Nat. Hist.). *New synonymy.*

The female holotype of *deplanatus* Eggers was compared directly to four paratypes of *longideclivis* Wood. This species is 2.0-2.3 mm in length, not 3.0 mm as stated in Eggers's description. In addition to British and French Guiana it also occurs in Colombia.

Xyleborus discretus Eggers

Xyleborus discretus Eggers, 1933, Mem. Trav. Lab. d'Ent. Mus. Nat. d' Hist. Nat., Paris 1(1):29 (Holotype, female; Marcapata, Peru; U.S. Nat. Mus.).

Xyleborus usticus Wood, 1968, Great Basin Nat. 28:3 (Holotype, female; Bartica District, British Guiana; British Mus. Nat. Hist.). *New synonymy.*

When *usticus* Wood was named, the distribution of *discretus* Eggers in French Guiana was overlooked. When the holotype of *discretus* was compared to a topotypic paratype of *usticus*, the synonymy was immediately apparent. This species is now known from Costa Rica, Venezuela, British and French Guiana, and Peru. As indicated above, the name *discretus* has priority.

Xyleborus gilvipes Blandford

Xyleborus gilvipes Blandford, 1898, Biol. Centr. Amer., Coleopt. 4(6):205 (Holotype, female; Zapote, Guatemala; British Mus. Nat. Hist.).

Xyleborus mexicanus Eggers, 1931, Ent. Blätt. 27:19 (Holotype, female; Maravatio, Michoacan, Mexico; Zool. Mus. Berlin). *New synonymy.*

The holotypes of *gilvipes* Blandford and *mexicanus* Eggers were both examined and compared directly to my specimens. They clearly represent the same species. The junior name *mexicanus* is here placed in synonymy.

Xyleborus godmani Blandford

Xyleborus godmani Blandford, 1898, Biol. Centr. Amer., Coleopt. 4(6):197 (Holotype, female; Bugaba, Chiriqui, Panama; British Mus. Nat. Hist.).

Xyleborus caelebs Blandford, 1898, Biol. Centr. Amer., Coleopt. 4(6):198 (Holotype, male; Volcan de Chiriqui, Chiriqui, Panama; British Mus. Nat. Hist.). *New synonymy.*

The holotypes of both *godmani* Blandford and *caelebs* Blandford were compared to definitely associated males and females from Panama and Costa Rica. Although the two sexes are very different anatomically, it is entirely clear that only one species is represented by the two names. The name *caelebs* is here placed in synonymy because of page priority and by choice of the first revisor.

Xyleborus guatemalensis (Hopkins)

Ambrosiodmus guatemalensis Hopkins, 1915, U.S. Dept. Agric. Rept. 99:56 (Holotype, female; Trece Aguas, Alta Verapaz, Guatemala; U.S. Nat. Mus.).

Xyleborus anisandrus Schedl, 1954, Dusenia 5:44 (Syntypes, females; Rio Claro, Brazil; Schedl Coll.). *New synonymy.*

The holotype of *guatemalensis* Hopkins and the syntype of *anisandrus* Schedl in the Schedl collection were both compared to my material from Costa Rica, Panama, Colombia, Venezuela, and Brazil. I am unable to see even minor differences in the 32 specimens examined. The junior name *anisandrus* is here placed in synonymy.

Xyleborus intrusus Blandford

Xyleborus intrusus Blandford, 1898, Biol. Centr. Amer., Coleopt. 4(6):213 (Syntypes, females; San Geronimo, Guatemala; British Mus. Nat. Hist.).

Xyleborus howardi Hopkins, 1915, U.S. Dept. Agric. Rept. 99:65 (Holotype, female; Washington, D.C.; U.S. Nat. Mus.). *New synonymy.*

Xyleborus scopulorum Hopkins, 1915, U.S. Dept. Agric. Rept. 99:66 (Holotype, female; Black Hills, South Dakota; U.S. Nat. Mus.). *New synonymy*.

The three syntypes of *intrusus* Blandford, the holotypes of *howardi* Hopkins and *scopulorum* Hopkins, and 42 other specimens were compared to my material. The material from the western United States, Mexico, and Guatemala range from 2.3 to 2.7 mm in length and clearly represent one species. Specimens from the eastern United States average slightly smaller in size, ranging from 2.2 to 2.5 mm in length. It is also noted that pronotal and elytral characters mentioned by Bright (1968, Canadian Ent. 100:1320) are not consistent and occur in both populations. In the absence of distinguishing characters or other means of separating these populations, I here place *howardi* and *scopulorum* in synonymy as indicated above.

Xyleborus lecontei (Hopkins)

Ambrosiodmus lecontei Hopkins, 1915, U.S. Dept. Agric. Rept. 99:56 (Holotype, female; Keene, Florida; U.S. Nat. Mus.).

Xyleborus gundlachi Eggers, 1931, Ent. Blätt. 27:20 (Holotype, female; Cuba; Zool. Mus. Berlin). *New synonymy*.

The holotypes of both *lecontei* Hopkins and *gundlachi* Eggers were examined and compared directly to my specimens. They are identical in all respects. The junior name *gundlachi* is here placed in synonymy.

Xyleborus sparsipilosus Eggers

Xyleborus sparsipilosus Eggers, 1933, Mem. Trav. Lab. d'Ent. Mus. Nat. d'Hist. Nat., Paris 1(1):34 (Holotype, female; Nouveau Chantier, Guyane Francaise; Paris Mus.).

Xyleborus inconveniens Schedl, 1948, Rev. de Ent., Rio de Janeiro 19:577 (Holotype, female; Hamburgfarm on Rio Reventazon, Limon, Costa Rica; Schedl Coll.). *New synonymy*.

The female holotypes of *sparsipilosus* Eggers and *inconveniens* Schedl were both compared to several of my females from Costa Rica. All represent the same species in all details. The name *inconveniens* must be placed in synonymy under the senior name *sparsipilosus*.

Xyleborus spathipennis Eichhoff

Xyleborus spathipennis Eichhoff, 1868, Berliner Ent. Zeitschr. 12:145 (Syntypes, female; Peru; Inst. Roy. Sci. Nat., Brussels).

Xyleborus coronatus Eichhoff, 1878, Mem. Soc. Roy. Sci. Liege (2)8:348 (Holotype, male; Brasilia interior; Inst. Roy. Sci. Nat., Brussels). *New synonymy*.

Xyleborus burgdorfi Hopkins, 1915, U.S. Dept. Agric. Rept. 99:59 (Holotype, female; Costa Rica; U.S. Nat. Mus.). *New synonymy*.

Xyleborus curtus Eggers, 1928, Arch. Inst. Biol. Sao Paulo 1:94 (Lectotype, female; Cachabe, Equador; U.S. Nat. Mus.). *New synonymy*.

Xyleborus femoratus Eggers, 1928, Arch. Inst. Biol. Sao Paulo 1:95 (Syntypes, females; Bahia, Brazil; Zool. Mus. Berlin).

The holotypes of *coronatus* Eichhoff and *burgdorfi* Hopkins, the lectotype of *curtus* Eggers, the Chapuis syntypes of *spathipennis* Eichhoff, three syntypes of *femoratus* Eggers, and 74 other specimens were examined and either compared directly to one another or to specimens in my collection including several series of definitely associated males and females. Only one species is represented; *coronatus*, *burgdorfi*, *curtus*, and *femoratus* are placed in synonymy as indicated above.

Xyleborus tumucensis Hagedorn

Xyleborus tumucensis Hagedorn, 1905, Bull. Mus. d'Hist. Nat., Paris 6:414 (Three female syntypes; Riviere Lunier, Tumuc-Humac, Guyane Francaise: Paris Mus.).

Xyleborus guayanensis Eggers, 1933, Mem. Trav. Lab. d'Ent. Mus. Nat. d'Hist. Nat., Paris 1(1):28 (Male and female syntypes; Nouveau Chantier, Guyane Francaise; Paris Mus.). *New synonymy.*

The female syntype of *tumucensis* Hagedorn that has been labeled "type," the male syntype and two female cotypes (the female syntype is missing from the Paris Museum) of *guayanensis* Eggers, and 43 other specimens of this species were examined and compared directly to one another. Only one species is represented. The error evidently occurred when Eggers (1933) misidentified specimens of *geayi* Hagedorn which he reported as *tumucensis*. The name *guayanensis* Eggers is placed in synonymy under the older name *tumucensis*.

Xyleborus vespatorius Schedl

Xyleborus vespatorius Schedl, 1931, Ann. Mag. Nat. Hist. (10)8:339 (Holotype, female; San Ignacio, Argentina; Schedl Coll.).

Xyleborus corniculatus Schedl, 1949, Rev. Brasil Biol. 9:275 (Holotype, female; Santa Catarina, Brazil; Schedl Coll.). *New synonymy.*

Xyleborus corniculatulus Schedl, 1949, Rev. Brasil Biol. 9:275 (Holotype, female; Trinidad; Schedl Coll.). *New synonymy.*

The holotypes of *vespatorius* Schedl, *corniculatus* Schedl, and *corniculatulus* Schedl were examined and compared directly to one another and to my homotypes. The three names are based on what I consider to be minor variations of the same species. The declivital denticles of the holotype of *vespatorius* have been damaged, presumably by the chewing of siblings, thereby making recognition more difficult. The name *vespatorius* has priority over both *corniculatus* and *corniculatulus*.

Xyleborus volvulus (Fabricius)

Bostrichus volvulus Fabricius, 1775, Systema Entomologiae, p. 454 (Syntypes, females; America ligno Dom v. Rohr, presumably Cuba; Copenhagen Mus.).

Xyleborus torquatus Eichhoff, 1868, Berliner Ent. Zeitschr. 12:146 (Syntypes, female; Cuba, Brazil, Puerto Rico; presumably lost with Hamburg Mus.).

Xyleborus grenadensis Hopkins, 1915, U.S. Dept. Agric. Rept. 99:65 (Holotype, female; Grenada, West Indies; U.S. Nat. Mus.). *New synonymy.*

Xyleborus vagabundus Schedl, 1949, Rev. Brasil. Biol. 9:277 (Holotype, female; Mexico; Schedl Coll.). *New synonymy.*

Three syntypes of *volvulus* Fabricius, the holotypes of *grenadensis* Hopkins and *vagabundus* Schedl, and several hundred specimens from Florida and Baja California to Argentina, Africa, Hawaii, Micronesia, and Australia were examined. Apparently two distinct geographical races of this species existed prior to the advent of modern commerce: a northern one (*volvulus*), from central Mexico northward including Cuba and Florida; and a southern race (*torquatus*), from Central and South America. Over the past century, one or both races of this species were introduced to other areas where one race or the other predominated or else hybridized to form local populations either intermediate in anatomical details or highly variable in structure with both extremes and all degrees of intergradation represented. The southern race apparently has been introduced repeatedly into the range of the northern race and has maintained itself locally to some degree. Because of the extreme hybridization which occurred in areas outside of the American continents and the mixing taking place in Mexico, I see no possibility of the continued recognition of definite geographical races.

