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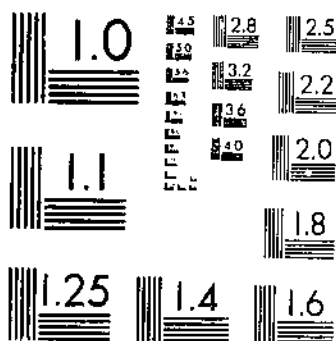
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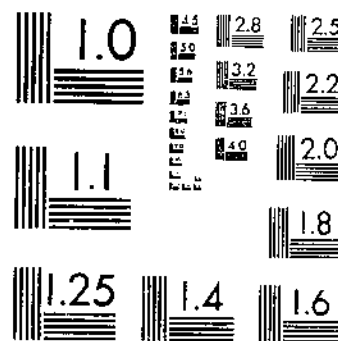
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THE LEPTOCONOPS KERTESZI COMPLEX IN NORTH AMERICA (DIPTERA
CLASIRIER, J. WIRTH, N. W. 1 OF 1

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MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A



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**THE LEPTOCONOPS
KERTESZI COMPLEX
IN NORTH AMERICA
(DIPTERA:
CERATOPOGONIDAE)**

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THE LEPTOCONOPS KERTESZI COMPLEX IN NORTH AMERICA (Diptera: Ceratopogonidae)

By J. CLASTRIER and WILLIS W. WIRTH¹

Biting midges of the genus *Leptoconops* Skuse, commonly referred to in the Western United States as "black gnats" (Smith and Lowe, 1948), are often extremely annoying bloodsucking pests in coastal or desert regions. The immature stages have been found usually in wet soil in depressions near lakes, ponds, streams, springs, or coastal lagoons, generally under conditions of considerable alkalinity or salinity.

Originally described from Egypt, the species *Leptoconops (Holoconops) kerteszi* Kieffer (1908) has since been reported from many different regions in the Northern Hemisphere, proceeding from east to west: Inner Mongolia (Okada, 1954), Egypt (Kieffer, 1908; Carter, 1921; Austen, 1921; Macfie, 1948), Sudan (Macfie, 1947), northern Chad (Clastrier et al., 1961), Tunisia (Carter, loc. cit.; Rioux et al., 1964), Algeria (Austen, loc. cit.), Italy (Coluzzi, 1967; Bettini and Finizo, 1968; Bettini et al., 1969a, 1969b, 1969c; Majori et al., 1970, 1971), France (Harant and Brunel, 1950; Rioux and Descous, 1965; Clastrier, 1972), and the United States (Carter, loc. cit.; Essig, 1926; Thorpe, 1931; Freeborn and Zimmerman, 1934; Rees and Smith, 1950; Knowlton and Kardos, 1951; Wirth, 1951, 1952; Bacon, 1953; Curtis, 1957; Ryckman, 1961; Jones, 1961; Foulk, 1968, 1969; Rees et al., 1969, 1970, 1971; Rees and Winget, 1970; Wirth and Atchley, 1973). This species has also been reported in the Southern Hemi-

sphere in South Africa (de Meillon and Hardy, 1953; Howell, 1970).

The use of new morphological characters in both males and females recently permitted the recognition, from those that had been confused under the name of *L. kerteszi*, of three distinct new species of the subgenus *Holoconops* from southern France (Clastrier, 1973) and eight other species from North Africa (Clastrier, 1973, 1974b, 1975a, 1975b). For these last eight, two names were restored (*L. laurae* (Weiss, 1912) and *L. peneti* (Langeron, 1913)) and six other species were described as new species.

Using the same characters associated with new criteria, we have been able to recognize 11 species that had gone under the name of *L. kerteszi* in North America. Of these, one previously known species, *L. kerteszi* var. *americanus*, described from Salt Lake, Utah, by Carter in 1921, is here restored. Freeborn and Zimmerman (1934) regarded *L. americanus* as a synonym of *L. kerteszi*, and subsequent American taxonomists, including Wirth and Atchley (1973), followed their synonymy. The 10 other species are new and described here. Although the true *L. kerteszi* is almost certainly excluded from the North American fauna, the complex of species that bears this name is here termed by custom, but without doubt improperly, the "*kerteszi* complex."

The 11 American species fall in 3 taxonomic groups, which are characterized in this bulletin. In each of these groups there is one or more common and widespread species, along with several species of restricted distribution, as shown on the maps (figs. 23-25). The evolutionary significance of this distributional pattern

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² The year in italic after authors' names refers to Literature Cited, p. 55.

may be of considerable interest, but until more data on the biology and breeding habitats of

each species have been assembled, any comments on this subject would be highly speculative.

GENERAL CHARACTERS OF SUBGENUS HOLOCONOPS

The general characters described here for this subgenus are based largely on the information given by Wirth and Atchley (1973) for the fauna of the Nearctic region and by Clastrier (1973, 1975a) for that of the Mediterranean subregion. Unless stated otherwise, the following characters are valid for all the species examined and will not be repeated in any of the specific descriptions.

Female and Male

Eyes.—Bare, widely separated, separation 0.37–0.40 of head width. *Vertex* with four setae in a row, which for convenience we named *supraorbital setae*. The base of these setae may be surrounded by a large, pale ring in the integument or is concolorous with the rest of the vertex. This character, which remains stable and useful for the separation of certain Old World species, is variable in the New World species and has not been used here. *Front* usually bare, except for the presence of one pair of setae in a single female, perhaps abnormal (see description of species C, p. 44, and fig. 22).

Antenna.—In the female (fig. 1) with 13 segments. The first three are of the form usually seen in the Ceratopogonidae, respectively, annular, cylindrical, and turbinate (top shaped). On the rest of the flagellum the segments are at first transverse, then progressively elongated to the 12th (XII), which is sometimes subglobular, globular, or longer than broad. XIII is elongated, about as long as the preceding 3 or 3½ segments combined. It is more often subcylindrical and very weakly narrowed in the midportion, pointed at the tip.

From III to XII each segment bears two hyaline *sensory setae* (*ss*) (fig. 1, *H*)—short and slender on III, strong and slightly curved on the distal segments, their length attaining or slightly surpassing that of the segment. These setae, which are diametrically opposed on III, progressively approach each other on the following segments in a proportion varying according to the species (fig. 1, *B*, *H*). They may nearly

touch each other on XII (fig. 1, *E*) and XI. In certain American species they are fused in a single hypertrophied seta (fig. 1, *C*), very rarely bifid at its extremity (fig. 1, *D*), situated in the middle of the space normally bounded by the pair of setae they represent. They have been observed on XIII in some Old World species. These setae permit the recognition on the antenna of two faces, internal (or mesal) and external (or lateral), whose respective dimensions are more and more unequally marked by the progressive shift in position of the sensory setae that limit them. When the sensory seta is unique, the external face becomes obsolete.

If this orientation concept is extended to the three segments devoid of sensory setae (I, II, XIII), the internal (*int*) or mesal face (fig. 1, *A*, *F*, *G*) of the antenna presents the following characters proceeding from the base to the apex: (1) On I there are one to five small setae without specific value, always present in *Holoconops* and also in the subgenus *Proleptoconops* Clastrier (1974b). (2) II is bare. (3) III bears three to four black setae, slender and rather short. (4) More generally the three following segments (IV–VI) bear black setae termed *basal setae* (*sba*) (fig. 1, *F*), of moderate length and thickness, numbering three or four on IV; extremely long and strong, numbering three, rarely four, on V; and a single one on VI (fig. 1, *F*). These setae are not strictly alike on a given segment, and in the following descriptions the appreciation of their length is always made in reference to their greater size. They may be specifically missing on VI (fig. 1, *G*) or the same on V and VI in certain Old World species.

For the American species the absence of the basal black seta VI has been observed in an occasional but not exceptional fashion on one or on both antennae of several specimens. This same basal black seta VI and the corresponding sensory seta present the peculiarity of permutation in most of the known species (Old and New World). In this case, sensory seta VI is located

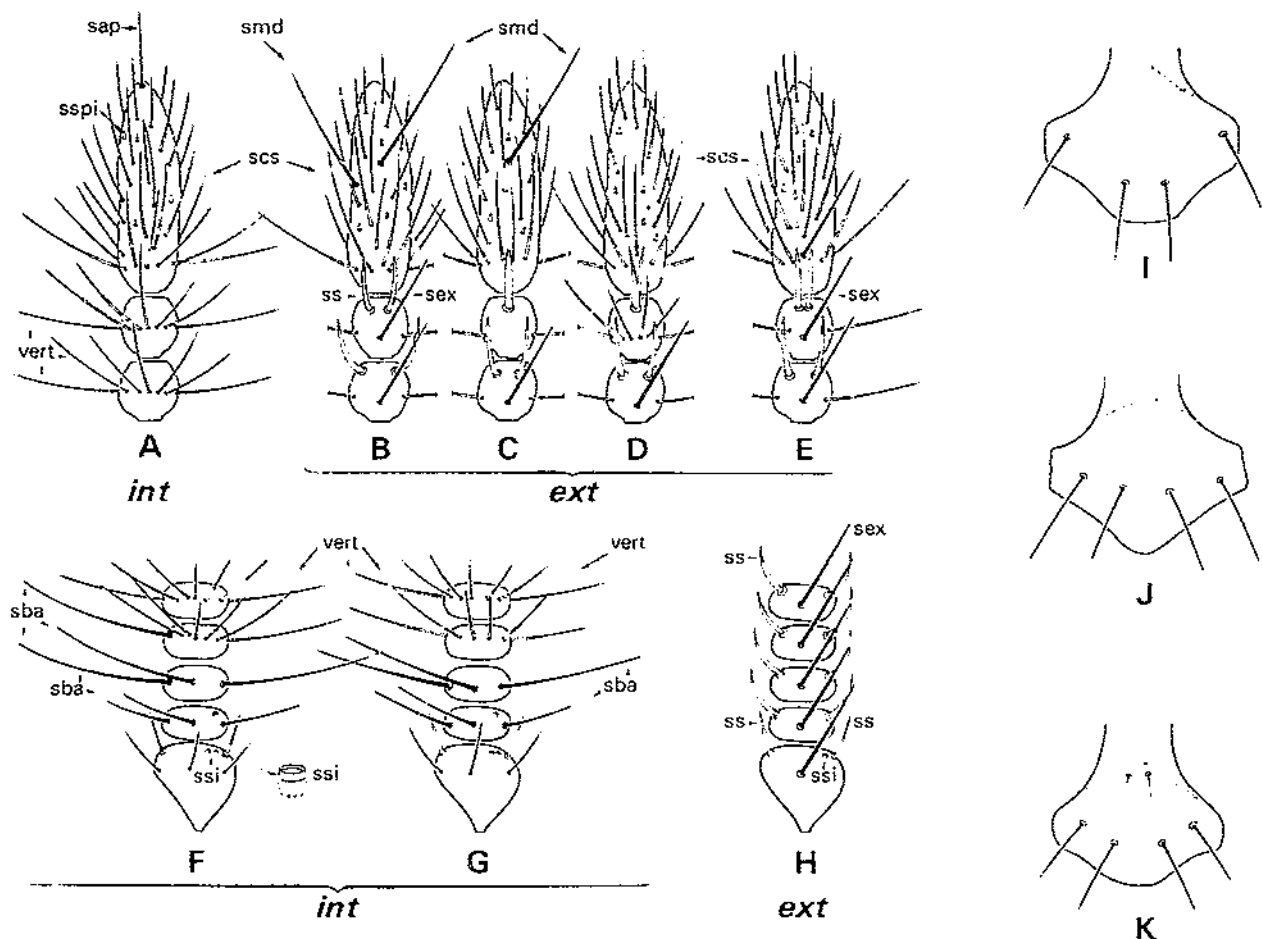


FIGURE 1.—*Leptoconops* (*Holoconops*) spp., female: Left, segments III-VII and XI-XIII of antenna, viewed from internal (*int*) and external (*ext*) faces; for A-K, see text. (*sap*, subapical black seta; *sba*, basal black seta; *ssc*, scattered setulae; *sex*, external black seta; *smd*, median black seta; *ss*, sensory setae; *ssi*, campaniform sensillum; *sspi*, minute sensory spinules; *vert*, verticils) Right, arrangement of four clypeal setae in *L. americanus* (I) and *L. whitselfi* (J) and six clypeal setae in *L. resi* (K).

between the hairs of the verticils and the basal black seta, which is itself displaced in an external position according to the previous definition (fig. 13, A). Although difficult to observe, this permutation is most often very distinct. Sometimes, however, it may appear incomplete; the sensory seta is found in the same axial plane as the basal black seta and distal to it. (5) From VI to XII each of the segments is provided with semi-verticils (*vert*) of colorless, hyaline hairs (fig. 1, A, F, G), whose number, length, and direction furnish excellent criteria in certain Mediterranean species, but they are nearly without value in the North American species (one or two hyaline hairs may equally be seen on V, more rarely on IV). (6) Segment XIII bears at the

base a semiverticil resembling the preceding, and at its tip is a *subapical black seta* (*sap*) (fig. 1, A).

On the external (*ext*) face (fig. 1, B-E, H): (1) I is bare. (2) On II, one or two very short and very slender setae, without specific value. (3) Beginning with III and on the following segments, a black seta termed *external seta* (*sex*) (fig. 1, H)—strong, stout, the length of which if flattened to the flagellum would reach or surpass the tip of the following segment (fig. 1, H). This seta is located proximad of the two sensory setae that delimit this face and at an equal distance from each of them. It may be doubled, rarely tripled, by one or two similar setae on one or several segments. This seta is

generally present up to XI (fig. 1, C, D,) or XII (fig. 1, B), with these variations less (X, IX), exceptionally more (XIII, fig. 1, E), until this seta is absent, the base of the segment remaining bare (fig. 1, C) or is occupied by some verticillar hairs (fig. 1, D). (4) XIII bears hyaline hairs basally, fewer in number than on the other face, that may be regularly aligned or disordered at different levels. This face may also bear at half its length black setae termed *median setae* (*smd*), whose interest is of primary importance because they permit the immediate separation of three distinct groups of species, according to whether they are two (fig. 1, B), one (fig. 1, C), or none (fig. 1, D, E).

Although some anomalies may now and then be observed, the risk of error appears minimal. The presence of a single, external black seta, unusual on XIII as we have just seen, might be another source of error, but the external seta is implanted basally at the level of the verticil of the other face (fig. 1, E) and is found at the same alinement as all the external black setae of the preceding segments, whereas the median black setae are implanted beyond the middle of the segment (fig. 1, B, C).

Finally all specimens examined have the following characters: (1) At the extremity of segment III, three *campaniform sensilla* (*ssi*) (fig. 1, F, H) situated on both sides of the sensory seta belonging to the series opposite the basal black seta on VI, numbering two on the internal face (fig. 1, F, G) and one on the external face (fig. 1, H). (2) One unique sensillum, similar to those preceding and similarly disposed, at the extremity of the internal face of IV (fig. 1, F, G). (3) Scattered setulae (*scs*) (fig. 1, A-E) and minute sensory spinules (*sspi*) (fig. 1, A) on the two faces of XIII. (4) Short pubescence on all the antenna (not shown in illustrations). None of these last features appears to be of any taxonomic value.

In the male, the first three segments of the antenna are, as in the female, respectively, annular, cylindrical, and top shaped with a long pedicel. The following segments are at first transverse, with the part situated beyond the verticils progressively and very slightly elongated up to X or XI; afterward the elongation is much more rapid and marked up to XV; the last segment is strongly clubbed. The respective pro-

portions of the segments, and particularly the last three, as well as the number and disposition of the hairs of the plume, are variable within species and do not have diagnostic value. The distribution of the pubescence, on the other hand, may be of some assistance. On all the specimens examined, pubescence is present on III, proximad of the insertion of the black hairs, as well as on XV beyond this insertion. These two sites are constant and will not be repeated in any of the specific descriptions as their presence is implied. We will report only the variations observed in certain species; they are, unfortunately, exceptional.

Palpus.—The first two segments are uniform among the species (female, male) and do not have specific value. In the female (fig. 5, C), segment III is somewhat expanded on one or several of its faces. It always bears a single *sensory pit*, well developed but with variable dimensions, often in the form of a truncated cone whose small base represents the opening. It contains numerous small sensory setae with globular heads that do not protrude outside the pore. The *sensory pore*, of variable diameter but always regularly rounded, is found in a site well defined anatomically. Although some individual variations are always possible, the shape of the third segment usually is constant for a given species. But, according to the manner in which the palpus is situated on the preparation or the angle from which it is seen, the aspect of the segment and of the sensory pit may vary and must be interpreted at the time of examination. To minimize this difficulty, the last two segments of the palpus are shown in the illustrations in the manner they would be shown on a head separated from the body and resting with its posterior face on the slide under conditions we consider normal. Moreover and whenever possible, segment III is shown under one or more different orientations. In some specimens the lateral (external) face is slightly depressed. As it is impossible to know whether this is a natural state or an artifact of mounting, such conditions are disregarded in the examination of the palpus.

In the male (fig. 6), when observed as previously, and in all the species studied, segment III is subcylindrical, slightly expanded from the base to the level of the sensory pit, more or less abruptly narrowed beyond, and cylindrical on

the remainder. The sensory pit, of small diameter and not very deep, opens in all its breadth on the internal face of the segment, where some sensory setae with globose heads are apparent. The slight variations are the location of the pit, which may be situated before or beyond the middle of the segment, and the respective lengths of segments III and IV.

Clypeus (fig. 1).—In the female and for most of the species examined, the clypeus bears four distal setae (two mesal and two lateral), whose location in a more or less transverse line is rather variable and of little importance except in *L. americanus*, where this is described; rarely one or another may be lacking or may be doubled by a similar supplementary seta. A small group of species is characterized by the presence of two additional short and slender setae at the base of the clypeus. In one of these species there is frequently associated a supplementary distolateral seta on each side. Numerous variations have been observed, and these basal setae may occasionally be absent. In spite of very poor conditions of observation, males of two species, corresponding to species whose females are provided with setae at the base of the clypeus, seem themselves to be without these setae. In this case, the clypeus in the male may present much less interest than in the female.

Mesonotum (fig. 2).—The number of setae situated laterally, between the margin of the mesonotum and the corresponding dorsolateral series (with the exclusion of the prescutellar setae), may furnish interesting information on certain species. These setae, respectively designated under the name anterolateral (*ant*) and posterolateral (*pst*) setae, according to whether they are situated immediately in front of or just behind the transverse suture, are counted separately on one side of the mesonotum. To express with a certain precision the amplitude and frequency of the variations observed, the counting of the anterolateral setae is generally given as a function of the different value of the posterolateral setae. If, for example, 8 anterior setae and 3 posterior setae were found 5 times, 11 anterior and 3 posterior were found 7 times, 9 anterior and 4 posterior were found 3 times, 10 anterior and 4 posterior setae were found 12 times, etc., the result would be written as follows, where the multiplicand indicates the number of

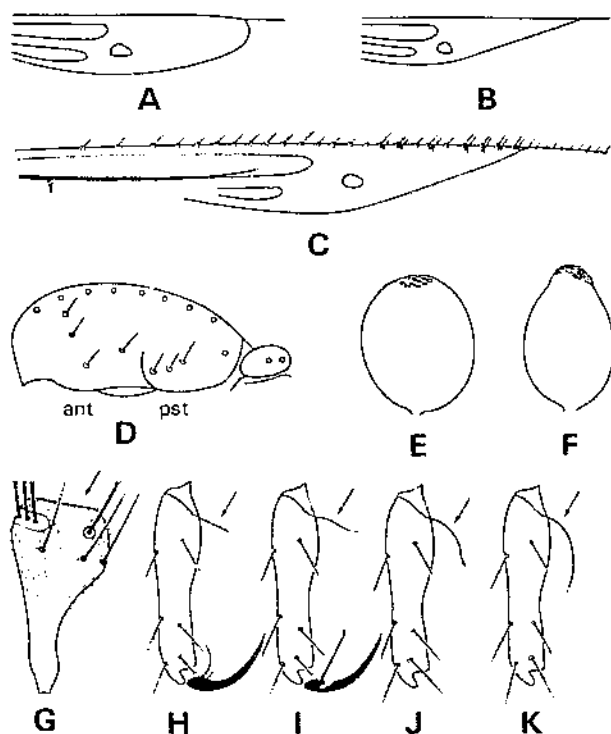


FIGURE 2.—*Leptoconops* (*Holoconops*) spp. Female: A, Wing stigma broad with tip rounded; B, triangular stigma with sharp-pointed tip; C, arrangement of setae of costa (numbering 31); D, mesonotal setae, anterolaterals (*ant*) and posterolaterals (*pst*), with formula (4+3); E, spermatheca with head regular and smooth without diverticulum; F, spermatheca with caplike diverticulum. Male: G, Antennal segment III with pubescent tip (*L. atchleyi*); H, basal seta (see arrows) of fifth tarsomere strictly erect; I, erect curved; J, doubly curved; K, decumbent; claw provided at base with curved seta as well as small rectilinear seta (H) or strong branch without accessory seta (I).

anterior setae and the multiplier the frequency of this number: For three posterior setae: (8)×5, (11)×7, etc.; for four posterior setae: (9)×3, (10)×12, etc.

When the specimens are few, the lateral setae are counted on both sides of the mesonotum to give a better picture of their distribution. If moreover all the combinations are different, they are reported in extenso; for example, where the preceding values would not be found more than once, they would be written (8+3), (11+3), (9+4), (10+4). These diverse elements then are tabulated for each group of species, or subgroups more narrowly defined, to permit comparisons and to judge their value as well. In

this case, the setae are not counted separately but together (anterior + posterior), giving the total number of lateral setae, although only one side of the mesonotum is concerned. For each of the 4 preceding combinations, the number would be, respectively, 11, 14, 13, 14. The lateral setae are more numerous in the female than in the male, but they vary in the same way for each sex.

Wing (fig. 2).—In the female, specific variations are very slight and almost totally without value in the Mediterranean species. In the American species the *stigma* represents an important taxonomic element. It may be broad, with the posterior margin convex and nearly parallel to the costa, and the distal extremity more or less broadly rounded; or it may be narrow, triangular, the posterior margin nearly rectilinear and directed straight toward the costa, with the distal extremity forming a very narrow angle with the costa. In the male, no difference has been noted among species in the general shape of the wing.

The number of setae borne by the costa appears to provide in the two sexes certain indications of concordance or divergence. In the female they are implanted in a single series up to the radial cell, which they slightly surpass, and in two series beyond; one following the preceding, very regular; the other slightly laterad and more or less scattered. At the extremity of the stigma, the setae of the costa are not always easily distinguished from those of the anterior margin; one recognizes the first as those that are implanted on a small tubercle. In the male the costal setae form a single series from one end to the other, often terminated by two contiguous setae and always followed by a denuded area (if one excepts microtrichia); their analysis does not present any difficulty. In one sex or the other the setae at the base of the wing generally may be more widely spaced than the others, so that frequently the interspaces are most prominent. The setae are more numerous in the female than in the male, but they vary in the same way for the two sexes. The amplitude of the variations is given for each species, whereas their frequency is reported in tabulated form for a group or subgroup. For convenience the setae therein are counted by 2's (20, 22, 24, 26, etc.).

The hyaline appearance or degree of infusca-

tion of the wing membrane and the stigma and the dimensions of the microtrichia serve sometimes to furnish characters of much less value (female, male).

Legs.—The combs, or the respective lengths of the different segments, do not furnish any element of diagnostic interest. This is true of the large comb of the hind tibia in particular, which is formed of four spines, rarely three, of which the length and thickness appear to vary more within a species than from one to the other.

Following Carter's (1921) publication, the number of black spines (fig. 5) on the ventral side of the four anterior basitarsi was considered as extremely variable in "*L. kerteszi*," even for specimens having a common origin. For the species of the Mediterranean subregion, the number has been shown to vary in the same way in the male and in the female, and within rather narrow limits it represents a considerable element of concordance or specific divergence. This same element of concordance is found again in the American species for the anterior basitarsus, but the systematic value of the spines is much more important on the midbasitarsus. One can immediately distinguish between the species that bear *median spines* (*mss*) on the midbasitarsus, whatever number, and those that do not bear them (individual variations may constitute a very rare anomaly).

With one or two rare exceptions, the tarsal spines are extremely stout, long, and black and cannot cause confusion with the hypertrophied spinulose setae also situated on the ventral side of the basitarsi. To describe sufficiently and precisely their variations within a single species, formulas with three values have previously been used, (2-1-2) for example, corresponding to two basal spines, one median, and two apical, multiplied by the frequency of this combination found for a certain number of specimens examined. In the preceding example, if the formula has been found 20 times, it would be written (2-1-2) × 20. We have disregarded the basal and apical spines because they nearly always number two, and we have reduced the formula to the median spines alone. In the preceding example the new formula is (1) × 20; the parentheses are conserved to differentiate the multiplicand from the multiplier. To simplify further, the spines of the posterior basitarsus,

of much less interest, have been disregarded. These spines are normally counted on both sides of a specimen, but some legs may be lost or some basitarsi hidden, and the number of combinations reported may be less than twice the number of specimens examined.

Independent of the spines and the usual pilosity, the tarsi bear setae of a special morphology, whose position on the ventral side and at the extremity of the tarsomeres makes one think that they make contact with the support on which the insect is at rest. For this reason, but without otherwise prejudging their true function, they have previously been designated under the rather imprecise name of *tactile setae* (fig. 5). These setae are strong but of a medium length, regularly curved, the concavity oriented toward the base of the segment, hyaline, and rarely with blackish reflection. They are implanted on a bulky, rounded, similarly hyaline base. These setae have not been found useful in separating the North American species.

In the male the fifth tarsomere on all legs bears two setae of great taxonomic value in spite of their inconspicuous appearance (fig. 2). They are situated at the extreme base of the ventral side where the segmental surface is first visible. These setae may be short, rather slender, erect on the integument, and strongly rectilinear (*erect setae*); or they may be long and rather strong, curved from their base toward the tip of the segment in the form of an arc of a circle as if they were falling or hanging (*decumbent setae*). Between these two extremes are two intermediate forms. In one the seta is nearly erect but weakly curved toward the base of the tarsomere (*erect-curved seta*); in the other the seta is broadly curved like the decumbent seta but less strong and shorter, then broadly curved in the reverse sense (*doubly curved seta*). The erect seta is not always easily separated from the erect-curved seta and the decumbent seta from the doubly curved seta, but experience shows that in the species with which we are concerned this does not constitute a serious difficulty. In effect, each seta corresponds to a certain morphology of the genitalia, which must be confirmed by examination. In any case, only an examination strictly lateral to the fifth tarsomere will permit correct appreciation of the form of these setae, which is rarely the case if

the specimens are mounted in toto. One or two other setae, slightly distad of the preceding, may present the same appearance as the preceding, but they are more difficult to see and the risk of error is very great. Their use therefore is not practical.

In the female all the *claws* are simple, equal, and armed at the base with a long seta, which is slightly curved toward the dorsal side. In the male the two claws of the same leg may be simple and resemble those of the female, or they may be mixed, the external claw bearing a curved hair and the internal claw a strong rectilinear or very slightly sinuous branch (fig. 2). All the males described here possess mixed claws on the anterior two pairs of legs and simple claws on the posterior pair. The seta or the branch may be doubled on its distal margin by a minute rectilinear seta but in an inconstant and irregular manner without diagnostic value.

Abdomen.—The abdomen has not furnished us any diagnostic element. On all the females examined, preserved in alcohol or mounted for a long time, the terga are uniformly dull brown, the sterna are pale brown, and the pleural membrane is pale yellowish except one species, *L. asilomar*, which is entirely and uniformly black.

In all the females examined the genital armature is uniform from one species to another, and because it has often been described and illustrated, it will not be repeated here. The lateral arm of the genital plate seems to show slight differences but not in a very reliable or useful manner. Only the *spermathecae* show interesting characters (fig. 2). There are three in all the species forming the *kerteszi* complex. Two are very large and the third one is half the length and breadth of the others. The two large ones are always well pigmented and bear a very short neck basally. Some show at the head a prominent dilation or diverticulum, the surface of which is irregularly embossed; in others not so provided, the contour is regularly rounded, and the surface appears smooth and even. All bear at the head numerous small pale dots and most often also a group of very slender filaments generally designated under the name of spines, which are not always visible (fig. 7). The third spermatheca has the form of an elongated sac,

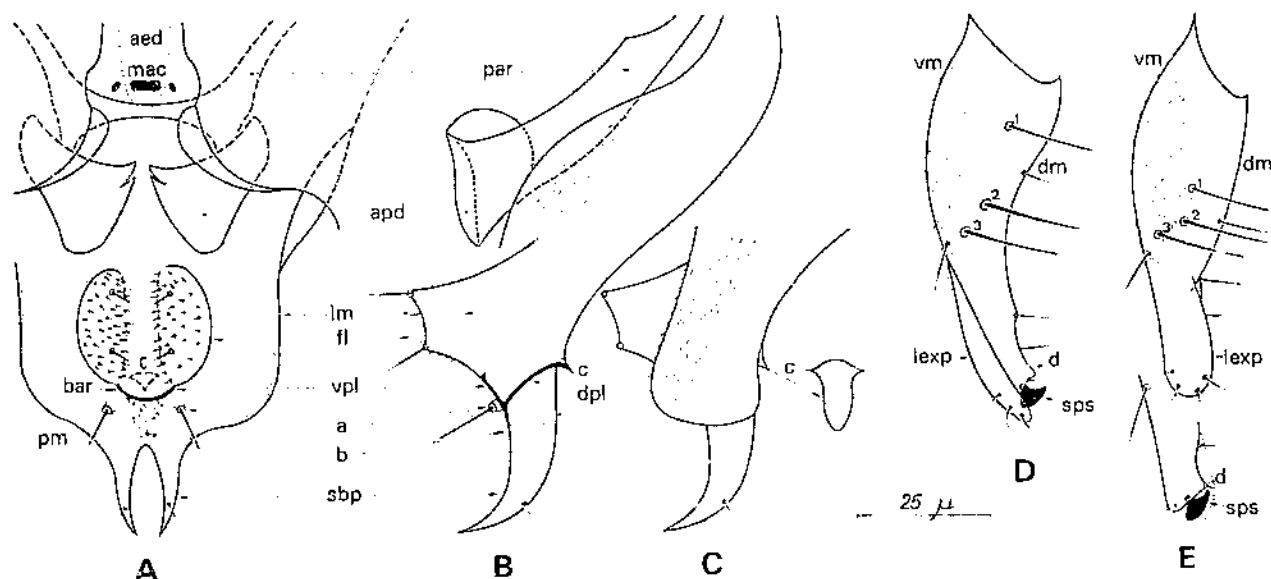


FIGURE 3.—*Leptoconops (Holoconops)* spp., male: A, Median and posterior parts of genitalia in ventral view; B and C, same parts in lateral view, without aedeagus or macules, with dorsal process of tergum IX isolated, dorsal view (at twice magnification of A); D, dististyle with ventral setae 1, 2, and 3 in basimedial position; E, dististyle with same in median position. (a, setae on posterior margin of tergum IX; aed, distal extremity of aedeagus; apd, apical dilation of parameres; b, median pigmented band of tergum IX; bar, bar; c, dorsal process of tergum IX; d, cone of dorsal margin of dististyle bare (D) or bearing seta (E); dm, dorsal margin of dististyle; dpl, dorsal plate of tergum IX; fl, fleshy setose lobes of tergum IX; lexp, lamelliform expansion of ventral margin of dististyle; lm, lateral margin of tergum IX; mac, macule and accessory macules; par, distal half of parameres (partial view); pm, posterior margin of tergum IX; sbp, submedian processes of tergum IX; sps, spatulate spine of dististyle; vm, ventral margin of dististyle; vpl, ventral plate of tergum IX)

whose tint or pigmentation seems to resemble that of the other two or is much fainter.