The types of *grenadensis* Hopkins and *vagabundus* Schedl both represent normal minor variations of the northern race and must be placed in synonymy.

FLIGHTS OF THE WESTERN THATCHING ANT, *FORMICA OBSCURIPES* FOREL, IN NEVADA (HYMENOPTERA: FORMICIDAE)[1]

William H. Clark[2] and Peter L. Comanor[2]

Abstract.— Observations indicate that *Formica obscuripes* flies earlier in Nevada than in other parts of the country where the flights have been recorded. The alate males are the first to emerge from the nest. These are eventually succeeded by alate females, and finally only females are seen. *F. obscuripes* flew during periods when air temperatures were 20.5-26.5 C, when relative humidities were about 18%, and when solar input was about 1.35 langleys. Slight winds approaching 3 mph did not keep the ants from flying but may have influenced their direction of flight.

The nests of *F. obscuripes* observed near Reno differ from those reported in other areas in that they do not have such an extensive thatch covering them.

Flight activities have been reported for *Formica obscuripes* by McCook (1884). He states that the marriage flight of this ant in "Dakota" occurs in "the latter part of July, [when] numerous swarms of 'flying ants' are seen" and that "the appearance of the swarms continuing throughout August and into September" has been observed. Cole (1932) states that "winged males and females appear in large numbers during June and July." In North Dakota, flights occur in the month of June (Weber, 1935), and in Michigan, in June and early July (Talbot, 1959; 1972). It has been suggested that *F. obscuripes* does not have true nuptial flights and that winged forms leave the nest one or a few at a time (Weber, 1935). On the other hand, more recent observation suggests that *F. obscuripes* has conspicuous swarming and mating activities (Talbot, 1959; 1972). This seems to be substantiated by the polygymous habit of this ant (King and Sallee, 1956). Wheeler and Wheeler (1963) report winged females of *F. obscuripes* in nests from 6 June to 8 August and winged males from 23 May to 12 July in North Dakota.

Records of flight activities of this ant in the Great Basin have not been found in the literature. The Nevada flights reported below were first noted on 15 April and lasted until at least 10 May 1972, thus occurring almost two months earlier than previously recorded for this species.

F. obscuripes has been recorded in Nevada, but not previously in Washoe County (La Rivers, 1968).

Materials and Methods

Three nests of *F. obscuripes* were periodically observed from 15 April to 10 May 1972 in conjunction with other ant studies in the general areas of the study sites described below.

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Numbers of winged males and females on the nests, in nearby vegetation, and actually flying were noted. Temperature data were taken in C by two methods. At nest number 1, the temperatures were taken with a YSI 12 channel telethermometer, and temperatures at nests number 2 and 3 were taken with two standard laboratory glass thermometers. Ground surface temperatures and air temperatures at 10 cm above the ground surface were taken. Relative humidity was taken with a sling psychrometer operated as near the ground surface as possible, and wind measurements were made with a hand-held anemometer at 1 meter above ground surface. On 1 May, solar input, in langleys per minute (cal/cm^2/min), was taken with a weathermeasure recording pyranograph.

The three *F. obscuripes* nests observed during April and May 1972, all located just north of Reno, Washoe County, Nevada, occur at elevations of about 1550 m and are separated by distances of up to 15 miles. The vegetation of these areas is dominated by *Artemesia tridentata*, basin big sagebrush. Numbers of subordinate species vary among the sites. The chief ones are *Chrysothamnus viscidiflorus*, *C. nauseosus*, *Ephedra viridis*, *Ribes velutinum*, *Tetradymia canescens* and *Bromus tectorum*. Nest number 1 is 1.1 m in diameter and 30 cm high. It is constructed around a living *Chrysothamnus nauseosus* shrub, and its thatch is relatively thin and composed mainly of *Ephedra viridis* stems, *Artemesia tridentata* bark, and grass overlying a base of coarse, decomposed granite sand. Nest number 2 is 79 cm in diameter and 25 cm high. This nest is built around living and dead *Artemesia tridentata* and *Tetradymia canescens*, with its thatch constructed mainly of sage bark and grass. Nest number 3 is 50 cm in diameter and 15 cm tall and is in living and dead *Artemesia tridentata* and *Chrysothamnus viscidiflorus*. Its thatch is composed mostly of *Ephedra viridis* stems, sage bark, and grass.

These three nests differ from the nests described by Cole (1932), Weber (1935), and Wheeler and Wheeler (1963) in the extent of the thatching. These workers state that the thatch material covers the mound and extends into the soil to varying depths, to a maximum of about 30 cm. The three nests observed in this study have a thin layer of thatch on top, with the lower sides composed mostly of bare gravel and occasional sticks or grass stems. None of the nests observed has a thatch that extends to or into the ground.

RESULTS

The first winged individuals of *F. obscuripes* observed were males noted on the morning of 15 April. About a dozen winged males were observed in *Chrysothamnus nauseosus* near nest number 1. After these winged ants were noticed, two other *F. obscuripes* nests were located and occasionally observed. On 18 April, seven males were collected from the surface of nest number 2 in the time period from 10:00 to 10:30 a.m. None were observed in surrounding plants. Nest number 3 was located on 19 April, but no winged individuals were found; however, two winged males were seen on nest number

2. On 29 April at 2:45 p.m., winged males were again observed on nest number 2.

On 1 May 1972, nest number 1 was observed for a day (see Table 1), and a maximum of fourteen females flew per minute at 10:25 a.m., representing the height of the flight, when the air temperature at 10 cm above ground surface was 25 C (see Figure 1).

Discussion

According to Weber (1935), when "the air is calm, the sky quite clear, the temperature above 60 F (15 C), and the humidity above 50%, the ants take flight." These temperatures were taken at 10 inches (25.4 cm) above ground level (Talbot, 1971). Talbot (1959) found that *F. obscuripes* "began flying at about 70 F (21 C), provided they were not wet, the grass was not swaying, and the sky was not darkening." The correspondence of flights with rising temperatures in the morning is supported by work on several species of *Formica* elsewhere (Talbot, 1964). The flights observed in Nevada all occurred within the temperature range given by Talbot (1959; 1972).

During the flights recorded for Nevada, a breeze was always present, the sky was clear, and the temperature was always above

Fig. 1. Alate *Formica obscuripes* females on *Chrysothamnus nauseosus* 1 May 1972.

Table 1. Flight activities of *Formica obscuripes* at nest number 1 on 1 May 1972.

Time[1]	Air Temp.[2] (C)	Ground Surface Temp. (C)	% Relative Humidity	Wind (mph)	Solar Input (g-cal/cm^2/min)	No. alate ants on surface		No. alate ants on plants		Flights/minute alate females
						♂	♀	♂	♀	
8:30 a.m.	18.5	24.5	44	0	0.90	0	4	0	0	0
8:40	18.5	26	—	..	0.98	3	25	1	8	0
9:00	20	29.5	24	0	1.045	3	78	2	27	0
10:00	23	38.5	18	2.3	1.27	5	58	2	100	0
10:20	25	41	—	..	1.33	2	27	2	120	3
10:25	25	41	—	..	1.35	0	19	1	113	14
11:00	26.5	45.5	18	2.9	1.435	0	5	1	45	6
11:45	28	50	—	..	1.50	0	0	1	0	0
12:00	28.5	52	16	0.8	1.52	0	0	1	0	0
1:00-5:00 p.m.	32-22.5	55-39	17-18	0-3.2	1.54-1.01	0	0	0	0	0
5:20	22	30	—	..	0.90	0	3	0	0	0

[1] Pacific Daylight Saving Time

[2] 10 cm above ground surface

15 C. The humidity during these flights was always below 50%, with a relative humidity of about 18% during flights which occurred on 1 May 1972. The wind was not strong, usually averaging 2-3 mph, and did not seem to inhibit the flight of the ants. As they were observed to fly from the *Chrysothamnus* stems which were moving in the wind, the wind did seem to influence the direction of flight. On 1 May, the wind was from the east and the ants were flying westward and northwestward. The alate ants flew upward for one to about five meters, occasionally straight up, but usually at an angle to the west. Several times females would begin flight in an easterly or southerly direction and after attaining an altitude of several meters would shift to a westerly direction. This change in flight direction could be a result of the light winds present. The same type of wind conditions prevailed on 4 May, and again the ants flew in a westerly direction. Three winged females appeared on the nest surface for a short time at 5:20 p.m., then returned into the nest. Winged ants were seen outside the nest when the corresponding solar input ranged from 0.98 to 1.52 langleys and were observed to fly when the solar input ranged from 1.33 to 1.435 langleys.

On 4 May at 10:00 a.m., nest number 1 had 10 females on the surface and 45 were located in nearby shrubs; three males were observed in shrubs. Sixteen females and one male flew in a one-minute time period, when the air temperature was 20.5 C. At 10:30 a.m. nest number 3 had one winged female on the nest surface. On 10 May at 8:45 a.m., nest number 2 had seven winged females on the surface and one in a sagebrush. At 9:45 a.m., nest number 3 had 10 winged females on the nest and 20 in sagebrush.

An additional *F. obscuripes* nest on Austin Summit, Lander County, Nevada, elevation 2286 m, was found to have no winged individuals present outside the nest during the morning of 12 May 1972.

Winged males of *F. obscuripes* were much fewer than females. Males were also the first winged forms observed to leave the nest in April; gradually more females were present, until finally in May only females were flying. These observations agree with those of Talbot (1959) for this species.

Our observations indicate that *F. obscuripes* flies earlier in Nevada than elsewhere where it has been observed. Sudd (1967) states that "ants of deserts and steppes do not fly in late summer, when the queens would be exposed to hot, dry weather in the time when they are founding colonies. The flight is delayed till spring." The earlier flights in Nevada could be an avoidance of the summertime hot, dry weather; or, it may be that the ants simply develop sooner in this climate.

ACKNOWLEDGEMENTS

The authors thank Drs. George C. and Jeanette Wheeler for the species determination of *F. obscuripes*.