Although the *genitalia* of the male often have been described or illustrated, some anatomical review and definitions are necessary to recognize the often extremely small details that aid in separating the species (fig. 3). In males of two American *Holoconops*, *L. bequaerti* (Kieffer) and *L. linleyi* Wirth and Atchley, the ninth tergum terminates posteriorly in one to three very long, rather characteristic processes, by which the species are easily recognized. In all the others, particularly in the males we have seen of the *kerteszi* complex, this tergum forms a broad gutter opening ventrally and progressively narrowed from the base on the proximal two-thirds and much more enclosed, narrow with parallel margins, on the distal third. The ventral face of the ninth tergum is occupied and hidden on the basal part by the remainder of the hypopygium. It is free and entirely visible on the distal part. It will be termed in this bulletin in a restrictive sense the extremity of the ninth

tergum or still more simply the *ninth tergum*. With the exception of one North African species (*L. laurae* (Weiss, 1912)), in which the tergum is regularly rounded, this distal part appears quadrangular with slight variations in the form or dimensions, respectively, of the sides.

One may distinguish: (1) The lateral margins (lm), each of which does not represent a simple linear border, but a more or less thickened wall, elevated ventrally to a certain height, and corresponding to the side of the gutter; these margins bear a short pubescence on the midportion of their lateral face. (2) The posterior margin (pm), with two long submedian processes (sbp) curved toward the ventral face and bearing a moderate-sized hair toward the midportion of the dorsal face. (3) At a very slight distance from the posterior margin, two small setae, respectively, borne by a conspicuous tubercle (a). (4) Proximad of these setae, two fleshy and setose lobes normally directed ventrally (fl), but rather deformed or flattened laterally by the slide-mounting process and without taxonomic

value; each bears a short pilosity, with two hairs that are longer and stronger than the others. The ninth tergum bears medially a narrow, slightly pigmented band (*b*) originating on the two submedian processes of the posterior margin, then divided into two plates. The ventral one (*vpl*) is directed invariably toward the base of the fleshy lobes and presents itself ventrally in the form of a transverse incurved bar (*bar*). The dorsal one (*dpl*) is variable. In four American species (*L. americanus*, *asilomar*, *whitseti*, and *catawbae*), it is curved posteriorly and forms an extremely small, conspicuous, black process (*c*) at the dorsal surface of the tergum. In all the other species examined (Old and New World), it fuses with the tergum without changing direction and disappears (see fig. 20, *B*, *G*). The proximal margin of the ninth sternum may present in its midportion a triangular enlargement or a more or less developed tubercle, whose possible presence will be pointed out, although its specific value is questionable (see fig. 20).

The *basistyle* does not furnish any diagnostic characters. The *dististyle* has very much the same form from one species to another. It is very broad on the proximal half, progressively narrowed and slightly bent on its axis on the distal half, but it has a certain value. At the tip of the ventral margin (*vm*) is developed a generally translucent *lamelliform expansion* (*lexp*) of variable breadth that is lightly incurved and tends to cover the tip of the dististyle. The latter is most frequently oblique, the ventral margin is always the longest, and it bears a short but strong black spine at the rounded extremity, without appreciable specific value, named the *spatulate spine* (*sps*). The dorsal margin (*dm*) is terminated by a small tubercle (*d*) bearing or not bearing a moderate-sized hair. The vestiture of this complex includes a short pubescence on the external face; about 10 short, weak, uniformly arranged, colorless hairs; and 3 particularly long and strong, blackish or black hairs, situated on the ventral face and easily recognized (1, 2, 3), whose location on the dististyle may be basimedial (*D*) or median (*E*). In certain orientations the basimedial disposition of the setae may appear to be median, as in figure 14, *D*, because of the very strong obliqueness of the articular surface. To avoid any error of interpretation, it is necessary to locate the first

ventral seta by referring to the limit of the pigmented surface that is immediately proximal (in dotted lines in the illustration) and not by reference to the extreme base of the dististyle.

The *aedeagus* (*aed*) comes partially to view in the space left free between the bases of the two dististyles, in the form of two small sclerotized plates, capped by a fleshy common part, rounded at its extremity, transparent, and poorly visible. These sclerotizations are highly uniform in the Mediterranean species. They appear to differ very slightly but in a constant manner in the American species, and for this reason they are shown in the illustrations but not described further.

The two basal halves of the *parameres*, consisting on each side of a strongly sclerotized, obliquely oriented plate, lack systematic value. The two distal halves (*par*), united in their midportions by a transverse bar and delineating an "H," may be directed obliquely but the inverse of the preceding, or they may be disposed perpendicular to the axis of the hypopygium. Each of them is terminated by an apical dilation (*apd*), of a form characteristic in *L. bellini* Wirth and Atchley (1973) (presence of a retrorse appendage on the ventral face and of five to six teeth on the internal margin), but nearly invariable in the species of the *kerteszi* complex. When the distal halves of the parameres are perpendicular to the axis of the hypopygium, they are hidden from ventral view by these dilations (fig. 20).

At the level of the aedeagus but buried deeply is a granulose or filamentous mass, rather dense and pigmented, with imprecise limits, corresponding perhaps to a glandular formation, which has been called the *macule* (*mac*) without prejudging its nature. It is sometimes accompanied on each side by an accessory macule, which is much smaller. After dissection of the genitalia, the macule appears free of the aedeagus, set on a membranous mass, uniting on their ventral faces the two distal halves of the parameres. From the systematic point of view, the macules have some importance.

As with the female palpus and the basal setae of the fifth tarsomere of the male, the anatomical characteristics of the genitalia and particularly the apical dilation of the parameres appear to show considerable morphological variation ac-

cording to the angle of observation. Therefore for consistent comparisons, all the descriptions and illustrations in this bulletin have been made from preparations presenting the orientation that we consider the best and the most natural, that is, genitalia separated from the body and resting perfectly flat on the side on their dorsal face, without excessive compression by the cover glass. Even under these conditions, at least in certain cases, important variations in aspect are again possible (see fig. 20).

Pupa

(Fig. 9)

Few studies have been made of the morphology of the *Holoconops* pupae (Mayer (1934) for *L. bequaerti* (Kieffer), Smith and Lowe (1948) under the name of *L. kerteszi*, Krivosheina (1962) for *L. borealis* Gutsevich, and Clastrier (1972) under the name of *L. kerteszi*). Subsequently Clastrier (1973) showed that this last identification was incorrect and that the name *L. kerteszi* pertained in this particular case to three new species of *Holoconops*: *L. gallicus*, *acer*, and *pugnax*. The pupa described belonged to the first of these three species. The pupa of the other two differed only in the form of the abdominal hooks and some details of the respiratory horn.

The pupae of the three North American species were similar to the pupa of *L. gallicus*, whose description is not reviewed here but is the model for those given in this bulletin. The lettering and numbering of the setae previously used are preserved, and newly described elements are indicated by arrows (fig. 9).

Cephalothorax.—The ventral face does not bear any setae. One circular white spot (No. 8) has been shown at the mesoposterior extremity of the *ocular plate* (*oc*); three or four other similar spots are also present on the lateral margin of the same extremity. In addition, another submedian spot is visible on each side of the sheath of the *proboscis* (*prob*). On the dorsal face properly speaking, posterior to the *respiratory horns*, to the two *tabular eminences* (*tab*), and to the elements 4, 5, and 6, are two pairs of small, rounded, clear spots. The *metathorax* (*meta*) bears a pair of small submedian clear spots, in addition to the three

elements previously shown under No. 9. Finally on the sheath of the *halter*, which laterally prolongs the metathorax, is a protuberance corresponding to the base of this organ, without specific value.

Abdomen.—The first segment (I), reduced to only the dorsal face, bears on its anterior margin, laterad of seta 9 of the metathorax, a prominent sclerotization marked with a pale circle, without specific value. Most of the pale circles observed in the pupa represent the superficial part of a cylindrical formation included in the integument. According to their location, the surface may be bare or have in the center a small, erect papilla, shown in the illustration by a black dot in the center of the pale circle.

Smith and Lowe (1948) found a difference in the arrangement of spines or hooks on the posterior margin of segments VIII and IX between the male and the female: "The male pupa is similar to the female, but has . . . a different arrangement of spines on the eighth and ninth segments. The arrangement of spines is the same on the eighth segment as it is on the preceding seven segments. The ninth segment has the same arrangement of spines as the eighth segment of the female."

We have not found any difference between the two sexes for the three European and three American species examined, but in the male the separation of segments IX and X is not always marked, and the two spines borne by IX may escape observation. Krivosheina (1962) also shares this last opinion if judged by the scheme 1 in her figure 2, where only nine abdominal segments are designated, the last, armed with two perfectly visible lateral spines, resulting in fact from the fusion of IX and X. But the schemes 5 and 6 of her figure 3, which represent segments VIII, IX, and X, have for the legend: "Two last abdominal segments . . ." which appears to express an opinion the inverse of the preceding. From the systematic point of view, segments IX and X are less uniform than they appear to be at first and may present good specific characters.

During pupation, when the imago is completely formed, the pigmentation of the mesonotum begins in the prescutellar region, often in the form of a Greek cross, which is obscured rapidly

in the general coloration of the thorax. Observed on some pupae of *L. americanus* and *L. whitseti* that died before eclosion of the adult, this initial cruciform pigmentation has been seen also in some European pupae.

The morphological characters of the pupa

scarcely vary from one species to another and can be seen only in specimens mounted perfectly in dorsal or ventral position without excessive compression of the cover glass and without deformation, at least of the last three abdominal segments.

CHARACTERS OF SPECIES STUDIED

(Figs. 1-4)

Among the *Holoconops* known from the Nearctic region, one group of three species is characterized in the female by the presence of two spermathecae and in the male by the strictly specific polymorphism of the genitalia entailing the ninth tergum (*L. bequaerti*, *L. linleyi*) or the apical dilation of the parameres (*L. belkini*). All the others, characterized by the presence of three spermathecae in the female and by the uniformity of the genitalia in the male, form what we call the *kerteszi* complex s. lat. The females of this complex can be divided into three groups according to whether segment XIII of the antenna bears two median black setae (group 1), only one of these black setae (group 2), or whether these setae are entirely absent (group 3).

The first group, very well characterized, is also defined by other characters. Female: Sensory setae of antennal segments XI and XII separate; stigma of the wing broad, rounded at the tip; median spines present on the midbasitarsus; spermathecae smooth and uniform at the head, without diverticulum. Male: Median spines present on the midbasitarsus; basal setae of the fifth tarsomere strictly erect; setae of the posterior margin of the ninth tergum very broadly separated, fleshy setose lobes nearly contiguous to the latter; median pigmented band forming a small process dorsally on the surface of the tergum. One species of this group, *L. catawbae* (Boesel, 1948), is already known. The female of *catawbae*, which has widely variable chaetotactic characters, differs from all the other species by the minuscule size of the sensory pit of the palpus, which is not as broad as its opening, and the male differs by having simple claws on all the legs and by the presence of a single denticle at the distal extremity of the parameres. Because it is separated from the other species by these exclusive characters, and since it is already described and is not a member

of the *kerteszi* complex, this species will not be treated again here.

The second and third groups, which perhaps should more exactly be called subgroups, are equally defined by other common characters, opposed to the preceding. Female: Sensory setae of antennal segment XII, and sometimes also on XI, most often united in a single hypertrophied seta; stigma of the wing triangular, the distal extremity sharp pointed; median spines absent on the midbasitarsus; spermathecae provided with a diverticulum. Male: Median spines absent on the midbasitarsus; basal setae of the fifth tarsomere variable but not erect; setae of the posterior margin of the ninth tergum very close together; the fleshy setose lobes broadly separated from the last; median pigmented band attenuated nearly to disappearance, without forming a process on the tergum. Until more fully studied and lacking understanding of some of the characters of the female antenna, these last two groups or subgroups appear to differ from each other by the possible presence of setae at the base of the clypeus in some females of the third group and by the position of the three ventral setae of the dististyle in the male—basimedial in the second group and median in the third.

The use of the female antennal setae alone to divide into three groups the species forming the *kerteszi* complex in North America is not as simplistic as one would suppose. Their value is supported by the use that has already been made of them in separating several Mediterranean species, as well as by the presence of the same character in a described Asiatic species (Clastrier, 1974a), and is confirmed by the specific characters of the known males.

Two kinds of alterations may, however, be observed in this general outline: The simultaneous presence in certain species of characters

belonging to two different groups (*L. atchleyi*, *vargasi*, *andersoni*) and individual variations in chaetotaxy. Far from constituting a difficulty, the first anomaly facilitates recognition of species because it attracts immediate attention. Individual anomalies of chaetotaxy are numer-

ous, variable according to the origin of the samples, and due to excess or to lack. When they concern setae without taxonomic value, they remain insignificant. In the inverse eventuality they are not a serious impediment if they are unilateral, which is nearly always the case, or if

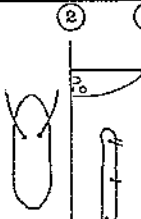

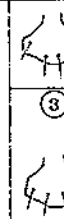
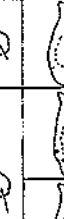
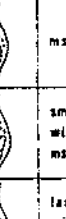
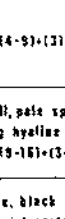
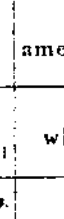
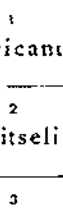
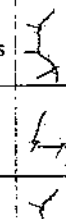





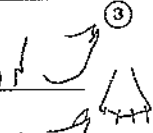

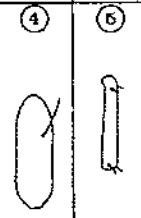

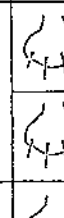
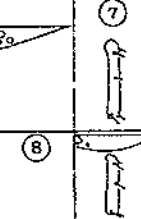

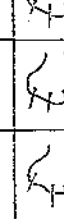
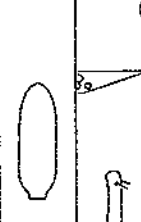

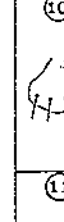
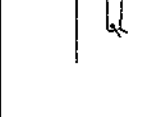

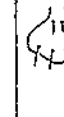
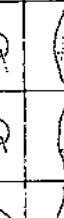
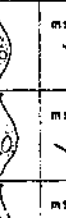
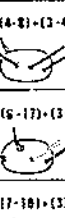
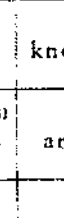
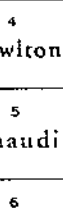
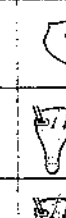


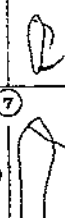
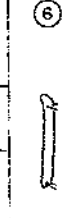

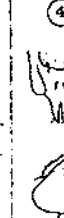
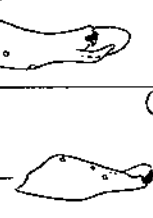

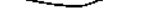

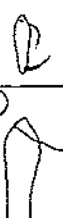





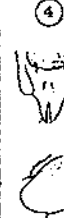


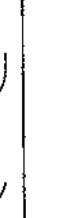



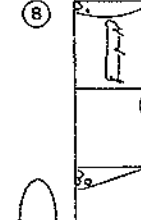
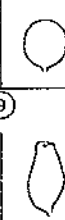
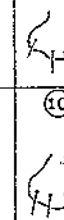
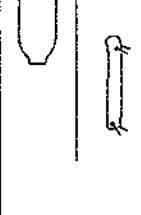

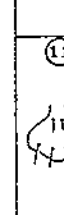
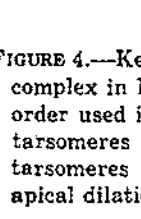
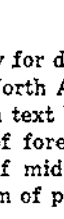
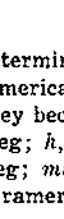




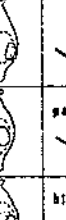
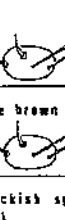
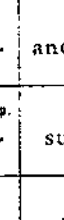
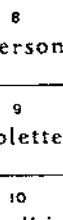
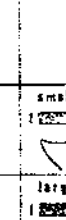
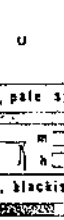
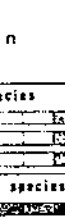
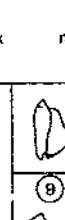
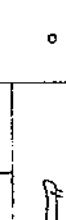
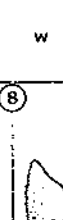
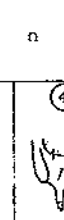


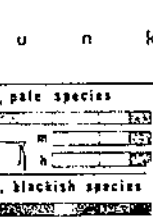


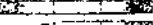

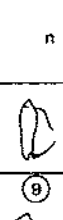





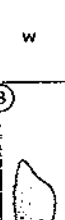
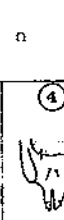
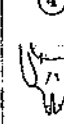









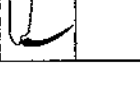
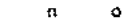
FEMALES					MALES					
ANTENNA XIII WING STIGMA MIDBASITARSUS	SPERMATOCYTES	CLYPEUS	PALPUS	MISCELLANEOUS	SPECIES	MISCELLANEOUS	MIDBASITARSUS 5th TARSOMERE	DISTISTYLE	TARSUM IX	
  	 	 	 	ms: (4-9)-(3)	1 americanus		 			
				small, pale sp. wing hyaline ms: (9-16)-(3-6)	2 whitseti					
				large, black sp. wing infuscated ms: (13-19)-(4-7)	3 asilomar					
           	   	   	   	ms: (4-8)-(2-4)	4 knowltoni	   	    	   	   	
				ms: (6-17)-(3-4)	5 arnaudi					
				ms: (7-10)-(3)	6 atchleyi					
				ms: (8-10)-(3-5)	7 vargasi					u n k n o w n
            	    	    	    	ms: (4-8)-(2-4)	8 andersoni	    	     	    	    	
				pale brown sp.	9 sublettei					small, pale species 
				blackish sp.	10 foulki					large, blackish species 
				front: bare	11 reesi					small, pale species 
				front: 2 setae	12 sp. C					p post: m condition h: 
						u n k n o w n				

FIGURE 4.—Key for determining females (from left to right) and males (from right to left) of *Leptoconops kerteszi* complex in North America; for certain species, order of progression through characters may differ slightly from order used in text key because of constraints imposed by table format. (f, coloration of tibia and three proximal tarsomeres of foreleg; h, coloration of three proximal tarsomeres of hindleg; m, coloration of three proximal tarsomeres of midleg; ms, number of lateral setae of mesonotum (anterior + posterior); p, anterior half of apical dilation of parameres, showing two teeth; sp, species)

bilateral on a specimen belonging to a normal series, because in this case one's attention is again attracted. But in the event a taxonomic anomaly is bilateral, there is grave risk that identification will be impossible or entail an error if one does not take care to verify all the specific characters.

Therefore we have attempted on the one hand to give the greatest number possible of confirmatory characters (setae of the mesonotum, of the costa, etc.) and on the other to give the numerical data for each of them, such as the nature, amplitude, and frequency of variation according to the number of specimens examined. Since their taxonomic value is very unequal, certain characters have been repeated and compared within each of the three species groups to make known their possibilities and their limits. Unless noted to the contrary, the expressions "one seta more" or "one seta less" concern only one side of the insect's body (vertex, antenna, clypeus, mesonotum, etc.).

Independent of variations and anomalies, there is, moreover, the case where, after more or less narrow definition of groups or subgroups, the characters used seem to attain the limits of their possibilities, without one's being able to go

over them or past them to the determination of species. This impasse, already pointed out for the Old World species, has been found in North America for some species of the third group. Present-day examination with light microscopy seems unable to furnish new characters. Probably other techniques, such as those for studying ultrastructure, will be needed.

Length of body is measured from the anterior margin of the mesonotum to the extremity of the cerci (female) or the genitalia (male). When on a preparation the abdomen is found in hyperextension following compression by the cover glass, we have preferred not to give this value. Longitudinal dimensions of the wing are taken from the arculus. Unless otherwise noted, the third palpal segment of the type (female, male) is always illustrated with the fourth palpal segment. For the midbasitarsi, the adjective "unarmed" means absence only of the median spines. All the illustrations, except the first four, are drawn to the same scale to permit comparisons. The locality data are not given at the end of each specific description but are summarized under Distribution of Species. The references to *Leptoconops* of the Old World indicate only those species examined and described in the previously cited publications.

KEYS TO LEPTOCONOPS KERTESZI COMPLEX IN NORTH AMERICA

(Fig. 4)

FEMALES

- | | | |
|--------|---|-----------------------------|
| 1. | Antenna with XIII bearing two median black setae; wing with stigma broad, rounded at tip; midbasitarsus bearing at least one median spine; spermathecae without diverticulum (group 1)----- | 2 |
| | Antenna with XIII bearing one median black seta; wing with stigma triangular, with sharp-pointed tip; midbasitarsus and spermathecae various (group 2)----- | 4 |
| | Antenna with XIII bearing no median black setae; stigma of wing, midbasitarsus, and spermathecae various (group 3)----- | 8 |
| 2 (1). | Clypeus with mesal setae closer to each other than to corresponding lateral setae and distinctly distal to them; mesonotum with four to nine anterolateral setae, three posterolaterals; (wing 1.10-1.40 mm long; stigma more or less brown; palpus with III symmetrically broadened in midportion, opening of sensory pit of small diameter and located on anterior face)----- | 1. <i>americanus</i> Carter |
| | Clypeus with mesal and lateral setae nearly in straight line and equidistant; mesonotal setae more numerous----- | 3 |

- 3 (2). Small, pale species (wing 1.10-1.45 mm long); wing and stigma hyaline; mesonotum with 9-16 anterolateral setae, 3-6 posterolaterals; spermathecae usually elongated; palpus with III expanded on distal portion and more or less clubbed, sensory pit on mesal face 2. *whitseti*, n. sp.
- Large, entirely black species (wing 1.45-1.60 mm long); wing and stigma strongly infuscated; mesonotum with 13-19 anterolateral setae, 4-7 posterolaterals; spermathecae more or less subspherical; (with reservations—palpus with sensory pit in form of sac prolonged toward base of segment, pore smaller and located farther distad than in preceding species) 3. *asilomar*, n. sp.
- 4 (1). Midbasitarsus without median spines 5
- Midbasitarsus bearing one median spine, at least on one leg of pair 7
- 5 (4). Spermathecae with diverticulum 6
- Spermathecae without diverticulum, even and smooth and more or less flattened on head, etc. (see couplet 7¹) 4. *atchleyi*, n. sp. (in part)
- 6 (5). Sensory seta VI in alinement with others; wing with stigma hyaline; mesonotum with four to eight anterolateral setae, three to four posterolaterals; third palpal segment massively expanded, sensory pit more or less cornuate, with small pore; spermathecae with well-developed diverticulum 4. *knowltoni*, n. sp.
- Sensory seta VI displaced; wing with stigma brownish; mesonotum with six to seven anterolateral setae, three to four posterolaterals; third palpal segment elongated, nearly fusiform, sensory pit hemispherical with pore of large diameter; spermathecae with diverticulum poorly developed 5. *arnaudi*, n. sp.
- 7 (4). Spermathecae without diverticulum, even and smooth and more or less flattened at head; wing with hyaline stigma; mesonotum with 7-10 anterolateral setae and 3 posterolaterals; palpus with third segment elongated as in *arnaudi* but sensory pit in form of sac directed toward base of segment 6. *atchleyi*, n. sp. (in part)
- Spermathecae with diverticulum; wing slightly browning with darker stigma; mesonotum with 8-10 anterolateral setae and 3-5 posterolaterals; palpus with third segment massively expanded, sensory pit more or less cornuate with small pore (nearly as in *knowltoni*) 7. *vargasi*, n. sp.
- 8 (1). Wing with stigma broad, rounded at tip, brown; midbasitarsus bearing at least one median spine; third palpal segment globose, sensory pit hemispherical and proportionately very broad, pore of very large diameter; spermathecae without diverticulum, regular and smooth at head 8. *andersoni*, n. sp.
- Wing with stigma triangular, with sharp-pointed tip; midbasitarsus without median spine; palpus various; spermathecae with diverticulum 9
- 9 (8). Clypeus without setae on proximal portion 10
- Clypeus bearing one to three small setae on proximal portion (only exceptionally lacking) 11
- 10 (9). General color pale brown; sensory seta VI displaced; palpus with sensory pit medium sized, in form of slender, truncated cone, directed transversely, diameter of base slightly broader than that of opening, this proportionately very broad and not preceded by outline of neck of retort 9. *sublettei*, n. sp.
- General color blackish brown; sensory seta VI in alinement with others; palpus with sensory pit voluminous, in form of truncated cone, flattened, and slightly oblique, diameter of base distinctly broader than that of opening, latter preceded by outline of neck of retort 10. *foulki*, n. sp.

¹ This species is keyed out in two places; the presence of the median spine on the midbasitarsus is not constant; for the complement of this information, see couplet 7.

- 11 (9). Front bare; sensory seta VI displaced; spermathecae slightly narrowed at their tip, gradually prolonged by subcylindrical portion representing large diverticulum whose surface is nearly regular, marked only with pale spots. 11. *reesei*, n. sp.
 Front bearing strong black seta on each side; sensory seta VI in alignment with others; spermathecae strongly narrowed at their tips, with diverticulum of very small size, projecting, and surface extremely irregular. 12. species C

MALES

1. Tergum IX with short dorsal process present, setae of posterior margin very broadly separated from each other, setose fleshy lobes located very close to them; dististyle with three ventral setae in basomedian position; midbasitarsus armed; fifth tarsomere with basal setae strictly erect (group 1). 2
- Tergum IX without dorsal process, setae of posterior margin located close together, setose fleshy lobes broadly removed from them; dististyle and midbasitarsus variable 4
- 2 (1). Clypeus with two median setae distinctly distad of two lateral setae, and much nearer to each other than to corresponding lateral setae; (palpus with sensory pit located at middle or immediately past middle of segment III; apical dilations of parameres rather globular; tergum IX with two strong setae of setose fleshy lobes normally located) 1. *americanus* Carter
- Clypeus with four setae equidistant and nearly in straight line 3
- 3 (2). Brown species; palpus with sensory pit located moderately beyond middle of segment III; mesonotum with four to eight anterolateral setae and three to four posterolaterals; tergum IX with two strong setae of setose fleshy lobes and two setae of posterior margin located nearly in same plane perpendicular to axis of genitalia; apical dilation of parameres somewhat globular; dististyle with spatulate spine and tubercle at tip of dorsal margin weakly developed 2. *whitaei*, n. sp.
- Black species; legs with numerous, conspicuous long hairs; palpus with sensory pit located very broadly past middle of segment III; mesonotum with 7-11 anterolateral setae and 3-6 posterolaterals; tergum IX with 2 strong setae of setose fleshy lobes normally located; apical dilation of parameres very distinctly elongated; dististyle with spatulate spine and tubercle at tip of dorsal margin strongly developed 3. *asilomar*, n. sp.
- 4 (1). Dististyle with three ventral setae in basomedian position; midbasitarsus variable 5
- Dististyle with three ventral setae in median position; midbasitarsus unarmed 8
- 5 (4). Midbasitarsus unarmed 6
- Midbasitarsus armed (see couplet 7²) 6. *atchleyi*, n. sp. (in part)
- 6 (5). Fifth tarsomere with decumbent basal setae; dististyle with ventral margin prolonged distally beyond distal margin, lamelliform expansion extremely developed and broadly surpassing spatulate spine 4. *knowlton*, n. sp.
- Fifth tarsomere with erect-curved basal setae; dististyle with ventral margin not prolonged past distal margin, and lamelliform expansion just overlapping spatulate spine. 7
- 7 (6). Antenna with segment III and those following not pubescent at their tips; midbasitarsus unarmed 5. *arnaudi*, n. sp.
- Antenna with segment III and two or three following pubescent at their tips; midbasitarsus armed 6. *atchley*, n. sp. (in part)

² As in the female and for the same reasons, this species appears twice in the key; for the complement of this information, see couplet 7.