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A NEW SPECIES OF SOIL MITE FROM WESTERN COLORADO (ACARI: CRYPTOSTIGMATA, PELOPIDAE)[1]

Harold G. Higgins[2] and Tyler A. Woolley[3]

ABSTRACT.— A new species of soil mite from Hayden, Colorado, is described. This species, *Peloptulus tanytrichosus*, is the first representative of the genus in North America. The species is described, figured, and compared with *P. foveolatus* Hammer, 1961. Eight specimens were taken from different habitats, including aspen litter, scrub oak litter, and beneath greasewood and pepper grass.

During the summer of 1971, a number of soil samples were taken in the vicinity of a coal-burning power plant near Hayden, Colorado. During these investigations several new species of soil mites were taken from different ecological niches in the project area. Among others is a new species in the genus *Peloptulus*. This genus is known from Europe and Peru, South America, but to our knowledge has never before been recorded from North America.

Peloptulus tanytrichosus, n. sp.

(Figs. 1, 2, and 3)

DIAGNOSIS.— Sensillum much longer than any known species, extending well beyond level of translamella; lamellar tip without cusps.

DESCRIPTION.— Color deep reddish brown; prodorsum about as long as broad; rostrum squarish, lateral margins flaring somewhat anteriorly; lamellae long, reaching nearly to tip of rostrum, covering much of the prodorsum, without cusps or notched tip; translamella narrow, longer than broad, closer to rostrum than notogaster; lamellar hairs heavy, setose, attached on inner margin of lamellae near their tips, and flaring outward; interlamellar hairs weak, smooth, about as long as distance between lamellae at their insertion, inserted below anterior border of hysterosoma, in the arch between the pseudostigmata, extending forward slightly beyond the sclerotized line connecting the pteromorphs; sensillum long, in some specimens more than three-fourths as long as lamellae, with swollen, setose head and long, narrow pedicel; pseudostigmata oval, with heavy, sclerotized lips rising above surface of prodorsum; pedotectum I with a long, slender, pointed tip that can be seen from the dorsal side.

Hysterosoma rounded in outline with dorsal setae and markings as shown in Figure 1; the two posterior setae are slightly larger, with more squarish tips than the rest; specimens show some variation in size and length of dorsal setae.

Camerostome flask-shaped; genital opening squarish, about as long as wide and shorter than anal opening, each genital plate with

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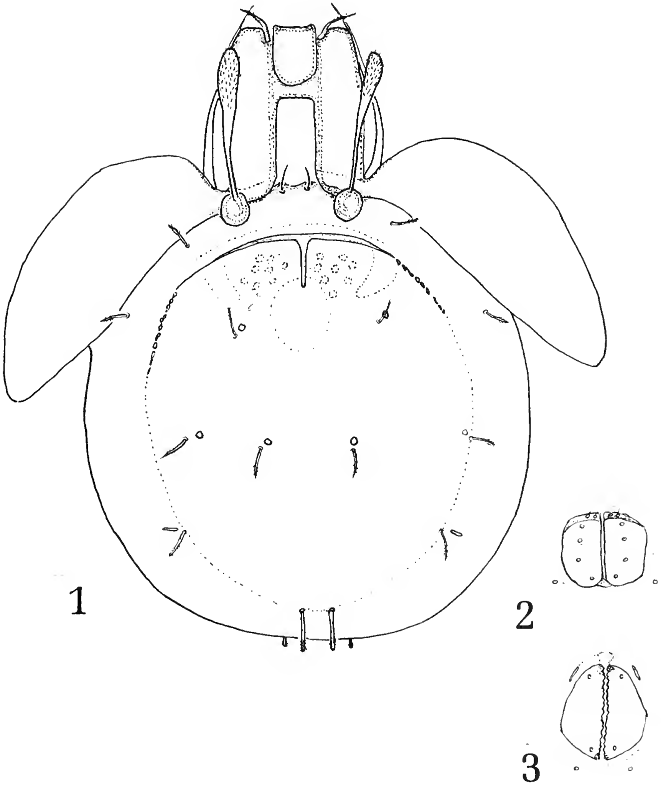

Figs. 1-3. *Peloptulus tanytrichosus*, n. sp.: 1, dorsal aspect, legs omitted; 2, genital area; 3, anal area.

six setae as shown in Figure 2; anal plates somewhat egg-shaped, inner edge of anal plates wavy; distance between genital and anal opening equal to about length of anal opening as shown in Figure 3.

Legs heterotridactylous, the middle claw larger than laterals.

Size.— Length, .45 mm; width, .34 mm.

Collection Data.—The type, a male, and on other male specimen were collected from litter under aspens, 4 miles S Seneca Road, Hayden, Colorado, 1-VIII-1971, by H. G. Higgins; 1 specimen from under aspens, 4 miles S Seneca Road, Hayden, 8-VI-1971, by H. G. Higgins and T. A. Woolley; 3 specimens from under scrub oaks, 4 miles S Seneca Road, 1-VIII-1971, by H. G. Higgins; 1 specimen from under scrub oaks near spoil bank, Wolf Creek North, Hayden, 9-VI-1971, by H. G. Higgins and T. A. Woolley; 1 specimen from under greasewoods and pepper grass, 4 miles S Hayden, 9-VI-1971, by T. A. Woolley and H. G. Higgins.

Discussion.— The most striking difference between this species and other known species of the genus *Peloptulus* is the long sensillum. This species differs from the South American species *P. foveolatus* Hammer by lacking the reticulations on the body, a cusped lamellae, and having a much longer sensillum. The sensillum of *P. foveolatus* reaches nearly to the translamella. The trivial name from the Greek *tanytrichosus* means "long hair" and refers to the long sensillum.

This mite appears to live in a number of habitats, since it has been found in litter under quaking aspen, in litter under scrub oak, and in rather dry soil under greasewoods and pepper grass. In the small collection under study it appears that this species shows individual variation in the length of sensillum, but the relative length as it relates to the translamella is a diagnostic feature of importance. It appears that the sensillum of males is slightly longer than the sensillum of females. In addition, the species from the dryer scrub oaks and greasewoods seem to have a narrower translamella than those from the more moist aspen litter.

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A CHECKLIST OF THE MACROINVERTEBRATES OF THE PROVO RIVER, UTAH

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James R. Barnes,[1] and David A. White[1]

Abstract.— A checklist of the aquatic macroinvertebrate species from the Provo River, Utah, was compiled from field collections and from literature sources.

Recent water control activities and proposed developments along the Provo River in Provo Canyon have served to stimulate research on aquatic life in this river. Many studies of aquatic life deal either directly or indirectly with the aquatic insects in the stream. Previous studies of aquatic insects in the Provo River are either unpublished theses or incidental references in papers of a broader scope (Edmunds, 1952). The most complete studies were conducted by Gaufin (1949, 1951, 1959).

Students at the University of Utah studied the Trichoptera (Merkley, 1948), aquatic Coleoptera (Todd, 1952), Chironomidae (Brooks, 1955), and Plecoptera (Sessions, 1960) of the Provo River.

Incidental references to the species of aquatic insects were made by Needham and Christensen (1927), Hazzard (1934), Moffet (1936), Chandler (1941), Tanner (1941), Anonymous (1948), Dunstan (1951), Anderson (1960), Musser (1961), and Braithwaite (1962).

The present study was conducted during the winter of 1969-70. Collections were taken from 10 stations located along the Provo River from 5½ miles above Woodland, Utah, downstream to the U. S. 91 highway bridge in Provo, Utah.

The main purpose of this paper is to make available, in one place, a complete list of the aquatic invertebrates which have been collected from the Provo River. Table 1 lists all organisms collected during the present study and from previous pertinent studies (Merkley, 1948; Gaufin, 1951; Todd, 1952; Gaumer, 1952; Brooks, 1955; Sessions, 1960; Gaufin, Nebeker, and Sessions, 1966).

The collection of *Sialis* sp. (Sialidae) has not, as far as we know, been previously reported in the literature for northern Utah. In this study, immatures of *Sialis* were collected on several occasions in the Provo River downstream from Woodland, Wasatch Co., Utah. One specimen of *Sialis* has been collected from Hobble Creek, east of Springville, Utah Co., Utah. Dr. Arden R. Gaufin, University of Utah (Pers. Comm., 1972), has collected *Sialis* from the Weber, Provo, and Bear rivers.

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in this study. Thanks are also due to Dr. Roy T. Sawyer, College of Charleston, Charleston, South Carolina, who identified the Hirudinea.

TABLE 1. Checklist of the Macroinvertebrates of the Provo River, Utah. (Parentheses around number indicates specimens not classified to species. 1 = present study; 2 = Gaufin, 1951; 3 = Merkley, 1948; 4 = Sessions, 1960; 5 = Todd, 1952; 6 = Brooks, 1955; 7 = Gaufin, Nebeker, and Sessions, 1966; 8 = Gaumer, 1952; 9 = Edmunds, 1952.)

ORGANISM	COLLECTOR
Collembola	2
Coleoptera	
Caraboidea	
Amphizoidae	
Amphizoa lecontei Matthews	5
Dytiscidae	
Bidessus affinis (Say)	5
Hydroporus planiusculus Fall	(2), 5
Hydroporus pervicinus Fall	5
Hydroporus occidentalis Sharp	5
Hydroporus transpunctatus Chandler	
Hygrotus masculinus (Crotch)	5
Hygrotus patruelis (LeConte)	5
Hygrotus tumidiventris (Fall)	5
Laccophilus decipiens LeConte	5
Laccophilus astristernalis Crotch	5
Oreodytes crassulus (Fall)	5
Oreodytes congruus (LeConte)	5
Agabus cordatus (LeConte)	5
Agabus hypomelas Mannerheim	5
Agabus seriatus intersectus Leech	5
Agabus oblongus Fall	5
Agabus approximatus Fall	5
Agabus austini Sharp	5
Agabus strigulosis (Crotch)	5
Agabus kenaiensis Fall	5
Agabus erichsoni Gemminger & Harold	5
Agabus tristis Aubé	5
Ilybius subaenus Erickson	5
Ilybius fraterculus LeConte	5
Rantus divisus (Aubé)	5
Rantus longipes Sharp	5
Rantus hoppingi Wallis	5
Dytiscus marginicollis LeConte	5
Dytiscus dauricus Gebl.	(1), (2), 5
Dytiscus circumsinctus Ahrens	5
Acilius semisulcatus Aubé	5
Cybister explanatus LeConte	5
Haliplidae	
Brychius horni Crotch	5
Haliplus immaculicollis Harris	(1), (2), 5
Haliplus leechi Wallis	5
Peltodytes callosus (LeConte)	5
Gyrinoidea	
Gyrinidae	
Gyrinus bifarius Fall	5
Gyrinus consobrinus LeConte	5