- 8 (4). Basal setae of fifth tarsomere doubly curved and very long, nearly decumbent; species small; general color pale brown; foretibia broadly pale at tip; proximal two tarsomeres on all legs yellowish, last three pale brown; apical dilation of parameres with proximal tooth obtuse, not digitiform.....9. *sublettei*, n. sp.
 Basal setae of fifth tarsomere short, erect curved.....9
- 9 (8). Larger species, general color blackish; foretibia narrowly or not at all paler at tip; all tarsi pure brown, except forebasitarsus pale on proximal half; apical dilation of parameres with proximal tooth long and distinct, digitiform.....10. *foulki*, n. sp.
- Small species, general color pale brown; foretibia broadly yellowish at tip; all basitarsi, and variably second tarsomere, yellowish, remainder of tarsi pure brown; (genitalia unsuitable for study in available specimens).....11. *reesi*, n. sp.

DESCRIPTIONS OF LEPTOCONOPS (HOLOCONOPS) SPECIES

1. *Leptoconops (Holoconops) americanus* Carter

- Leptoconops kerteszi* var. *americanus* Carter, 1921: 22 (female, Utah, figs.); Essig, 1926: 541 (notes, in part, Utah records); Rees and Smith, 1950: 9 (Utah, systematic and habitat notes, control); Rees, 1958: 741 (Utah, biology, control); Rees et al., 1969: 1 (Utah, biology, control).
- Leptoconops kerteszi* Kieffer; Knowlton and Kardos, 1951: 163 (Utah records, in part); Bacon, 1953: 27 (Washington, biting man); Rees and Winget, 1970: 121 (Utah, biology, control); Rees et al., 1970: 1 (Utah, biology, control, lab colony); Rees et al., 1971: 266 (Utah, colonization).

Female (fig. 5).—General color brown. Length of body 2.0 (1.55–2.40) mm. Length of wing 1.10–1.40 mm. Variations and anomalies based on 100 specimens; reported for comparison with those of *L. asilomar*.

Antenna.—Dull brown. Segment IV strongly transverse; following ones regularly and very slightly narrowing up to XII, which remains transverse (rarely longer than broad); their length increasing slightly from first to last; XIII subcylindrical; length equal to that of preceding 3.5–4.0 segments combined. Basal black setae: On IV relatively long, possibly attaining half length of those on following segments and sometimes as long as or little longer than verticils; on V and VI long (2.5–3.0 times diameter of segment on which they are borne) and strong. Variations: Single extra basal black seta on one side of VII, one time; absence of basal black seta on one side of VI, eight times. Verticils of five to seven (rarely eight or nine) short hairs, about 1.5 times as long as diameter of segment. Sensory

setae: Seta on III opposed to sensilla most frequently absent or atrophied; elsewhere of less diameter than that of basal black seta on V and VI, and broadly separated up to XII; on VI, respective positions of basal black seta and corresponding sensory seta are reversed. External black seta present up to X or XI (from IX to XII, exceptionally on XIII); in case it is absent, base of segment remains bare; on XIII, two median black setae longer than diameter of segment. Variations: One median seta extra, five times; one median seta less, seven times, once on teratological antenna. Presence of one external black seta observed four times on one side, and once on both antennae.

Palpus.—Segment III brownish black, symmetrical and strongly swollen on dorsal and ventral faces, much less laterally. Sensory pit of medium size, in form of truncated cone, axis of which would be directed toward tip of segment; opening generally of small diameter, situated at middle of anterior face and more or less approaching mesal face. IV brown, as long as or little shorter than III.

Clypeus (fig. 1).—Two mesal setae distinctly distad of two lateral setae and nearer to each other than to corresponding lateral seta. When due to individual variation, first character tends to fail, second always remains reliable. Variations: Lateral setae; 1 seta extra, 10 times; on both sides, 4 times; 1 seta on 1 side and 2 on other, 1 time. Mesal setae; one seta less, three times.

Mesonotum.—Black. Combinations of anterolateral setae with three posterolaterals on

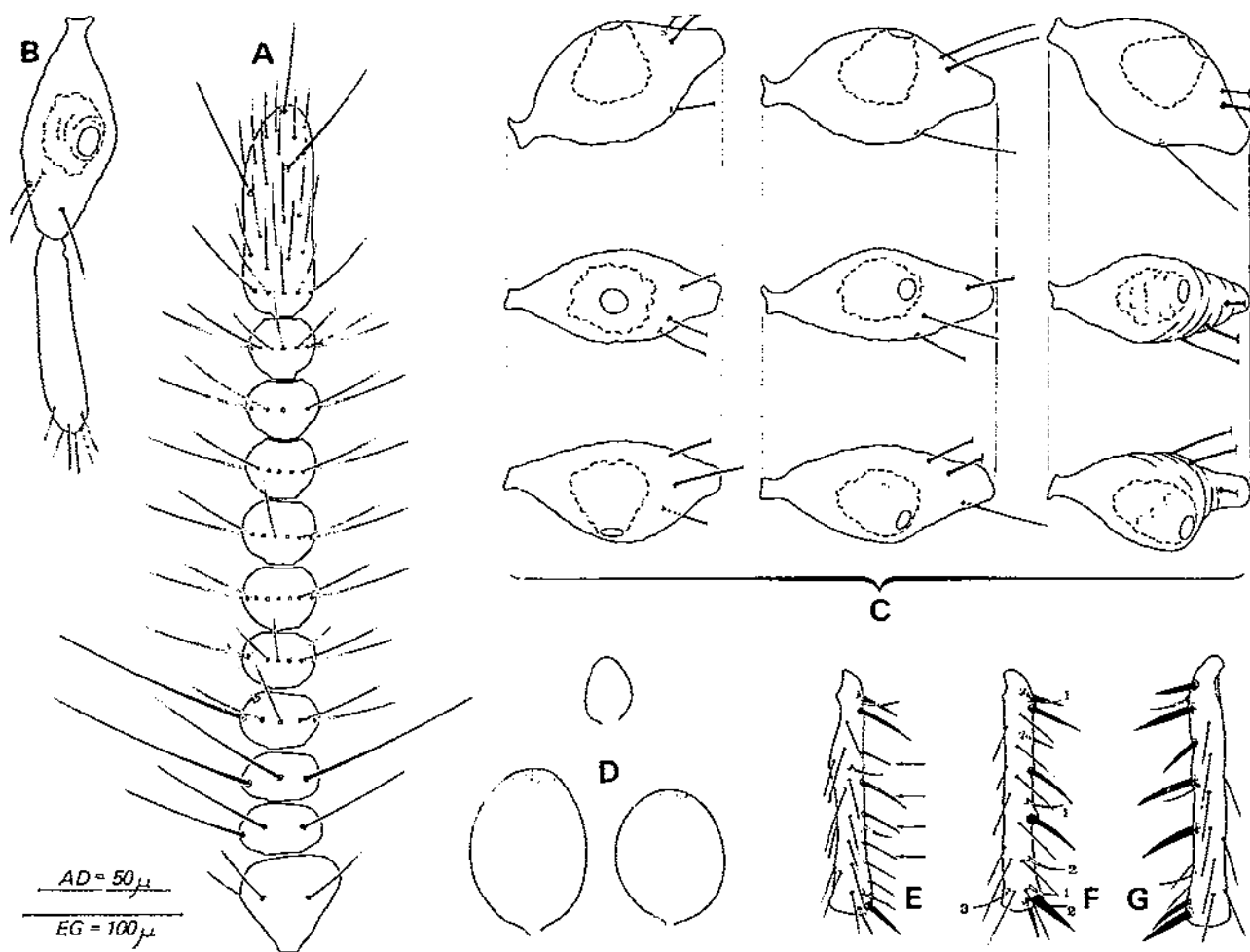


FIGURE 5.—*Leptoconops americanus* Carter, female: A, Antenna viewed from internal (mesal) face; B, last two segments of right palpus; C, changes in appearance of palpal segment III due to orientation on slide: Above, schematic of this segment in lateral view in orientations successively erected, horizontal, and depressed; middle, images obtained in microscopic examination; below, images obtained by same orientations as above except rotation of 90° on axis; D, spermathecae; E, forebasitarsus of specimen whose median spines are interpreted as delicate (arrow indicates four elements counted); for comparison: F, Forebasitarsus of *L. whitelyi*, with basal (1), median (1, 2), and apical (1, 2, 3) tactile setae; G, forebasitarsus of *L. asilomar*.

all specimens examined: (4)×4, (5)×24, (6)×28, (7)×30, (8)×9, (9)×5.

Wing (fig. 8).—Pale grayish brown. Stigma broad, tip rounded; most frequently slightly brownish. Radial cell small but well formed, ellipsoidal or triangular with angles rounded. Microtrichia of medium size and rather pale. Costal setae 25–30.

Legs.—Femora and tibiae brownish black; foretibia slightly paler at tip; tarsi brownish yellow, paler on most of forebasitarsus and sometimes also on two others; dorsal face darker. Tarsal formulas (note: On certain speci-

mens, spines of forebasitarsus are very slender, whereas hairs situated on same margin are considerably hypertrophied, so that it may be difficult, even impossible, to distinguish one from the other. In the following analysis we have counted only those elements having at least the size of normal spines): Foreleg: (1)×17, (2)×92, (3)×74, (4)×16, (5)×1; midleg: (1)×73, (2)×93, (3)×34.

Abdomen.—Two large spermathecae ovoid; surface regularly and perfectly smooth, without trace of diverticulum. Very small, round, pale spots on head; also scarcely visible spines. These

spermathecae may vary indiscriminately between "almost spherical," as in the specimens examined by Carter (1921), to very elongated. The frequency between the 2 forms has been counted; 2 equal subspherical spermathecae, 50 times; 2 equal, very elongated spermathecae, 28 times; 1 spermatheca subspherical, the other elongated, 22 times. Third spermatheca, same tint as others, pyriform; narrowed at base in a minute neck that is often invisible or absent. Dimensions on holotype: 62×45 , 50×42 , $25 \times 16 \mu$.

Male (fig. 6).—Length of body 1.80 (1.65–2.00) mm. Length of wing 1.35–1.55 mm. Eight specimens examined; variations and fre-

quency reported for comparison with those of *L. asilomar*.

Antenna.—Pubescence normal.

Palpus.—Last two segments blackish. Sensory pit located in middle or immediately past middle of segment III; IV subcylindrical, slightly clubbed, little more than half as long as III.

Clypeus.—Usually as in female, but once four setae in straight row and nearly equidistant.

Mesonotum.—Combinations of anterolateral setae with three posterolaterals on all specimens examined (both sides): (3) \times 4, (4) \times 10, (5) \times 1, (6) \times 1.

Wing.—Entirely hyaline, at times very slightly infuscated at extreme base as well as on costa,

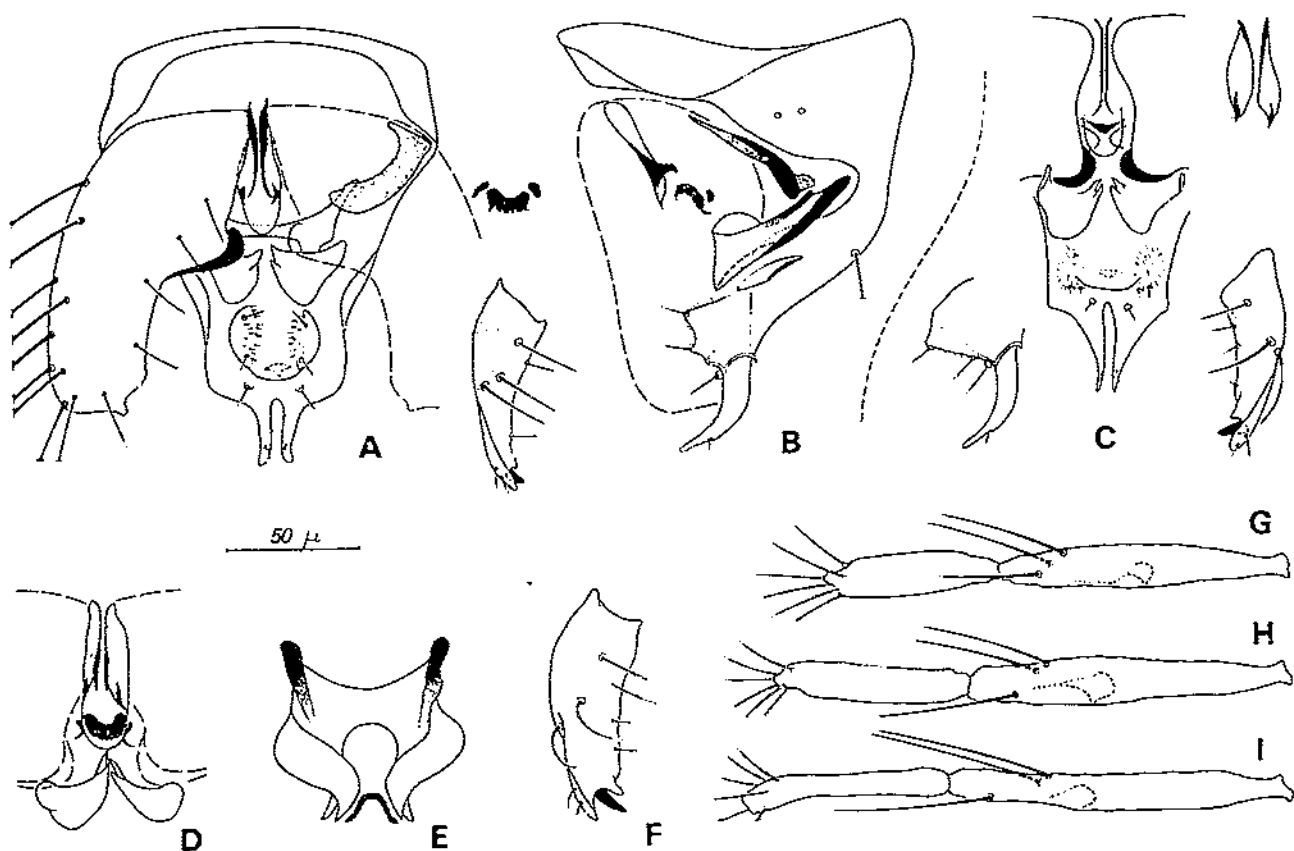


FIGURE 6.—*Leptoconops americanus* Carter, male: A, Genitalia in ventral view (macules and dististyle shown separately); B, genitalia, without dististyle, in lateral view (lateral margin of tergum IX shown in stippling in its distal part). *L. whitseii*, n. sp., male: C, Median part of genitalia whose aedeagus is not yet pigmented, with macule visible by transparency (center); aedeagus of another specimen (right, above), fleshy setose lobes in lateral view, showing orientation of their margin (left), and left dististyle in ventral view (right, below). *L. asilomar*, n. sp., male: D, Aedeagus, macule, and apical dilations of parameres; E, distal half of parameres and macules (in inverted U) on preparation compressed by cover glass; F, right dististyle. Last two segments of right palpus of *L. americanus* (G), *L. whitseii* (H), and *L. asilomar* (I).

radial veins, and cells they enclose. Costal setae relatively short, sparse (9-19), leaving many voids at base of wing.