Table 1. (Continued)

Gyrinus pleuralis Fall	5
Gyrinus picipes Aubé	5
Gyrinus affinis Aubé	5
Hydrophiloidea	
Hydrophilidae	
Helophorus oblongus LeConte	(2), 5
Helophorus obscurus LeConte	5
Telophorus nitidulus LeConte	5
Berosus infuscatus LeConte	5
Berosus styliferous Horn	5
Hydrous triangularis (Say)	5
Tropisternus ellipticus (LeConte)	5
Tropisternus dorsalis (Brullé)	5
Tropisternus californicus (LeConte)	5
Hydrobius fuscipes Linnaeus	(2), 5
Hydrobius scabrosus Horn	5
Paracymus subcuprens (Say)	5
Crepitis moratus (Horn)	5
Helochares maculicollis Mulsant	5
Enochrus hamiltoni (Horn)	5
Enochrus conjunctus (Fall)	5
Dryopoidea	
Dryopidae	
Helichus striatus LeConte	(1), 2, 5
Elmidae	
Elmis ornata Schaffer	5
Heterlimnius quadrimaculatus (Horn)	(1), 2, 5
Heterlimnius corpulentus (LeConte)	2, 5
Narpus concolor (LeConte)	5
Narpus angustus Casey	2
Simsonia quadrinotata (Say)	5
Zaitzevia parvulus (Horn)	(1), 2, 5
Microcylloepus pusillus LeConte	2
Diptera	
Chironomidae	(1)
Calospectra sp.	6
Chironomus sp.	2
Diamesa sp.	6
Harnischia sp.	6
Hydrobaenus sp.	6
Cricotopus sp.	6
Corynoneura sp.	6
Psilodiamesa sp.	6
Syndiamesa sp.	6
Pentaneura sp.	2, 6
Tendipes sp.	6
Tanytarsus sp.	2
Procladius sp.	2
Spaniotoma sp.	2
Tipulidae	
Antocha sp.	1, 2
Eriocera sp.	2
Dicranota sp.	2
Hexatoma sp.	1, 2
Pedicia sp.	2
Holorusia sp.	2
Phalacrocere sp.	2
Tipula sp.	1, 2
Rhaphidolabis sp.	2

Table I. (Continued)

Psycodidae	
Pericoma sp.	1, 2
Empididae	
Hemerodromia sp.	2
Roederiodes sp.	2
Simuliidae	
Simulium sp.	1, 2
Tabanidae	
Chrysops sp.	2
Dixidae	
Dixa sp.	2
Rhagionidae	
Atherix variegeta Walker	1, 2
Muscidae	
Limnophora aequifrons Stein	2
Heleidae	
Palpomyia sp.	2
Stratiomyiidae	
Euparyphus sp.	2
Odontomyia sp.	2
Deuterophlebiidae	
Deuterophlebia sp.	2
Blepharoceridae	
Agathon sp.	1
Blepharicera sp.	2
Ephemeroptera	
Baetidae	
Baetis bicaudatus Dodds	2
Baetis intermedius Dodds	2
Baetis tricaudatus Dodds	1, 2
Callibaetis fuscus Dodds	9
Ephemerellidae	
Ephemerella coloradensis Dodds	2
Ephemerella doddsi Needham	1. 2
Ephemerella grandis grandis Eaton	1, 2
Ephemerella hecuba (Eaton)	2
Ephemerella inermis Eaton	1, 2
Ephemerella infrequens McDunnough	2
Ephemerella maragrita Needham	9
Ephemerella tibialis McDunnough	2
Heptageniidae	
Cinygmula mimus (Eaton)	9
Cinygmula par (Eaton)	9
Epeorus (*Iron*) *albertae* (McDunnough)	2
Eperous deceptivus (McDunnough)	2
Epeorus longimanus (Eaton)	2
Epeorus sp.	2
Heptagenia criddlei McDunnough	2
Heptagenia solitaria McDunnough	1, 2
Heptagenia elegantula (Eaton)	2
Rhithrogena doddsi McDonnoungh	9
Rhithrogena morrisoni (Banks)	9
Rhithrogena robusta Dodds	9
Siphlonuridae	
Ameletus oregonensis McDunnough	1
Ameletus velox Dodds	2
Ameletus sp.	1

Table 1. (Continued)

Siphlonurus occidentalis Eaton	2
Parameletus columbiae McDunnough	9
Leptophlebiidae	
Paraleptophlebia debilis (Walker)	2
Paraleptophlebia heteronea (McDonnough)	1, 2
Paraleptophlebia memorialis Eaton	9
Paraleptophlebia packi (Needham)	
Tricorythidae	
Tricorythodes minutus minutus Traver	1, 2
Plecoptera	
Chloroperlidae	
Alloperla pallidula (Banks)	(1), 2, 4, 7
Alloperla borealis (Banks)	4, 7
Alloperla lamba Needham and Cleasen	2, 7
Alloperla pintada Ricker	4, 7
Alloperla coloradensis (Banks)	4, 7
Alloperla severa (Hagen)	4, 7
Alloperla signata (Hagen)	4, 7
Paraperla frontalis Banks	4, 7
Utaperla sopladora Ricker	4, 7
Nemouridae	
Brachyptera nigripennis (Banks)	1, 2, 4, 7
Brachyptera pacifica (Banks)	2, 4, 7
Brachyptera pallida (Banks)	1, 7
Capnia confusa Claassen	1, 4, 7
Capnia columbiana Claassen	2, 4, 7
Capnia gracilaria Claassen	4, 7
Capnia lemoniana Nebeker and Gaufin	7
Capnia ligulata Hansen	7
Capnia logana Nebeker and Gaufin	7
Capnia nana wasatchae Claassen	7
Capnia uintahi Gaufin	7
Eucapnopsis brevicauda (Claassen)	4, 7
Paraleuctra occidentalis (Banks)	2, 7
Paraleuctra sara (Claassen)	(2), 4, 7
Isocapania crinata (Needham and Claassen)	7
Isocapania grandis (Banks)	7
Nemoura californica Claassen	(1), 4, 7
Nemoura cinctipes Banks	2, 4, 7
Nemoura columbiana Claassen	4, 7
Nemoura besametsa Ricker	1, 2, 4, 7
Nemoura oregonensis Claassen	2, 4, 7
Nemoura haysi Ricker	7
Perlomyia utahensis Needham and Claassen	7
Perlidae	
Acroneuria pacifica Banks	1, 2, 4, 7
Claassenia sabulosa (Banks)	1, 2, 4, 7
Perlodidae	(1), 2, 4, 7
Arcynopteryx signata (Hagen)	1, 4, 7
Arcynopteryx parallela (Frison)	2, 4, 7
Isogenus aestivalis (Needham and Claassen)	7
Isogenus modestus (Banks)	(1), (2), 4, 7
Isoperla ebria (Hagen)	1, 2, 4, 7
Isoperla fulva Claassen	4, 7
Isoperla mormona Banks	2, 4, 7
Isoperla patricia Frison	4, 7
Isoperla pinta Frison	4, 7
Diura knowltoni (Frison)	4, 7

Table 1. (Continued)

Pteronarcidae	
Pteronarcys californica Newport	1, 2, 4, 7
Pteronarcella badia (Hagen)	1, 2, 4, 7
Trichoptera	
Brachycentridae	
Brachycentrus aspolus Ross	3
Brachycentrus americanus (Banks)	1
Brachycentrus occidentalis (Banks)	2, 3
Brachycentrus sp.	1, 2, 3
Micrasema bactro Ross	2, 3
Helicopsychidae	
Helicopsyche borealis (Hagen)	1, 2, 3
Hydropsychidae	
Arctopsyche grandis (Banks)	(1), 2, 3
Cheumatopsyche analis (Banks)	(2), 3
Hydropsyche californica Banks	(1), (2)
Hydropsyche cockerelli Banks	3
Hydropsyche occidentalis Banks	3
Hydropsyche oslari Banks	3
Parapsyche elsis Milne	2, 3
Pycnopsyche sp.	3
Hydroptilidae	
Agraylea multipunctata Curtis	3
Agraylea saltesea Ross	3
Hydroptila consimilis Morton	3
Hydroptila sp.	(2), 3
Neotrichia panneus Denning	3
Neotrichia sp.	2
Ochrotrichia atylata Ross	3
Ochrotrichia logana (Ross)	2
Tascobia brustia (Ross)	2, 3
Lepidostomatidae	
Lepisostoma pluviale (Milne)	(2), 3
Lepisostoma unicolor (Banks)	3
Lepisostoma podager (McLachlan)	3
Lepisostoma cascadense (Milne)	3
Leptoceridae	
Oecetis sp.	1, 2, 3
Limnephilidae	
Chyranda centralis (Banks)	3
Dicosmoecus atripes (Hagen)	(2), 3
Dicosmoecus unicolor (Banks)	3
Hesperophylax consimilis (Banks)	(1), 2, 3
Limnephilus arizona Ross	2, 3
Limnephilus sp.	(1), 3
Neophylax sp.	2
Neothremma alicia Banks	(1), 3
Oligophlebodes minutus (Banks)	3
Philoptomidae	
Dolophilus garbriella (Banks)	2, 3
Trentonius aequalis (Banks)	2, 3
Chimarra sp.	2
Psycomyiidae	
Psychomyca flavida Hagen	3
Tinodes sp.	3
Rhyacophilidae	
Anagapetus debilis Ross	3
Glossosoma alascense Banks	(1), 3

Table 1. (Continued)

Glossosoma parvulum Banks	2, 3
Glossosoma verdona Ross	3
Rhyacophila acropedes Banks	(1), (2), 3
Rhyacophila angelita Banks	3
Rhyacophila coloradensis Banks	3
Rhyacophila harmstoni Ross	3
Rhyacophila hyalinata Banks	3
Rhyacophila lobifera Betten	1
Rhyacophila pellisa Ross	3
Rhyacophila verrula Milne	3
Hemiptera	
Corixidae	1, 2
Gerridae	1, 2
Mesoveliidae	1, 2
Saldidae	1
Belostomatidae	1
Odonata	
Coenagrionidae	1, 2
Aeshnidae	1
Aeshna palmata Hagen	*
Corduliidae	
Somatochlora semicircularis Selys	*
Megaloptera	
Sialidae	
Sialis sp.	1
Crustacea	
Cladocera	
Daphnia sp.	1
Amphipoda	
Gammarus sp.	1, 2
Hyallella azteca (Saussure)	2
Isopoda	
Asellus tomalensis Harford	1
Hydracarina	
Atractides sp.	1, 2
Calonyx sp.	8
Eylais sp.	8
Hydryphantes sp.	8
Hygrobates sp.	8
Laminipes sp.	8
Lebertia sp.	8
Limnesia sp.	8
Megapus sp.	8
Panisus sp.	8
Piona sp.	8
Sperchon sp.	8
Testudacarus sp.	8
Oligochaeta	1, 2
Hirudinea	2
Cystobranchus verrilli Meyer	1
Dina dubia Moore and Meyer	1
Dina parva Moore	1
Eropbdella punctata (Leidy)	1
Helobdella stagnalis (Linnaeus)	1
Nephelopsis obscura Verrill	1

Turbellaria	1, 2
Polycelis sp.	**
Nematoda	1, 2
Mollusca	
Physdae	
Physa sp.	1
Planorbidae	
Gyraulus sp.	1
Lymnaeidae	
Lymnaea sp.	1
Bulimidae	
Fluminicola sp.	1
Ancylidae	
Ferrissia sp.	1
Sphaeriidae	
Sphaerium sp.	1, 2

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**Braithwaite, 1962.