Legs.—Femora and tibiae blackish; tarsi pale brown except forebasitarsus, which is yellowish in midportion but not at ends, and hind basitarsus, which is entirely pale. Basal setae of fifth tarsomere strictly erect. Spines of forebasitarsus sometimes, as in the female, difficult to distinguish from hypertrophied hairs of ventral margin. Foreleg: (2)×8, (3)×6, (4)×2; midleg: (1)×5, (2)×6, (3)×4.

Genitalia.—Ninth tergum quadrangular, rather short, its posterior margin not exceeding tips of basistyles; lateral margins much broader basally than distally; median processes of posterior margin extremely long and very slender, two setae of same margin very broadly separated; fleshy setose lobes nearly contiguous with latter; dorsal extremity of median pigmented band projecting on tergum in form of black, more or less elongated process. On dististyle, three setae of ventral face located in basomedian position, one nearest base slightly weaker than others. Lamelliform expansion well pigmented, and only partially covering spatulate spine; small, conical tubercle of other margin not bearing hair at tip. Aedeagus as illustrated. Distal half of parameres normally oblique, rarely perpendicular to axis of genitalia; apical dilation very nearly in form generally observed, but two digitations conically elongated and highly pigmented, resembling teats of cow, giving impression of volume and not of simple sawteeth as is usually the case. Macule voluminous, loose, in form of transverse rectangle; accompanied slightly proximad on each side by triangular, extremely compact, accessory macule.

Pupa (fig. 9).—Described from two pupae (female, male) dying before emergence of adults, but well formed and readily identifiable.

Cephalothorax.—Respiratory horn very small (40-50μ), subglobose, bearing two rows of eight spiracular papillae whose diameter is relatively important.

Abdomen.—Hooks very similar to those of *L. gallicus*, little shorter and little less curved, and tubercles bearing them more elongate, but variations observed in two species overlap. In female, contrary to usual condition, posterior margin of ventral face of segment VIII not

bearing submedian callosities, but weak linear sclerotization, which is directed toward anterior portion of segment in design of inverted V. In both sexes, two hooks of segment IX are implanted in slightly dorsal position, on voluminous protuberance, strongly projecting laterad. Otherwise see illustration.

Types.—Lectotype female (Type No. 24351, USNM) designated by Wirth and Atchley (1973) from three female syntypes described by Carter (1921), Salt Lake, Utah, 26, vi, H. S. Barber, "biting devilishly." One paralectotype in USNM, one paralectotype in British Museum (Nat. Hist.), London (from Liverpool School of Tropical Medicine).

Distribution.—California, Colorado, Idaho, Nevada, Oregon, Utah, Washington, Wyoming (fig. 23).

Discussion.—We have chosen a "plesiotype" male from three male specimens from Great Salt Lake, south end, Tooele County, Utah, July 1969, P. G. Lawyer.

A male from Goodale Creek, Inyo County, Calif., remains undetermined. It is in poor condition and differs from the other specimens by the palpus (rather short and stocky, sensory pit situated at distal fourth of segment III, IV nearly as long as III), the wing (entirely brown), and the genitalia to the extent their examination is possible (tergum IX of triangular form, setae of posterior margin invisible, parameres difficult to view).

In a series of three females, two larvae, and six pupae from Bodie, Mono County, Calif., reared 23.vi.1965 from moist sand in a ditch by R. Doty, all are typical *L. americanus* except that one of the pupae differs from the others, being very similar to that of *L. whitseti*. Four females collected by R. H. Whitset at Furnace Creek, Death Valley National Monument, Inyo County, Calif., 14.iv.1962, are somewhat atypical for *L. americanus* and may possibly be *L. whitseti*. We also have two females from Saratoga Springs, Death Valley, collected while biting man 23.iv.1955 by Belkin and McDonald, that resemble the preceding series. From these records we must acknowledge that the possibility exists that *L. whitseti* also occurs in the Owens Valley as well as on the California coast, although more likely we seem to be dealing with extremes of variation in populations of *L. americanus*.

2. *Leptoconops (Holoconops) whitseti*, new species

Leptoconops kerteszi Kieffer; Whitset and Schoepner, 1965: 493 (Pebble Beach, Calif.; females attracted to carbon dioxide traps).

Female (fig. 7).—General color brown. Length of body 1.90 (1.45–2.10) mm. Length of wing 1.10–1.45 mm. Variations and anomalies based on 70 specimens; reported for comparison with those of *L. asilomar*.

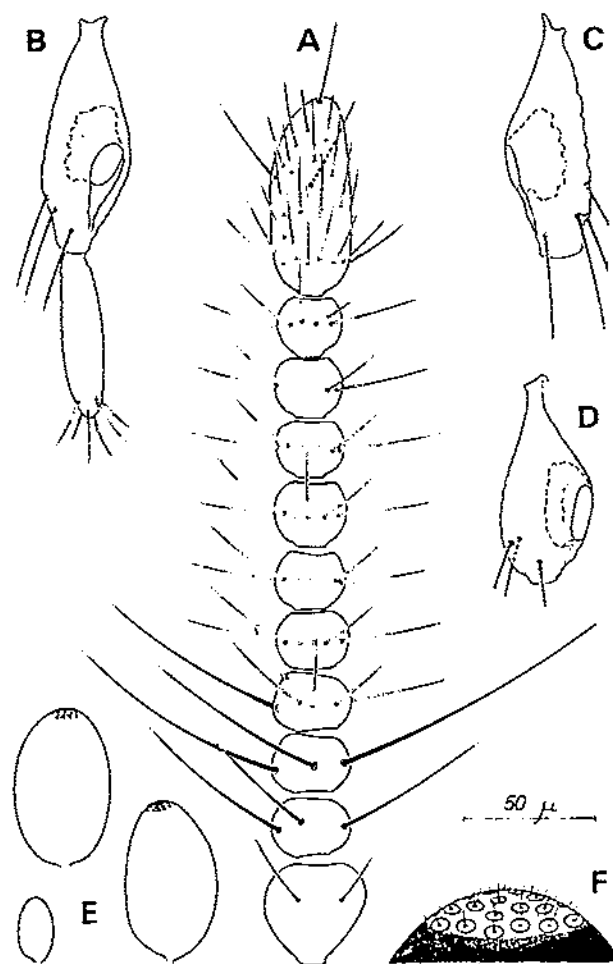


FIGURE 7.—*Leptoconops whitseti*, n. sp., female: A, Antenna viewed from internal (mesal) face; B, last two segments of right palpus; C, third segment of left palpus; D, third segment of right palpus of specimen from Saratoga Springs that may be *L. whitseti* or *L. americanus*; E, spermathecae; F, head of spermatheca greatly enlarged, showing pale cap, rounded spots, and spines whose bases are perfectly visible.

Supraorbital setae.—One additional lateral seta, four times; one additional median seta, one time; on both sides, one time; one less median seta, two times.

Antenna.—Proximal segments usually less transverse than in *L. americanus*, and XII subglobose, flagellum appearing nearly moniliform; XIII shaped like sugarloaf, slightly narrowed in midportion. Basal black setae also usually weaker than in preceding species, but proportionately much longer; on IV twice as long as diameter of segment and more than length of verticillar hairs; on V and VI three to four times as long as segment diameter, longest on V always surpassing that on VI. Variations: One basal seta absent on VI on one side, one time. Hairs of verticils (six to eight) very short, about 1.5 times as long as diameter of segment. Sensory setae: On III, seta opposite sensilla is most often absent or atrophied, as in *L. americanus*; elsewhere they are always distinct, except twice when they were fused in single seta, on one side on XII; on VI, respective positions of basal black seta and corresponding sensory seta are reversed. External black seta present up to XI or XII, rarely XIII (on one side, four times; on two sides, two times; double on one side, one time); when it is missing on segment, corresponding base remains bare; on XIII, two median black setae which are most often, like subapical black seta, scarcely as long as greatest diameter of segment. Variations: One median seta more, three times; on two sides, one time; one seta less, two times.

Palpus.—Segment III dull brown, mainly swollen on distal half of mesal face, and somewhat in form of a club. Sensory pit of medium size, hemispherical or in shape of truncated cone, occupying middle part of segment; opening wide, situated beyond middle of mesal face, with tendency to overlap onto ventral face; otherwise it seems to be prolonged by groove, or gutter, extending to apical limit of pigmentation of segment. IV slightly paler and always shorter than III.

Clypeus (fig. 1).—Four setae arranged in nearly straight line, equidistant from each other. Variations: 1 lateral seta more, 13 times; 1 mesal seta less, 1 time.

Mesonotum.—Brown. Combinations of antero-lateral setae, according to number of postero-

laterals: Three posterolateral setae: (9)×5, (10)×2, (11)×2; four posterolaterals: (9)×9, (10)×5, (11)×10, (12)×10, (13)×3, (14)×2; five posterolaterals: (8)×1, (9)×3, (10)×2, (11)×3, (12)×3, (13)×3, (14)×1, (18)×1; six posterolaterals: (11)×1, (13)×1, (14)×1, (16)×1.

Wing (fig. 8).—Very faint gray rather than brown. Stigma broad, rounded at tip; not infuscated but marked with coarse, grayish, or refractive "granulations." Microtrichia slightly stronger than in *L. americanus*. Costal setae 32–51.

Legs.—Femora and tibiae brownish; knees black; foretibia yellowish on tip; basitarsi yellowish; distal tarsomeres very weakly infuscated. Tarsal spines all distinct and not causing confusion (fig. 5); on other hand, basal or apical spines may exceptionally number three, of which one is then counted as a median: Foreleg: (1)×2, (2)×5, (3)×58, (4)×51, (5)×18, (6)×4; midleg: (1)×3, (2)×27, (3)×94, (4)×11, (5)×1.

Abdomen.—Two large spermathecae slightly less pigmented than in *L. americanus*; subequal, oval or subcylindrical, sometimes asymmetrical, but nearly always elongated. Head of spermathecae perfectly smooth and bearing numerous small, round, clear spots, frequently grouped in a cap, which is slightly paler than remainder of spermatheca; spines distinct. Third spermatheca much less pigmented than others, with or without very short neck at base. Dimensions on holotype: 58×36, 58×32, 25×14μ.

Male (fig. 6).—Described from two specimens apparently dying immediately after eclosion, only head being very weakly pigmented and rest of body colorless. Length of body 1.8–2.0 mm depending on degree of extension of abdomen. Length of wing 1.40 mm. Variations and frequency reported for comparison with those of *L. asilomar*.

Antenna.—Pubescence present on distal portion of XIV.

Palpus.—Sensory pit located beyond middle of segment III. As in female, opening is prolonged toward apex of segment by groove or gutter, but this feature, very frequent in males, is found in two other species of this group. Segment IV distinctly shorter than III.

Chelys.—Four setae strictly in straight line;

equidistant in one specimen; two median setae much closer together in other specimen.

Mesonotum.—Lateral setae (both sides): (6+3), (4+4), (5+4), (8+4).

Wing.—Generally hyaline tint, but without significance since specimens had not acquired their normal pigmentation. Costal setae (both sides): 19, 20, 21, 21.

Legs.—Basal setae of fifth tarsomere strictly erect. Spines of forebasitarsus: (4)×1 and (5)×3; midbasitarsus: (3)×2, (4)×1, (5)×1.

Genitalia.—Unsuitable for description in one of the specimens; visible with difficulty and only its midportion represented in the other. Tergum IX in specimen examined, with two strong setae of fleshy setose lobes not in two different levels in anteroposterior sense as in *L. americanus* and *L. asilomar*, but on one level, ventral margin of lobes becoming distal and nearly perpendicular to axis of genitalia. Dististyle—spatulate spine and tubercle located at tip of dorsal margin stronger than in *L. americanus*, but weaker than in *L. asilomar*.

Proximal of three ventral setae is weak; two others as long and as strong as in *L. asilomar*. Aedeagus and macule of this specimen scarcely pigmented; aedeagus of genitalia dissected from pupa dying before eclosion of adult, and paradoxically better pigmented than in other, as shown in illustration; it is very similar to that of *L. americanus*. Apical dilation of parameres, however, very near to that of *L. asilomar*, appearing identical with latter species in some specimens.

Pupa (fig. 9).—Two exuviae (female) and 19 pupae (4 females, 15 males) dying before eclosion of adult.

Cephalothorax.—Respiratory horn nearly same size as in *L. americanus* (50–65μ), but elongate; bearing two rows of seven (six to eight) spiracular papillae. Internal spiracular chambers located at end of rows, particularly those on shorter side, are directly distinctly toward apex of horn (these are directed toward base, or transversely, in two other species studied).

Abdomen.—Length and curvature of hooks are intermediate between those of preceding and following species, more nearly like those of *L. gallicus*. In female, posterior margin of ventral face of segment VIII with usual callosities, but here forming irregular arch in midportion of

segment. In both sexes, hooks of segment IX are borne dorsally on well-developed lobe, but less voluminous and less projecting laterally than in preceding species. Otherwise see illustration.

Types.—Holotype, female, Pebble Beach, Calif., Del Monte Property, 23 September 1964, R. H. Whitsel (Type No. 72227, USNM). Allotype, male, same data but 11 August 1964, R. Schoepner, reared. Paratypes, 116 females, 4 males, 46 pupae, 50 larvae (listed in section on Distribution of Species).

Distribution.—California (Monterey and Santa Barbara County beaches) (fig. 23).

Discussion.—This species is named for R. H. Whitsel, formerly of the San Mateo County (Calif.) Mosquito Abatement District, in recognition of his important contributions to our knowledge of California *Leptoconops*.

3. *Leptoconops (Holoconops) asilomar*, new species

Female (fig. 8).—Eight specimens examined. Because of poor slides, making examination difficult, we cannot separate this species from the preceding species by the major characters used in this study. This species is distinguished, however, by a number of characters which, considered together and overriding the limits of individual variations, appear to us to justify specific differentiation.

Compared to the preceding species: General color true black. Length of body 2.0–2.5 mm. Length of wing 1.45–1.60 mm (distinctly larger than the preceding species).

Palpus.—Black. Insofar as examination permits comparison, segment III more distally enlarged and more in form of club than in *L. whitseli*. Sensory pit prolonged farther toward base of segment III; its opening narrower and more distal than that of *L. whitseli*.

Mesonotum.—Combinations of anterolateral setae according to number of posterolaterals:

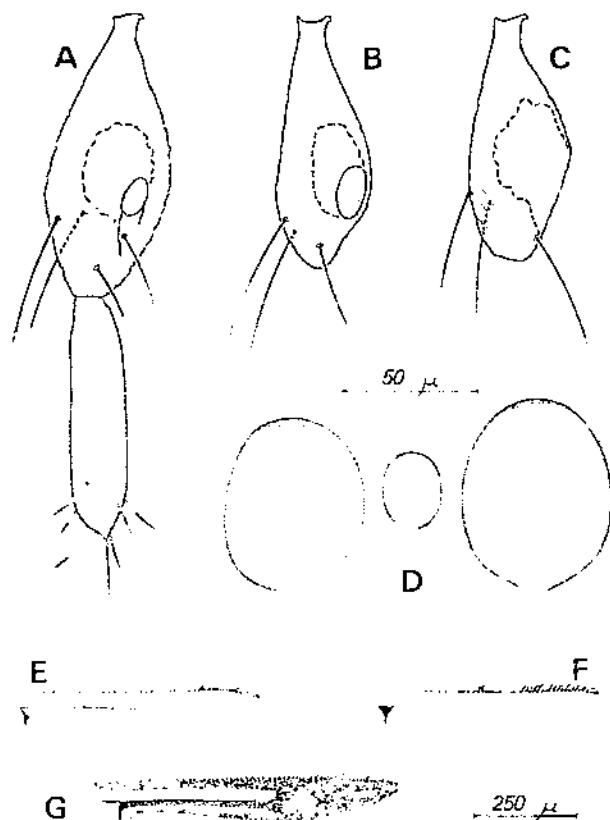


FIGURE 8.—*Leptoconops asilomar*, n. sp., female: A, Last two segments of right palpus; B and C, third segment of right palpus of two paratypes; D, spermathecae (very strongly compressed by cover glass); G, wing, showing costal, subcostal, and radial veins, stigma, and radial cell; for comparison, same elements in *L. americanus* (E) and *L. whitseli* (F).

Four posterolateral setae: (18)×1; five posterolaterals: (13)×1, (14)×1, (15)×1, (17)×1, (18)×1; six posterolaterals: (18)×1; seven posterolaterals: (19)×1. Variations and frequency of total number of lateral setae for three species of group 1 as follows:

Group 1 species	Frequency of occurrence for indicated number of lateral setae																									
	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26						
<i>americanus</i>	4	24	28	30	9	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
<i>whitseli</i>	—	—	—	—	—	5	12	11	12	12	7	5	2	1	—	1	1	—	—	—	—	—	—	—	—	—
<i>asilomar</i>	—	—	—	—	—	—	—	—	—	—	—	1	1	1	—	2	1	1	—	1	—	—	—	—	—	—

Wing.—Large, entirely brownish. Stigma pure brown; perhaps not quite as broad as in preceding species. Radial cell triangular and proportionately very large (approximately a third the

length of stigma, compared to a fourth in *L. whitseti*). Costal setae 46–64. Variations and frequency for three species of group 1 as follows:

Group 1 species	Frequency of occurrence for indicated number of costal setae																							
	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64				
<i>americanus</i>	2	2	2	8	18	18	14	11	9	9	3	2	2	—	—	—	—	—	—	—	—	—	—	—
<i>whitseti</i>	—	—	—	1	—	4	2	4	11	16	11	11	5	5	—	—	—	—	—	—	—	—	—	—
<i>asilomar</i>	—	—	—	—	—	—	—	—	—	—	1	—	—	2	—	2	1	1	—	1	—	—	—	—

Legs.—Also much longer than in preceding species: Foreleg 1.35 mm (compared to 1.0 mm for *L. whitseti*), midleg 1.6 compared to 1.2 mm, hind leg 1.9 compared to 1.4 mm. Femora and tibiae black; basitarsi yellowish brown; distal tarsomeres blackish. Tarsal spines much stronger

than in preceding species (fig. 5); formulas: Foreleg: (3)×1, (4)×6, (5)×4, (6)×3, (7)×1; midleg: (2)×3, (3)×6, (4)×7. Variations and frequency for three species of group 1 as follows:

Group 1 species	Frequency of occurrence for indicated number of tarsal spines on—													
	Foreleg							Midleg						
	1	2	3	4	5	6	7	1	2	3	4	5	6	7
<i>americanus</i>	17	92	74	16	1	—	—	73	93	34	—	—	—	—
<i>whitseti</i>	2	5	58	51	18	4	—	3	27	94	11	1	—	—
<i>asilomar</i>	—	—	1	6	4	3	1	—	3	6	7	—	—	—

Abdomen.—Spermathecae were poorly visible in available preparations, apparently subspherical except one spermatheca on one specimen, which is distinctly elongated. As in preceding species, no diverticulum on head, which is marked with more or less rounded, small, clear spots. It is impossible to measure the spermathecae.

Male (fig. 6).—Eleven specimens examined. General color pure black. Length of body 1.8–2.3 mm. Length of wing 1.6–1.7 mm.

Antenna.—Pubescence present on distal part of XIV and XIII.

Palpus.—Very elongated. Sensory pit up to two-thirds distance to tip of segment III,

generally much more distad than in *L. americanus* and *L. whitseti*. IV two-thirds as long as III.

Clypeus.—Variable. Proboscis nearly as long as height of head (this length may be variable in the female).

Mesonotum.—Combinations of anterolateral setae according to number of posterolateral setae: Three posterolateral setae: (8)×1; four posterolaterals: (7)×1, (8)×3, (11)×1; five posterolaterals: (8)×1, (10)×1, (11)×1; six posterolaterals: (8)×1, (11)×1. Variations and frequency of total number of lateral setae for males of group 1 as follows:

Group 1 species	Frequency of occurrence for indicated number of lateral setae												
	6	7	8	9	10	11	12	13	14	15	16	17	
<i>americanus</i> (both sides)	4	10	1	1	—	—	—	—	—	—	—	—	
<i>whitseti</i> (both sides)	—	—	1	2	—	—	1	—	—	—	—	—	
<i>asilomar</i>	—	—	—	—	—	2	3	1	1	2	1	1	

Wing.—Entirely brownish; costal and radial veins darker. Costal setae long, numerous (20–32), rarely leaving any voids at base of

wing. Variations and frequency for males of group 1 as follows:

Group 1 species	Frequency of occurrence for indicated number of costal setae											
	10	12	14	16	18	20	22	24	26	28	30	32
<i>americanus</i>	1	—	1	4	1	1	—	—	—	—	—	—
<i>whitseti</i> (both sides)	—	—	—	—	—	2	2	—	—	—	—	—
<i>asilomar</i>	—	—	—	—	—	1	—	3	3	3	—	1

Legs.—Femora and tibiae black, with numerous conspicuous long hairs, especially on tibiae; tarsi blackish, with pale areas as in *L. americanus*. Basal setae of fifth tarsomere strictly erect.

Tarsal spines: Foreleg: (4)×5, (5)×7, (6)×6; midleg: (2)×2, (3)×14, (4)×5. Variations and frequency for males of group 1 as follows:

Group 1 species	Frequency of occurrence for indicated number of tarsal spines on—									
	Foreleg					Midleg				
	2	3	4	5	6	1	2	3	4	5
<i>americanus</i>	8	6	2	—	—	5	6	4	—	—
<i>whitseti</i>	—	—	1	3	—	—	—	2	1	1
<i>asilomar</i>	—	—	5	7	6	—	2	14	5	—

Genitalia.—Difficult to examine on available slides. Apparently not differing from the preceding species except for some very small details. Dististyle—with proximal of three hairs on ventral face extremely weak, nearly colorless, two others very long and strong. Aedeagus as illustrated. Apical dilation of parameres very much elongated, progressively narrowed up to its mesal extremity; otherwise mesal teat always appearing to be distinctly shorter and paler than lateral one; according to compression of preparation by cover glass, apical dilation may present appreciably different appearance, approaching one or other of preceding species; in one specimen all distal half of parameres is reversed. Macule unique, crescent shaped, of loose texture except on proximal margin, which is denser; accessory macule not visible, but perhaps hidden by weak pigmentation on each side diffusing into surrounding tissue.

Pupa (fig. 9).—Three exuviae (two females, one male) and two pupae (female, male) dying before eclosion of adult.

Cephalothorax.—Respiratory horn very large (65–100 μ), elongated, each of the 2 rows with

12–18 spiracular papillae of relatively small diameter (respiratory horn illustrated, only 1 in series having convenient orientation, is largest of the 3 species, but its magnification in illustration is only half that of the other 2 species).

Abdomen.—Hooks longer, more slender, and little more curved than in two preceding species. In female, posterior margin of ventral face of segment VIII bears usual two callosities, which are large and transversely elongated. In both sexes, hooks of segment IX are borne on weak lobe, poorly differentiated, not projecting laterally and poorly visible; ventral in position in female, dorsal in male. Otherwise see illustration.

Types.—Holotype, female, allotype, male, three-fourths mi S. of Asilomar, Monterey County, Calif., 20 March 1964, R. Doty, reared (Type No. 72228, USNM). Paratypes, 92 females, 42 males, 50 larvae, 40 pupae (listed in section on Distribution of Species).

Distribution.—California (Monterey County beaches) (fig. 23).

Discussion.—We are indebted to Robert F. Schoeppner, San Mateo County Mosquito Abatement District, for the following notes on the

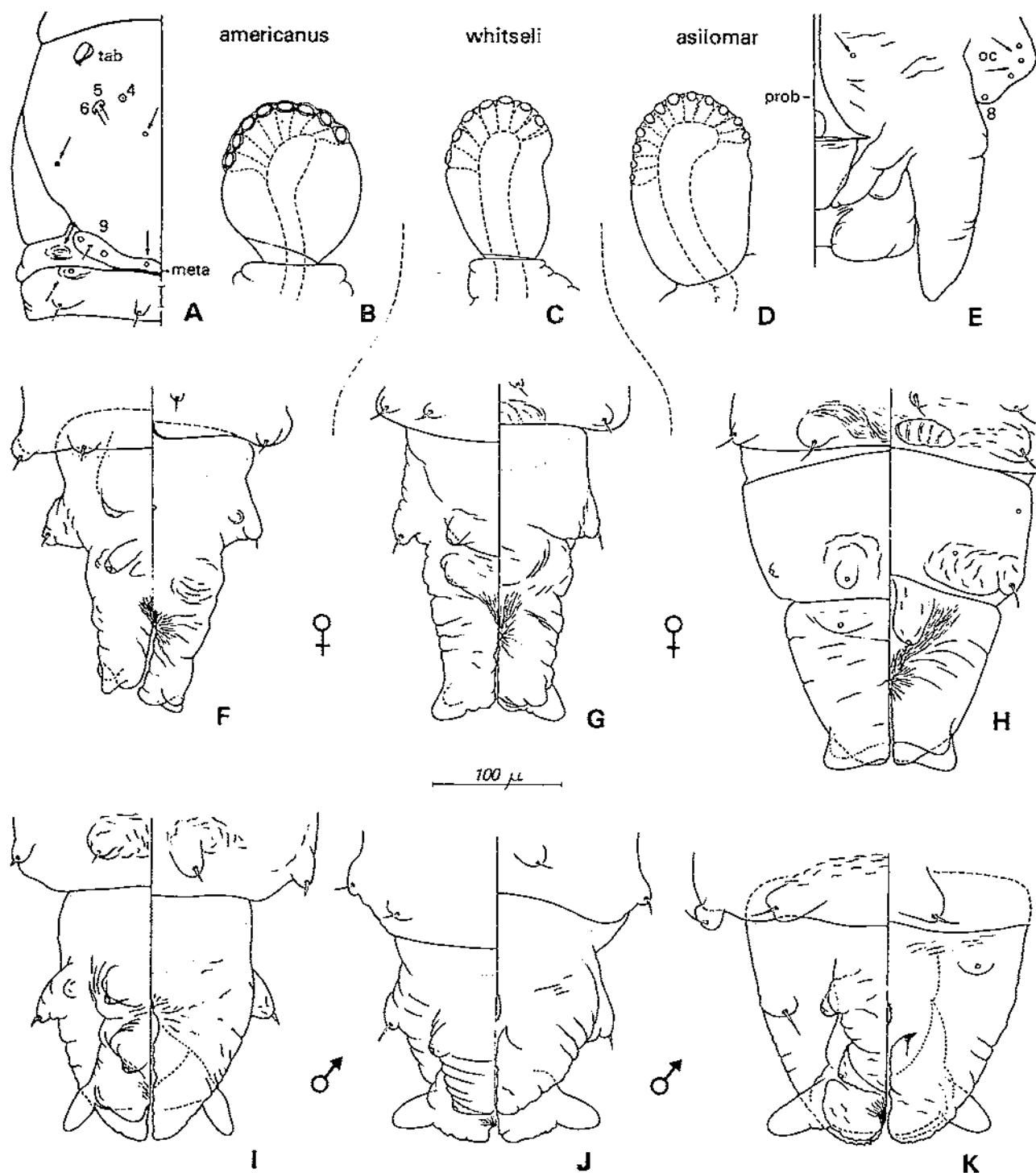


FIGURE 9.—Pupae of *Leptoconops americanus* Carter (A, B, F, I), *whitseti*, n. sp. (C, G, J), and *asilomar*, n. sp. (D, E, H, K): A, Dorsal face (left side) of cephalothorax and first abdominal segment (*meta*, metathorax; *tab*, tabular eminence; for numbered setae and spots, see text); B–D, respiratory horn; E, partial view of ventral face of cephalothorax, including tip of sheath of proboscis (*prob*), palpus, mouth parts, and ocular plate (*oc*); in A and E, arrows indicate new elements described (scale of enlargement variable); below, last two abdominal segments and posterior extremity of eighth segment in dorsal (left) and ventral (right) view.

breeding habitats of *L. whitseti* and *L. asilomar*. Both species were bred from the same 40- to 50-acre site owned by the Del Monte Properties in the Asilomar-Pebble Beach area approximately 4 miles south of Pacific Grove. This area of impounded fresh-water runoff from a nearby golf course was surrounded by high, clean, white sand dunes (fig. 26, A, B). The *Leptoconops* larvae were found in an algal layer one-fourth to one-half inch below the soil surface. Algal identifications by P. C. Silva, Department of Botany, University of California at Berkeley, included a wide variety of blue-green algae, of which *Aphanothece* was most common, with *Anabaena*, *Chroococcus*, *Gloethece*, and *Oscillatoria* also present; also a few desmids, green algae, and diatoms were present.

4. *Leptoconops* (*Holoconops*) *knowltoni*, new species

Leptoconops kerteszi Kieffer; Bacon, 1953: 27 (Washington, habits); Curtis, 1957: 18 (British Columbia, habits); Mulla, 1958: 55 (California, in human ear); ? Jones, 1961: 113 (Colorado, biting sheep); Foulk, 1966a: 230 (Salton Sea, Calif.; biology; control); Foulk, 1966b: 225 (Salton Sea, Calif.; emergence traps); Foulk and Sjogren, 1967: 281 (Salton Sea, Calif.; ecology); Foulk, 1969: 112 (Mecca, Calif.; biology; control); Jones et al., 1972: 507 (Texas, biting horse, possible vector of Venezuelan equine encephalomyelitis).