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A RECORD OF AN INDIGO BUNTING AND A WINTERING SAY'S PHOEBE FOR NORTHERN UTAH

Gary L. Worthen[1]

ABSTRACT.— A male indigo bunting (*Passerina cyanea*) and a female Say's pheobe (*Sayornis saya*) were taken at Salt Lake City, Utah on 20 May 1966 and 2 February 1966, respectively. Both birds are the northernmost records for Utah in the season in which they were taken.

On 20 May 1966 a freshly killed male Indigo Bunting (*Passerina cyanea*) was found dead near the Union Building on the University of Utah campus (4720 feet elevation), Salt Lake County, Utah. The bird was found beneath some large windows, into one of which it had apparently flown. The bunting seemed otherwise in good physical condition, weighed 17.6 grams, had no fat, and had testes that measured 8x6 mm.

Indigo Buntings are considered to be rare but regular summer residents in extreme southwestern Utah (Woodbury, et al., 1949; Wauer, et al., 1965), but this account furnishes the first specimen record of this species for northern Utah.

On 2 February 1966 a female adult Say's phoebe (*Sayornis saya*) was taken from a night roost in a small shack at the abandoned Saltair Resort on the shore of the Great Salt Lake, 17 miles west of Salt Lake City (4211 feet elevation), Salt Lake County, Utah (lat. 40° 47'N, long. 112°10'W). The bird was heavy in fat, weighed 19.55 grams, and was in apparently good condition except for the total absence of the flight feathers of the tail. The loss of the tail was apparently recent, as there was no indication of new feather growth in the area. The bird was measured and compared to measurements given by Bishop (1900), and would on that basis be assignable to *Sayornis saya yukonensis*.

The bird's crop was empty, but the gizzard had a small amount of unidentifiable food in it (.69 grams including the grit). Judging by the bird's apparent good health, heavy fat layer, and gizzard contents, it might be assumed that the bird was finding adequate food despite the rigorous Utah winter.

Woodbury, et al. (1949) list the Say's phoebe as a casual winter resident, with records from only central and southern Utah, and it is believed that this account constitutes the first wintering record for this species for northern Utah. Both of the above specimens are located in the University of Utah Museum of Vertebrate Zoology.

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COMMENTS ON TWO NAMES IN AN EARLY UTAH FLORA

James L. Reveal[1]

ABSTRACT.— Two new varieties described by Durand in 1859 from the Great Salt Lake area of northern Utah are discussed. One, *Erysimum asperum* var. *purshii*, is the oldest available name for the western United States variant of the species, while the second name, *Acerates decumbens* var. *erecta*, is a synonym of *Asclepias asperula*. Neither name has been included in botanical reference works nor in monographic studies. One new combination, *Erysimum asperum* var. *amoenum*, is proposed for the orange-flowered phase of the species found in southern Colorado and Utah.

In 1859, Elias Durand of the Academy of Natural Sciences of Philadelphia published an article entitled "A sketch of the botany of the basin of the Great Salt Lake of Utah," in which he summarized the flora based on collections made by John C. Frémont (1843 and 1845), Howard Stansbury (1849 and 1850), and Edwin O. Beckwith (1854), all associated with various expeditions sponsored by the United States government, and Mrs. Jane Carrington of Salt Lake City. Little is known about Carrington. Her collections were delivered to Durand by Colonel Thomas L. Kane, and Durand alludes to her as a "Mormon lady" in an unpublished catalogue of his plant collection; I have been unable to add more than the 1857 date when she obtained her plants (Reveal, 1972). Since she was the first woman botanist (or at least plant collector) in Utah, it is hoped that historians will discover more about this person.

While in Paris recently, I had an opportunity to review Carrington's collections deposited in the Durand Herbarium at the Muséum National d'Histoire Naturelle, Laboratoire de Phanérogamie. While time did not permit a full investigation of the 59 species attributed to her by Durand, two specimens representing new entities were studied.

Erysimum asperum (Nutt.) DC. var. *purshii* Durand, Trans. Amer. Philos. Soc. II, 11:159. 1859. Durand states: "The very same form as Pursh's specimen in herbarium of Phila. Acad. of Nat. Sci. Stems simple, several from the same root, smaller than the preceding [sic., alluding to var. *asperum*], scarcely 1 foot high, few-flowered; radical leaves entire, or nearly so; siliques 1½-2 inches long."

LECTOTYPE: UTAH: Salt Lake Co.: Near the Great Salt Lake, Salt Lake Valley, June 1857, *Carrington s.n.* Holotype, P!

The Pursh collection, cited above, is also in the Durand Herbarium, but without data. It seems wise to select the Carrington specimen as the lectotype although the description could equally apply to either collection.

Erysimum asperum is a widespread and highly variable species that is composed of several weakly defined varieties. The type of the

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species comes from the Great Plains and has more or less spreading fruits. The western United States material with yellow flowers and erect fruits should be called var. *purshii.* Hitchcock (1964) was unable to determine which name should be applied to this phase, being unaware of Durand's publication. In most western floras, this phase has been called *E. capitatum* (Dougl. ex Hook.) Greene, although Welsh et al. (1965) call this plant simply *E. asperum.*

Those specimens with orangish or reddish flowers from the southern Rocky Mountains and high mountains of Utah should be called *E. asperum* var. *amoenum* (Greene) Reveal, comb. & stat. nov., based on *Cheiranthus nivalis* var. *amoenus* Greene, Pittonia 3:137. 1896. Holmgren (1959) and Welsh et al. (1965) have called this phase *E. wheeleri* Rothr. Similar plants occur sporadically in the Pacific Northwest but appear to represent another kind as yet undescribed (Hitchcock, 1964), while those of the southern Coast Range of California are called *E. asperum* var. *stellatum* J. T. Howell.

Acerates decumbens (Nutt.) Dcne. in DC. var. *erecta* Durand, Trans. Amer. Philos. Soc. II, 11:174. 1859. Durand states: "Stem erect, 3 feet high. Leaves scattered, sometimes verticilate in threes, ovate-lanceolate, 4-5 inches long and 1 broad, shortly petiolate. Umbel terminal solitary, globose, 2½-3 inches in breadth; pedicels pubescent; calyx and corolla green, crown deep purple."

TYPE: UTAH: Salt Lake Co.: Salt Lake City, 1857, *Carrington s.n.* Holotype, P!

This variety is a synonym of *Asclepias asperula* (Dcne in DC.) Woodson var. *asperula,* a common species which occurs in the central United States and northern Mexico. Woodson did not account for this name in his monograph of *Asclepias* (Woodson, 1954).

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NEARCTIC DESERT SAND DUNE ORTHOPTERA
PART XIV. A NEW *EREMOPEDES* (DECTICIDAE)

Ernest R. Tinkham[1]

Abstract.— A new species, *Eremopedes kelsoensis*, is described from the Kelso Sand Dunes, San Bernardino Co., California, with notes on its biology, song, host plants, desert distribution, orthopteran associates, and a key to species in the genus.

The genus *Eremopedes* is one of the best defined of the various eremophilous genera of our Southwestern Decticidae. The genotype *E. Scudderi* Cockerell is largely confined to the Coahuila Desert, one of three eremological components of the Great Chihuahuan Desert; the other two being the northern Pecos and the extreme southeastern Salado deserts. *E. covilleae* Hebard is known only from the type locality about 4-5 miles SE of Persimmon Gap in the Coahuila Desert, not nine miles S of the park entrance as assumed by Rentz and Birchim. *E. shrevei* Tinkham is known only from the type locality in the Salado Desert. *E. bilineatus* (Thomas) is widespread in southeastern Arizona and southern New Mexico; *E. balli* inhabits the pine zone in the mountains of Arizona and New Mexico. *E. pallidus* Tinkham, originally described as a variety of *E. balli*, inhabits sand dune areas of the Painted Desert, one of four eremological components of the Great Basin Desert. The giant *E. ephippiatus sonorensis* Tinkham inhabits the Hermosillo Desert, the southernmost of seven eremological components of the Great Sonoran Desert.

The new species herein described is largely confined to certain xeric dune areas and their sparse vegetation in the Lahontan Desert, the westernmost member of the Great Basin Desert.

Eremopedes is easily recognized by the long barrel of the pronotum, with its well-developed lateral lobes, and by the characteristic cerci of the males which demonstrate two types: in *scudderi*, *bilineatus*, *shrevei*, *covilleae*, and the new species the cercus is long and slender, somewhat undulate with median internal tooth; in *balli*, *pallidus*, *ephippiatus* and *e. sonorensis* the male cercus is much shorter and heavier. The status of *E. spinosa* Hebard remains to be determined.

Key to the Species of *Eremopedes*

1. Cerci slender, elongate, somewhat undulate, with internal median subapical prominence and tooth; metazonal lobes pale 2

   Cerci short, heavy, rather quadrate, with internal, subapical tooth; metazonal lobes black 6

2. Color green or gray; size large to small; form slender,

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with white dorso-lateral stripe running length of pronotum and body 3
Color green or gray; size medium, form heavier; dorsolateral stripe, if present, confined to abdomen 4

3. Size large; Sahuaro Desert .... *bilineatus*
Size small; Great Basin Desert .... *kelsoensis*

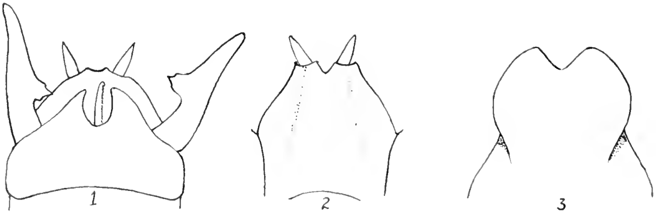
4. Dorsolateral lobes of pronotum with marginal areas pale; metazona concolorous with prozona 5
Dorsolateral lobes of pronotum with pale arcuate area; metazona broadly buff in color; Coahuila Desert .... *covilleae*

5. Size medium; penultimate abdominal notite very deeply notched; Coahuila Desert .... *scudderi*
Size small; grayish; posterior penultimate notite shallowly notched; Salado Desert .... *shrevei*

6. Size very large; Hermosillo Desert .... *e. sonorensis*
Size medium to small 7

7. Outer pagina of caudal femora unmarked; Painted Desert .... *pallidus*
Outer pagina of caudal femora with two black longitudinal stripes 8

8. Cerci of male as broad as long; Oak Zone .... *e. ephippiatus*
Cerci more slender; Pine Zone .... *balli*



Figs. 1-3. *Eremopedes kelsoensis*, n. sp.: 1, dorsal view of terminalia of male holotype showing penultimate abdominal tergite with U-shaped notch, cerci, left titillator, and cerci of subgenital plate; 2, ventral view of subgenital plate of male holotype; 3, ventral view of subgenital plate of female allotype.

Eremopedes kelsoensis, n. sp.

Comparison: *E. kelsoensis* is most closely related to the much larger *bilineatus* and is entirely confined to desert regions west of the Colorado River, whereas *E. bilineatus* is restricted to desert regions east of the Colorado River. There is no area of contiguity or intergrade. Relationships with the other species are clearly expressed in the Key.

DESCRIPTION.— Male holotype: Size small, slender, typical of more slender element of *Eremopedes*. Face typical of genus. Pronotum almost twice as long as broad; fore margin almost squarely truncate and very slightly emarginate; posterior margin almost squarely truncate; lateral lobes of pronotum fairly deep, especially at prozonal lobe; shallower in metazonal lobe area, ventral margin showing a very slight emargination immediately above oval tympanum which lacks hairy margin.

Abdominal penultimate notite bearing a moderate U-shaped emargination, but much shallower than very deep V-shaped emargination of *bilineatus*. Cerci slender, quite elongate, outer margin slightly undulate, inner margin bearing an internal, median, subapical prominence tipped with a minute tooth. Subgenital plate narrow, keeled, with a deep U-shaped median notch on posterior margin. Titillators straight, slightly spathulate with a row of retrose teeth on exterior margin.

Leg spination: Fore legs with long procoxal spine; fore femora unarmed; fore tibiae with ventral keels bearing six pairs of long aciculate spines (two pairs in basal half, four pairs in apical half), and outer dorsal ridge with basal spine on apical portion of synchronometer, the other two, one medianly and one apical. Mesotibiae with six pairs of ventral spines and four internal and two external dorsal spines widely and irregularly distributed. Caudal femora with externoinferior keel unarmed; internoinferior keel with six widely spaced small teeth in apical two-thirds. Caudal tibiae with 20-22 spines on ventral keels and six pairs of dispersed dorsal spines.

Living coloration: General coloration pale viridian. Head with entire face, antennal scrobes, and fastigium viridian; cheeks very pale green, occiput same palely tinged with very pale orange. Pronotum with median dorsal area dark green, outwardly edged with rusty orange; dorsolateral area nacreous white; dorsolateral lobar area deep green; prozonal margin nacreous, metazonal area rusty brown; meso- and metathoracic areas green. Abdominal notites deep green, with nacreous dorso-lateral stripe having both margins edged irregularly with rusty red. Sternites viridian; ventrolateral areas nacreous. Fore and middle legs greenish with some pale reddish tinge dorsally. Caudal legs with femora largely green, sulcus ventrally tinged with very pale red; tibiae pale viridian. Tegmina pale reddish brown.

Female allotype: Closely similar to holotype in body size and coloration; fore and middle legs with spination as in holotype. Caudal femora with only one spine on inner ventral keel. Caudal tibiae with 24-26 ventral teeth on each keel; 5-6 widely spaced dorsal teeth. Ovipositor long, exceeding the length of the body and slightly recurved in the apical three-quarters. Subgenital plate circular in outline with an open V-shaped median notch on the posterior margin.

TYPE MATERIAL.—Male holotype: Kelso Dunes, 10, 11-VI-1958, nymph which became adult 1-VIII, Creosote margin of dunes, E. R.

Tinkham. Calipered measurements in mm: body length 21.1; pronotum 5.8 x 4.8 max. breadth; exposed tegmina 3.0; caudal femora 19.8 x 2.5; cerci 2.1. Type in the Tinkham Eremological Collection.

Female holotype: Dunes on north side of Owens dry lake, Owens Valley, California (several miles west of Keeler), 26-VIII-1957; on *Suaeda torreyana*, night collecting, E. R. Tinkham. Calipered measurements in mm: total length to tip of ovipositor 43.2; ovipositor 25.1 x 1.4; body length 19.8; caudal femora 20.8 x 2.5. Allotype in the Tinkham Eremological Collection.

Male paratypes: 1 ♂, Kelso Dunes, San Bernardino County, 17-X-1970, on *Hymenoclea* in sand dune arroyo; 1, Kelso Dunes in Creosote margin, 11-VI-1958, 2, N side Owens Lake dunes, 26-VIII-1957, on *Suaeda;* 2, 1-2 miles W of Tonopah Dunes in Big Smokey Valley about 15 miles NW Tonopah, 19-IX-1957. All collected by E. R. Tinkham. 1, Adelante, 28-VIII-1957, Theodore Cohn.

Paratype males closely similar to holotype; size smallest from Adelante, Owens Lake, and Tonopah, maximum size from Kelso Dunes. Coloration closely similar except in Adelante male, which is dark greenish gray in coloration.

Calipered range measurements in mm: body length 16.3-21.5; pronotum 5.2-5.8 x 3.9-4.4; caudal femora 18.7-20.8.

Female paratypes: 3 same data as the allotype. Coloration same as in allotype. 2 subadults with shorter ovipositors. Calipered measurements in mm: adult, total length to apex of ovipositor 45.9; ovipositor 25.5, body length 23.0; pronotum 5.8 x 5.1; caudal femora 22.2. Eclosure of one subadult imperfect due to confinement. 1 female subadult: total length to tip of ovipositor 40.0 mm; ovipositor 21.1 mm and straight; body length 20.2 mm; pronotum 5.6 x 4.8 mm; caudal femora 22.3 mm.

Habitat.—At the Kelso Dunes *E. kelsoensis* inhabits the creosote margin, in good wet years, where also *Croton californicum*, *Rumex hymenelytra*, clumps of *Petalonyx Thurberi*, *Hilaria rigida*, and a stiff silvery *Gilia* sp. are always present. In good years *Oenothera deltoides*, *primaverens*, *Gilia aurea decora*, *Baileya pauciradiata*, and many other flowers are present. The arroyo that cuts a deep valley through the towering dunes is dominated by *Larrea divaricata*, *Acacia Greggii*, *Hymenoclea salsola*, *Opuntia echinocarpa*, *O. ramossimima*, *Haplopappus acradenius*, and other plants.

On the north side of dry Owens Lake, representing the Lahontan Desert, the principal dominants on the dunes are *Atriplex confertifolia*, *A. canescens*, *Sarcobatus vermiculatus*, *Suaeda Torreyanna*, *Artemesia tridentata*, *Franseria dumosa*, *Dalea polyadenia*, and *Distichlis* sp. One dune had a spring flowing out of the top of it, well surrounded by tules and other water-loving plants. On the west side of the towering Tonopah Dunes in Big Smokey Valley, about 15 miles NW of Tonopah, Nevada, the habitat ranged 1-3 miles west of the dunes which carried a stunted vegetation of *Atriplex spinifera*, *Coldenia plicata*, *A. canescens*, *Dalea polyadenia*, and perhaps other rarer plants growing on the sandy soil.

Figs. 4-5. *Eremopedes kelsoensis*, n. sp. Female allotype: 4, dorsolateral aspect; 5, dorsal aspect.

Eremography.— The Tonopah and Owens Lake dunes (north and west sides) lie within the periphery of the Lahontan Desert, the westernmost component of the Great Basin Desert. This desert is dominated by halophilous species of *Atriplex* in the saline valley bottoms and by *Artemesia tridentata* on the flanks or bajadas of the valleys. The Great Sonoras Desert is dominated by *Larrea divaricata* with its associated subdominants. The Kelso Dunes lying within the confines of the Gila Desert show many more northern elements, probably due to their elevation, which ranges between 2400 and 3100 feet, and their very cold winters, which undoubtedly make it possible for this northern element to exist at a more southern latitude. Thus the Tenebrionids, such as *Lariverius*, *Trogloderus*, and *Eusattus*, as well as *Ammcbaenetes* and *Eremopedes kelsoensis* and perhaps others, are examples of this eremographic picture.

Host plants.—At the Kelso Dunes, *Hymenoclea salsola* was the host plant, but it is not known which plant serves as the host plant in the creosote margin. At the north side of the Owens Lake dunes *Suaeda Torreyana* was the host, but elsewhere the host plant is not known.

Biology.— It is very evident that due to the severe winters of its environment *E. kelsoensis* must hatch from the over-wintered egg in the spring; its time of hatching varying with the character of the spring and with the moisture in the soil or sand. The first specimen captured at the Kelso Dunes on 10-11 June 1957, was a male nymph which became adult on 1 August 1957. This species was discovered during the first of four summers of study supported by the National Science Foundation, to which the author is most indebted. The time of adulthood would also depend on the time of the adventitious rains, if they do arrive, the emergence ranging anywhere from August into early October.

On 26 August 1957, at 10:30 p.m., the writer captured a pair that had just mated in a *Suaeda* bush at the north Owens Lake dunes; the male was still in the bush and the female was feeding on the spermothecal sac. In 1970 the rains came late, and although they did not touch the Kelso Dunes, heavy rains in the Granite and Providence mountains to the east sent a big arroyo down through the dunes for the first time in 15 years. This event accounted for the discovery of the two males on 17 October on *Hymenoclea salsola* after long and diligent searching.

Song.—the song is a soft and continuous "zee" characteristic of the genus *Eremopedes*.

Orthopteran associates.— At the Tonopah location the only associate was *Coniana snowi*, which is very rare in this xeric habitat. At the Owens Lake dunes *Anconia integra*, *Eremiacris*, *Ligurotettix coquilletti*, *Derotmema*, and *Aeoloplus* were the acridids and the tettigoniids were the new species and *Anoplodusa arizonensis*, the latter being the first of this rare decticid reported for Owens Valley, which is the Zoogeographical Center of this family. At the Kelso Dunes the associates were more numerous: Acridids were *Cibolacris*, *Tanaeocerus*, *Tytthotyle*, *Coniana*, *Eremiacris*, *Bootettix*, *Xeracris*, and *Trimerotropis p. pallidipennis*, although some of these have not been seen since the fifties. The tettigoniids were *Capnobotes fuliginosus*, *Anoplodusa arizonensis* (1954), and *Insara covilleae;* the rhaphidophorids were *Ammobaenetes* sp., *Macrobaenetes kelsoensis*, *Ammopelmatus kelsoensis*, and *Ceuthophilus fossor*.

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SEASONAL FOOD HABITS OF BARN OWLS IN UTAH

Dwight G. Smith,[1] Charles R. Wilson,[2] and Herbert H. Frost[2]

Abstact.— The food habits of a small colony of barn owls in central Utah were investigated from 30 January 1969 to 30 January 1970 to determine seasonal trends in prey species composition and abundance. An analysis of 783 pellets yielded 1845 prey individuals, of which mammals, primarily *Microtus*, were the most abundant during all seasons of the year. A wide variety of avian prey species revealed an opportunistic aspect of barn owl prey selection.

A majority of the numerous studies of barn owl (*Tyto alba*) food habits were determined from sporadic pellet collections deposited by an unknown number of owls over an indefinite period of time. Several exceptions include the investigations of the daily and seasonal food of barn owls in Davis, California (Evans and Emlen, 1947), the report of seasonal food habits of barn owls from 14 locales in England and Wales (Glue, 1967), the analysis of annual changes in the diet of barn owls in France (Saint Girons, 1968), and a long term study of the food habits of this owl in Germany (Uttendorfer, 1952). Our objective was to determine the seasonal food habits of a small colony of barn owls in central Utah. Prior to this study the barn owl was considered to be an uncommon permanent resident in Utah, and there was little information on its feeding ecology and economic status from this part of the Great Basin.

The colony was in the abandoned Ironton Steel Mill near Springville, Utah Co., Utah—a complex of 60 major brick and steel structures on approximately 500 acres of land. The colony numbered 26 individuals in the winter of 1968 but had increased to 38 individuals by late June 1969. From July 1969 through January 1970 the colony declined to 10 individuals. Large numbers of pigeons (*Columba livia*), starlings (*Sturnus vulgaris*), and house sparrows (*Passer domesticus*) also used the mill. The barn owls hunted within the steel mill complex and in adjacent habitats. Although the interior of the steel mill was largely devoid of vegetation, the adjacent habitats included extensive cattail (*Typha* sp.) marshes, cheat grass (*Bromus tectorum*) fields, and several shallow ponds. On the basis of 750 trap nights the most common small mammals within these habitats included meadow mice (*Microtus pennsylvanicus*), deer mice (*Peromyscus maniculatus*), house mice (*Mus musculus*), and vagrant shrews (*Sorex vagrans*).

Methods

The food habits of the barn owls were determined from pellet collections—the most practicable method, despite necessary limitations, for accumulating massive data on the food habits of nocturnal raptors (Errington, 1967; Southern, 1969). Pellets were collected

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biweekly from beneath the roosts of adult birds of the colony and separated into four time groupings, each representative of a seasonal period of barn owl activity and roughly corresponding with one of the four seasons. The spring period from 2 March to 1 June corresponded with the reproductive activities of the barn owl population; the summer period from 2 June to 1 September was characterized by the attentiveness of the adults to the newly fledged but still dependent young; the autumn period from 2 September to 1 December included the abandonment and subsequent dispersal of the majority of the young from the colony; and from 2 December through 1 March the remaining owls moved into well-protected winter residence structures.

Pellet analysis followed methods described by Marti (1969). Individual prey remains were identified by comparison with mammal and avian specimens of the Brigham Young University Life Sciences Museum natural history collections.

Pellet Deposition and Composition

Guérin (1928) reported that in France adult barn owls usually deposited two pellets per 24 hours. The first pellet is dropped about dawn on the hunting territory, while the second pellet is deposited at the roosting site before the owl resumes its hunting the following evening. We did not attempt to locate pellets dropped by the barn owls of Ironton on the hunting territory. At their roosting sites they deposited an average of one pellet per day during spring, summer, and early autumn, but this rate frequently declined during late autumn and winter. This decline in the winter pellet deposition rate correlated with severe weather conditions, and during several periods of snow cover and extreme cold no pellets were deposited for one to two days by one or more of the adult owls.

Spring and summer pellets were strikingly larger and averaged almost twice as many prey individuals per pellet than pellets found in autumn and winter (Table 1). In addition, summer pellets contained up to eight prey individuals per pellet compared to a maximum of five individuals per pellet from the autumn and winter pellets. The smallest pellets were found during rigorous winter conditions and usually contained but one prey individual. Errington

Table 1. Seasonal trends in pellet composition.

Season	No. Pellets Collected	Total No. Indv.	No. Indv. per Pellet	Range	Av. Dry Wt. of Pellets in grams*
Spring	346	889	2.6	1-7	10.6
Summer	198	509	2.6	1-8	9.1
Autumn	117	234	1.9	1-5	4.6
Winter	122	213	1.7	1-4	3.1
Totals	783	1845	Av. 2.2	Av. 1-6	

*Determined from 100 randomly selected pellets from each season, which were air dried for 10 days

(1931) and Stewart (1952) also noted a progressive decline in the size of the pellets deposited by barn owls during adverse climatic conditions and reported that several of their owls subsequently died of starvation. Although none of the barn owls of Ironton died during winter, it is probable that their populations in Utah and other more northern parts of their range may be limited by inherent food procurement difficulties during severe weather conditions.

Composition of Diet

There were 1845 prey individuals of 21 different species, including eight mammalian and 13 avian prey species (Table 2). On an annual basis, mammals comprised 90% of the total prey and were the most common prey of every season, although the frequency of their occurrence declined significantly during autumn ($x^2 = 35.8$, $P > 0.001$, $df = 3$). In contrast, the frequency of avian prey, while comprising only 10% on an annual basis, doubled during autumn.

Meadow mice were the most abundant mammalian prey species and appear to represent the single most important food item (81%) of the barn owls at Ironton. Other important mammal prey species included deer mice and house mice, but neither these nor any of the remaining mammal species comprised over 3% of the barn owl diet.

Only two avian species were present in pellets from every season: the starling, which was the second most common prey species, comprising 6.2% of the total annual prey; and the house sparrow, which comprised 2.4% of the total annual prey. Both species nested in Ironton and adjacent locales, and large flocks roosted within the buildings during the autumn and winter months. The frequency of their occurrence as prey rose signficantly during autumn ($x^2 = 16.9$, $P > 0.001$ and $x^2 = 23.4$, $P > 0.001$ for the starling and house sparrow respectively), coinciding with the sharp rise in their populations.

The majority of the other avian prey species were migrants taken infrequently. Especially large numbers of transient birds fed and roosted in the marshes and fields bordering Ironton, and the spring occurrence of a lesser yellowlegs (*Totanus flavipes*) and early autumn occurrence of bank swallows (*Riparia riparia*) and red-winged blackbirds (*Agelaius phoeniceus*) indicate that these migrants occasionally present suitable prey for barn owls. The occurrence of lesser yellowlegs and American coot (*Fulica americana*) reveals that barn owls may take larger birds, although these must approach the upper limits of the prey-size capabilities of the owls. Domestic pigeons were rarely found in the prey items, despite their abundance within the mill.

The American kestrel (*Falco sparverius*) prey individual was a recently fledged juvenile. Kestrels frequently perched in open, exposed locations during the late evening hours at the time when barn owls were initiating their nocturnal hunts; this individual was probably taken during this slight overlap in the activity periods of the two species. In contrast, essentially no overlap occurred during the

TABLE 2. Seasonal trends in number and occurrence of prey species of adult barn owls.

Prey species	Spring No.	Spring %	Summer No.	Summer %	Autumn No.	Autumn %	Winter No.	Winter %	Totals No.	Totals %
Microtus pennsylvanicus	753	84.7	426	83.6	152	65.0	171	80.0	1502	81.4
Phenacomys intermedius	9	1.0	9	1.8	13	5.6	2	0.9	33	1.8
Mus musculus	18	2.0	9	1.8	7	3.0	7	3.2	41	2.0
Sorex vagrans	8	0.9	4	0.8	4	1.7	2	0.9	18	1.0
Peromyscus maniculatus	18	2.0	22	4.3	8	3.4	6	3.0	54	2.9
Rattus norvegicus	1	0.1	1	0.2	3	1.3	2	0.9	7	0.4
Thomomys bottae	2	0.2	5	0.8	0	0.0	0	0.0	7	0.4
Sylvilagus auduboni	0	0.0	1	0.2	0	0.0	0	0.0	1	0.05
Total mammals	809	90.9	477	93.5	187	80.0	190	88.9	1663	90.0
Sturnus vulgaris	54	6.1	21	4.1	28	12.0	13	6.1	116	6.2
Passer domesticus	13	1.5	7	1.4	14	6.0	10	4.7	44	2.4
Columba livia	2	0.2	0	0.0	3	1.3	0	0.0	5	0.3
Agelaius phoeniceus	2	0.2	0	0.0	1	0.4	0	0.0	3	0.2
Falco sparverius	0	0.0	1	0.2	0	0.0	0	0.0	1	0.05
Molothrus ater	2	0.2	0	0.0	0	0.0	0	0.0	2	0.1
Fulica americana	2	0.2	0	0.0	0	0.0	0	0.0	2	0.1
Colaptes cafer	2	0.2	0	0.0	0	0.0	0	0.0	2	0.1
Totanus flavipes	1	0.1	0	0.0	0	0.0	0	0.0	1	0.05
Turdus migratorius	1	0.1	1	0.2	0	0.0	0	0.0	2	0.1
Riparia riparia	0	0.0	0	0.0	1	0.4	0	0.0	1	0.05
Colaptes auratus	1	0.1	1	0.2	0	0.0	0	0.0	2	0.1
Lophortyx californicus	0	0.0	1	0.2	0	0.0	0	0.0	1	0.05
Total birds	80	8.9	32	6.3	47	20.1	23	10.8	182	9.8
Grand Totals	889	99.8	509	99.8	234	100.1	213	99.7	1845	99.8

early morning hours because barn owls began roosting from one to three hours before kestrels were active.

In addition to the vertebrate prey species, some vegetable matter was recovered from the pellets. This material almost certainly represents the gut contents of the prey, and that which could be identified included fruits of Russian olive (*Elaeagnus angustifolia*) and seeds of various grasses (Graminae).

Discussion

The barn owls at Ironton were supported exclusively by the mammal and avian communities, despite the seasonal availability of large invertebrate (primarily Insecta) and amphibian populations. The year-round predominance of small rodents in their diet is in agreement with the findings of similar investigations from other areas of the range. This, coupled with the conspicuous lack of invertebrates in their spring and summer diets, indicates selective predation.

Within the limitations of their food habits, however, the barn owls at Ironton exhibited a considerable degree of opportunism. Hawbecker (1945) and Wallace (1948) noted that the owls of their respective studies tended to prey heavily on the most available animals of a community. Predation on the basis of availability is reflected in the present study by the high frequency of occurrence of *Microtus pennsylvanicus*, which was the most common mammal in the area.

The opportunism of barn owl predation is also revealed by both the variation in total number of prey species taken in the different seasons and the changes in seasonal frequency of several of the prey species. The largest variety of prey species were taken in the spring and summer months when transients and summer nesting birds greatly increased the potential prey available to the local barn owl population. In contrast, fewer different prey species were recorded from the decreased fauna of the autumn and winter months.

The changes in seasonal frequency of several of the prey species was also a function of their comparative exposure at different times of the year. This is shown by the autumn increase in the frequency of occurrence of starlings and house sparrows, whose increased autumn populations and preroosting flight behavior during the evening hours undoubtedly heightened their exposure to barn owl predation.

We conclude that the ability of the Ironton barn owls to effectively exploit the local prey populations was revealed by (1) their heavy utilization of the most abundant prey species, (2) their predation on additional species when available at specific times of the year, and (3) their response to local fluctuations of prey populations.

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GERMINATION OF *PINUS ARISTATA* ENGELM.

William H. Reid[1]

Abstract.— Seeds of *Pinus aristata* Engelm., bristlecone pine, from the type locality at the headwaters of Clear Creek in Colorado have a germination of 80 percent. Germination occurs within 10 days with or without vernalization. Scarified seeds are invaded by fungus and less than 10 percent germinate. Seedlings 10 and 180 days old do not survive exposure to -10C (14F) even when exposed to gradually decreasing temperatures to -4C (25F) for five weeks before treatment. Rapid germination, scarification mortality, and lack of cold hardness in seedlings work against the reproduction of bristlecone pine.

In a recent study of the *Pinus* subsection *Balfourianae* (the foxtail pines) Bailey (1970) described the eastern California and Nevada populations of *P. aristata* Engelm. as a new species, *P. longaeva* Bailey. A review of the literature shows that nearly all botanical work on *P. aristata* has used material from the far western populations now defined as a separate species. The Great Basin and Rocky Mountain populations—retained as *P. aristata*—remain virtually unstudied.

In Colorado, bristlecone pine occurs in rather small, pure, open stands scattered throughout the south central and southwestern parts of the state. The stands are found between 2500 meters (Cochetopa Pass) and 3700 meters (Cumberland Pass), most frequently on the gravelly soil of south- or west-facing slopes. This paper is part of an analysis of *P. aristata* from the type locality—the headwaters of Clear Creek in Colorado—and examines the germinability of the seed in an effort to understand the limited occurrence of this pine.

Seeds used in the study were collected from the north and east slopes of Mount Evans at an altitude of 3000 meters during October 1970. Germination tests were started during April 1971.

Seed Morphology.— The seed of *P. aristata* is typical of the genus *Pinus* (Martin and Barkley, 1961). The wing shows wavy, fingerprint-like lines. The testa has a mottled, dark brown surface and a papery brown nucellus. The length of the seeds with wings averages 16 mm. Seeds in a sample of 100 weighed an average of 24.5 mg with wings and 22.4 mg without wings.

One hundred seeds were opened; 88 had a firm, white endosperm and a pale yellow, well-defined embryo, with from 7 to 12 cotyledons. The 12 seeds without healthy embryos contained only a flake of dry tissue.

Imbibition.— Fifty seeds with wings removed were submerged in distilled water. At intervals they were removed, blotter dried, and weighed. Initial water uptake was rapid: 18 percent during the first hour. The weight gain continued at a reduced rate through germination (Fig. 1).

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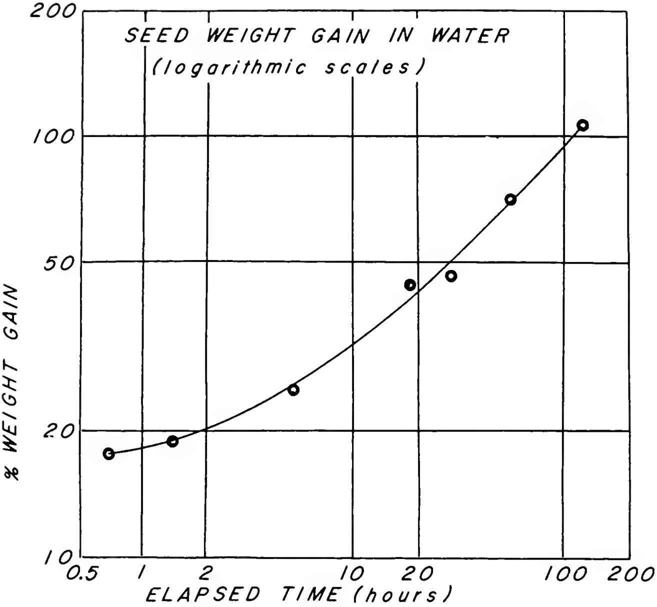

Fig. 1. Imbibition of *Pinus aristata*: percentage weight gain in water as a function of time since immersion.

Germination.— Forty seeds were placed on moist filter paper in petri dishes. Twenty were scarified by making a shallow 2-4 mm long cut on the flat side of the seeds. All of these scarified seeds were quickly invaded by fungus and none germinated. Of the 20 unscarified seeds, 15 (75 percent) germinated.

One hundred seeds were planted 10 mm deep in clay pots with four parts sand to one part peat moss. Of these, 80 were exposed to -10C (14F) for 100 hours prior to planting. Thirty-two of these were scarified as described above. All of the seeds had been collected in October and had, no doubt, been exposed to subfreezing temperatures prior to collection.

Germination occurred rapidly, with the first plants appearing during the 4th day, and no additional plants occurring after the 10th day. Of 20 planted as collected, 16 (80 percent) germinated. Of those vernalized but not scarified, 37 (77 percent) germinated, and only 3 (8 percent) vernalized and scarified seeds germinated. All of the seedlings not used for experiments were alive 60 days later.

Cold Hardness.— Four 14-day-old seedlings were exposed to -10C (14F) for 2 hours. All wilted and died. Six 180-day-old plants were placed in a growth chamber set for a 12 hour day, a day temperature of 13C (55F), and a night temperature of 7C (45F). Over a period of 14 days, the day temperature was reduced to 2C (36F). The day length was reduced to 9 hours. These temperatures were maintained for another 21 days.

Three of the pine seedlings were then put into a plastic bag to reduce dehydration and were placed in a freezer at -10C for 48 hours. The plants were then returned to the growth chamber and the temperature increased to 20C (68F). Those which had been in the freezer browned in 5 days and died.

Discussion.— The tests suggest the following:

1. *P. aristata* germinates rapidly with a high yield (ca. 80 percent);
2. less than 10 percent of the seeds will germinate if they have been scarified;
3. the seeds do not require long cold treatment prior to germination;
4. seedling bristlecone pine is sensitive to freezing and is killed by exposure to -10C (14F).

The seeds and seedlings of *P. aristata* do not appear to be well adapted to the climate found in their habitat in Colorado. At tree line, frost and snow can occur any month of the year. In the fall, severe storms followed by warm weather and a thaw are frequent, and the spring is often an irregular series of sunny days and heavy snows lasting into June (Marr, 1961). All of these factors work against the successful reproduction of this pine. The rapid germination must cause the death of many seedlings after thaws, and those growing in temporarily moist locations must often desiccate and die. In spite of these disadvantages, *P. aristata*, a pine that lives as much as 800 years in Colorado, has survived without morphological change in this area since the Miocene (Bailey, 1970).

Acknowledgments.— I would like to thank Dr. J. Bock for assistance in this study, and K. R. Sullivan for making extensive seed collections.

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SPECIAL NOTICE

NOTICE OF A NEW REPORT, ENTITLED "SYSTEMATICS COLLECTIONS: A NATIONAL PLAN . . ."

Draft copies of a Report entitled "Systematics Collections: A National Plan . . ." will be available at no charge *until 31 January 1973* from Philip S. Humphrey, Interim Secretary, Association of Systematics Collections, Museum of Natural History, University of Kansas, Lawrence, Kansas 66044.

The draft Report soon to be available, represents the combined efforts of a great many systematists over a period of more than a year and takes into account the many constructive and thoughtful comments stimulated by the Symposium on "Systematic Biology—The Development of a National Program on Resources and Resource Management" held at the National Academy of Sciences in July 1972. Following the Symposium in late September, a Writing Conference was held at the Belmont Estate, chaired by representatives of the Association of Systematics Collections, with generous support from the Smithsonian Institution. The 24 members of the "Belmont Writing Conference," all of them systematic biologists, were unanimous in their feeling that the systematic community and other communities of "users" of systematcs collections and associated resources should have an opportunity to review the Report and comment on it before its final publication and distribution, whch is now scheduled for March 1973.

The Report presents a "Natonal Plan" for making systematics collections and their associated resources a more effective national resource, better able to serve the needs of systematic biologists and those agencies of society which depend on systematic information in seeking solutions to various biomedical, environmental, agricultural, and other problems. The "Natonal Plan" presented in the draft Report is an important first step which, hopefully, will lead soon to solutions to some of the most basic problems which have been plaguing systematics collections and their associated resources for a great many years.

The editors responsible for preparing the Report for publication, will be doing so during the latter part of February 1973. It is hoped that all those interested in systematics collections and the services they provide will take the opportunity to read the Report in its draft form and provide the editors with thoughtful and constructive comments, all of which will be considered by the editors in their efforts to make the Report a more effective instrument for the communities it is designed to serve. J. C. Dickinson, Interim President, Association of Systematic Collections.

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