Leptoconops (*Holoconops*) *kerteszi* Kieffer; Wirth and Atchley, 1973: 45 (in part).

Leptoconops (*Holoconops*) *bequaerti* (Kieffer); Wirth and Atchley, 1973: 39 (in part; record from Padre Island, Tex.).

Female (fig. 10).—General color dull brown. Length of body 1.40 (1.20–1.75) mm. Length of wing 1.25–1.55 mm. Variations and anomalies based on 100 specimens; reported for comparison with those of *L. arnaldi*.

Supraorbital setae.—One mesal seta lacking on one side on two specimens.

Antenna.—Segments at first transverse, broadened from IV to VI, which is frequently but not always the broadest, then narrowed up to X, XI, and XII, which are slender and usually barrel shaped; XIII frequently longer than broad; XIII elongated, subcylindrical, narrowed in midportion. Basal black setae: On IV very short; on V and VI about 2.5 times as long as diameter of segment and slightly surpassing hairs of verticils. Variations: Absence of basal black seta on

VI, two times; presence of one basal seta on VII, one time. On specimens from Texas, all basal black setae are extremely short, less than twice as long as diameter of segment. Verticils of six to eight, rarely nine hairs, length less than twice diameter of segment. Sensory setae: As in *L. americanus* and *L. whitseti*, seta on III opposed to sensilla frequently lacking; on IV to X, long and very strong, with diameter equal to that of black seta on VI; on XI and XII, generally fused in single hypertrophied seta, rarely separate; on VI, sensory seta next to black basal seta in line with others. External black seta present up to IX or XI, rarely on XII; when it is lacking, base of segment remains bare, but its presence or absence does not seem to lie in fusion or separation of corresponding sensory setae; on XIII, single median black seta present. Variations: 1 seta more, 1 time; absence of this seta on 1 side, 12 times; on 2 sides, 3 times. In group of specimens examined, two more important aberrations have been observed: (1) In one female, on one side and on external face of segments IV–XIII, presence of two to six hairs of male plume, and absence of all external black setae, without any other sign of gynandromorphism elsewhere; (2) in one other female, one antenna teratological on all its length, as shown in illustration.

Palpus.—Segment III dull brown, strongly expanded on ventromesal face, subglobose or globose. Sensory pit in form of truncated cone whose axis would be perpendicular to that of segment along its greatest length, then bent toward apex at its extremity, which is slightly cornuate; opening (with some exceptions) much narrower than diameter of pit, and situated about middle of anterior face of segment on border of mesal face. IV paler and distinctly shorter than III, stocky in appearance.

Clypeus.—With four setae arranged equidistant in approximately straight narrow line; without characters of taxonomic value in this species nor three following. Anomalies: One lateral seta extra, one time; one mesal seta extra, two times; less, seven times.

Mesonotum.—Combinations of anterolateral setae according to number of posterolaterals: Three posterolateral setae: (4)×15, (5)×39, (6)×26, (7)×10, (8)×7; four posterolaterals: (5)×1, (6)×1, (8)×1.

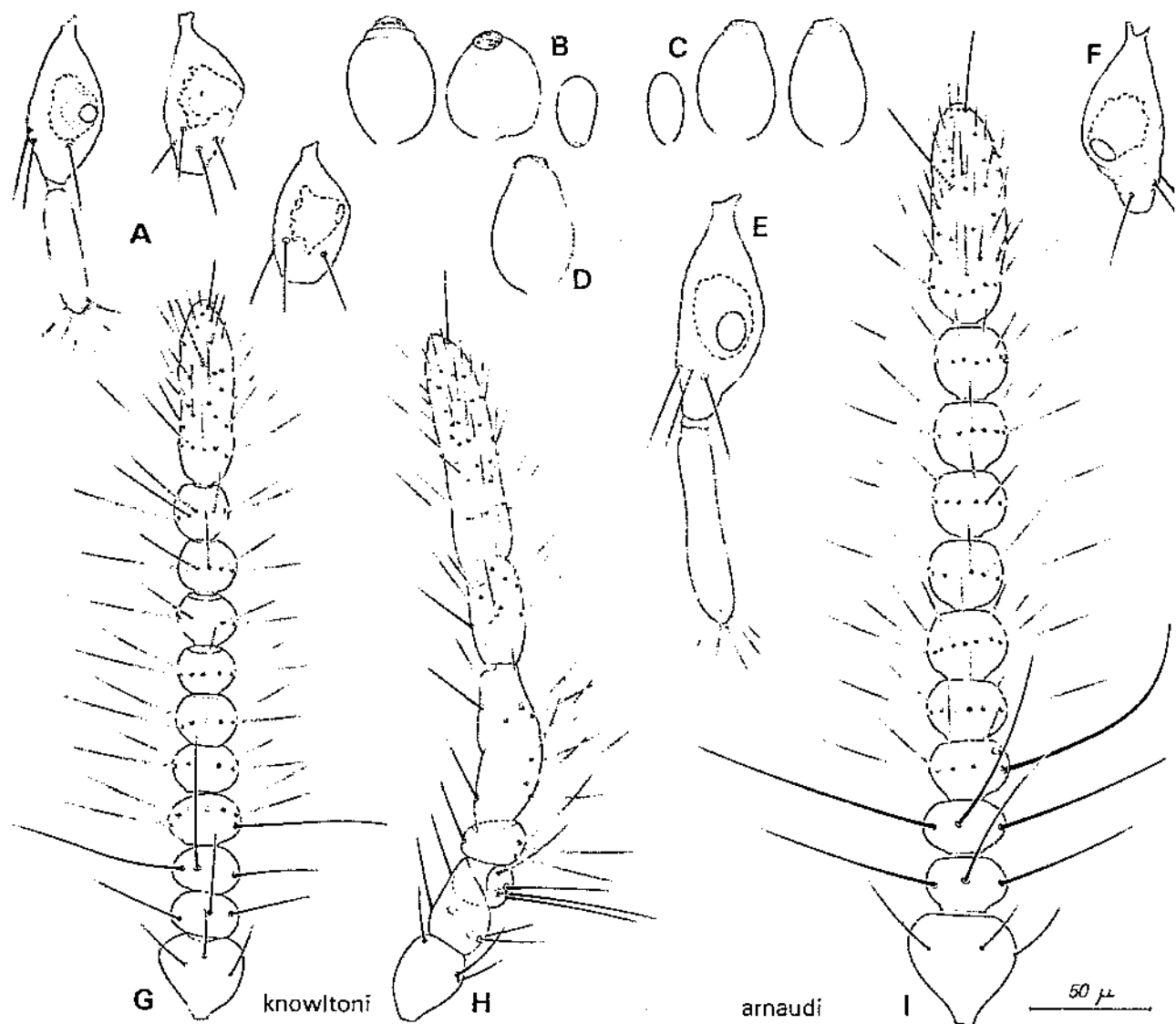


FIGURE 10.—*Leptoconops knowltoni*, n. sp. (A, B, D, G, H), and *L. arnaudi*, n. sp. (C, E, F, I), females: G, I, Antenna, internal face; H, abnormal antenna (left, external face; right, internal face); A, E, F, palpi; B, C, spermathecae of specimens of *L. knowltoni* with pale or spotted legs and of *L. arnaudi*, D, spermatheca of specimens of *L. knowltoni* with legs uniformly infuscated.

Wing.—Small, hyaline. Stigma triangular, tip sharp pointed; also hyaline. Microtrichia weak and poorly visible. Costal setae 21–37.

Legs.—Femora and tibiae pale brown; foretibia extensively yellowish at tip; first two tarsomeres yellowish, distal three weakly infuscated. Spines of basitarsus: Foreleg: (1) $\times 71$, (2) $\times 110$, (3) $\times 16$, (4) $\times 2$; midleg: Without median spines, except one time one very weak spine on one side.

Abdomen.—Two large spermathecae more or

less elongate ovoid, with basal neck frequently eccentric; bearing prominent, well-developed diverticulum on head, surface of which is very irregularly embossed and marked with small, slightly depressed, pale spots; deformed on type and impossible to measure. Third spermatheca yellowish, without neck. Approximate dimensions on one paratype: 55×35 , 60×32 , $28 \times 15 \mu$.

Male (fig. 11).—Length of body 1.25–1.50 mm. Length of wing 0.80–0.95 mm. Sixteen specimens examined; variations and frequency

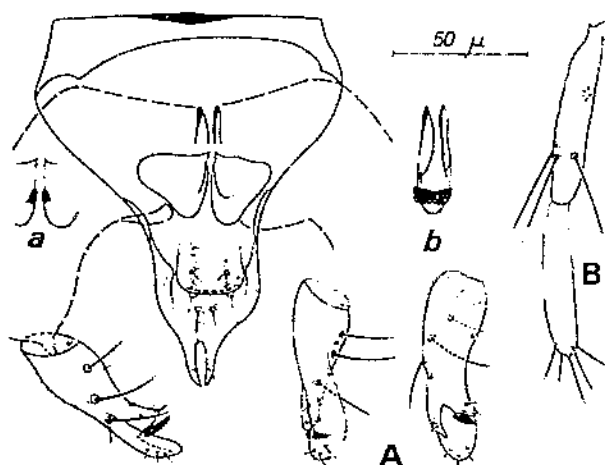


FIGURE 11.—*Leptoconops knowltoni*, n. sp., male: A, Median part of genitalia seen ventrally: Left and middle, right dististyle in ventral view under two slightly different orientations; right, left dististyle in dorsal view; a, denticulations of parameres when their distal halves are in strictly oblique position; b, aedeagus and macule; B, last two segments of right palpus.

reported for comparison with those of *L. arnaudi*.

Antenna.—With sparse pubescence present on distal part of XIV.

Palpus.—Last two segments blackish. Sensory pit always located distinctly on proximal half of segment III; its opening prolonged toward apex by gutterlike depression. IV much shorter than III.

Mesonotum.—Combinations of anterolateral setae according to number of posterolaterals: Two posterolateral setae: (3)×3, (5)×1; three posterolaterals: (3)×8, (4)×3, (5)×1.

Wing.—Hyaline; microtrichia very small, slightly enlarged toward anterior margin. Costal setae of medium size, sparse (6–11), very widely spaced at base of wing.

Legs.—Femora and tibiae brown, but foretibia yellowish on distal third; first two tarsomeres yellowish, distal three slightly brownish. Basal setae of tarsomere V decumbent. Tarsal spines (midbasitarsus unarmed): Foreleg: (1)×9, (2)×20, (3)×3.

Genitalia.—Tergum IX nearly as long as broad, not or scarcely surpassing tip of basistyles; lateral margin regularly thickened, prolonged nearly straight, at same time narrowing toward two submedian processes of posterior margin,

last virtually obsolete, and in any case dimensions extremely reduced; two setose fleshy lobes often in low position (distal) overlapping more or less transverse “bar,” and relatively less distant from two setae of posterior margin than in other species of group. Proximal margin of sternum IX presenting in its median part a sclerotized triangular thickening, highly pigmented, directed ventrally (erect), for this reason nearly invisible in ventral view, but possible to recognize by focusing microscope. Dististyle—three setae of ventral face widely spaced and in basomedian position; proximal one weaker than two others; latter extremely strong, black, longer than greatest breadth of dististyle, not rectilinear but curved as if they were coiled around segment. Tubercle located at tip of dorsal margin conical and strong; bearing short but strong, nearly spiniform seta. Ventral margin prolonged lengthily in form of appendage beyond distal margin, which is largely covered by broad, pigmented, lamelliform expansion; this complex especially characteristic, whatever orientation of dististyle. Aedeagus as illustrated. Apical dilation of parameres of form generally found in *kerteszi* complex, with following slight differences: In case apical half of paramere is directed obliquely, proximal tooth is obtuse, very broad at base, and rather abruptly narrowed at tip; distal tooth scarcely formed, very short, tip rounded, indistinctly separated from rest of dilation and not overlapping proximal one; in case distal half is nearly perpendicular to axis of genitalia, distal tooth appears very long and very slender, as in illustration; when distal half finally is perpendicular to this axis, dilation presents same aspect as that observed in *L. foulki* under same conditions (see fig. 20). Macule poorly visible, of loose texture, rectangular and transverse, with two posterior angles slightly prolonged distally; no accessory macule visible.

Types.—Holotype, female, allotype, male, near shore Salton Sea, Riverside County, Calif., 10–15 September 1964, J. D. Foulk, emergence trap (Type No. 72229, USNM). Paratypes, 67 females, 18 males (listed in section on Distribution of Species).

Distribution.—Arizona, California, Idaho, Montana, Nevada, Texas, Utah; Mexico (Sinaloa) (fig. 24).

Discussion.—This species is named for George F. Knowlton, Utah State University, Logan, in recognition of his long and steady interest in Utah biting midges.

In the female of this species, whose area of distribution is very broad, variations of color and structure are numerous; the latter occurs mainly on antennal segment XIII (length and form), the palpus (absolute and relative length of the last two segments, diameter of the opening of the sensory pit), and the spermathecae. In a very general but not absolute fashion, the specimens collected in California or Texas have the legs uniformly very pale or weakly infuscated, and in the latter case in the form of a broad median band on the femora and tibiae; the mesonotum is, on the other hand, extremely dark blackish, contrasting with the weak salmon tint of the body; the spermathecae are not elongate but nearly as broad as long, with a well delimited and characteristic, more or less remarkable diverticulum.

In females originating elsewhere, the femora and tibiae are uniformly brownish (except the tip of the foretibia); the mesonotum not as dark, the body of the usual tint; the spermathecae elongate ovoid, with the diverticulum proportionally broader and forming a cap over all the head of the organ, which it appears to prolong. But the pale spotted legs, or entirely brownish legs, also may be found in the same California series, and it is not unusual to observe the two forms of the spermathecae in the same individual.

As for the male, the 12 California specimens examined are inseparable from those from Utah (1 specimen) and Mexico. We believe therefore that we are able to identify as *L. knowltoni* all the material reported under this name in the section on Distribution of Species.

We have a series from Williams Spring, Organ Pipe Cactus National Monument, Pima County, Ariz., 14.ii.1970, P. H. Arnaud, Jr., which we are provisionally assigning to *L. knowltoni*, but they differ in the female antenna, in which XIII has two median black setae (seven times) or one median black seta (once). These specimens will key out to *L. americanus* on this character, but otherwise they seem to be typical *L. knowltoni*.

5. *Leptoconops (Holoconops) arnaudi*, new species

Leptoconops kerteszi Kieffer; Freeborn and Zimmerman, 1934: 261 (synonymy; male described; fig. genitalia; Bodega Bay, Calif.); Ebeling, 1975: 445 (biology, control).

Holoconops kerteszi (Kieffer); Smith and Lowe, 1948: 157 (Bodega Bay, Calif.; biology; immature stages).

Female (fig. 10).—General color dull brown. Length of body 1.7–2.4 mm. Length of wing 1.10–1.45 mm. Variations and anomalies based on 14 specimens.

Supraorbital setae.—On all specimens examined, two mesal supraorbital setae are nearer to each other than to corresponding lateral setae (this character is not specific and may also be present in preceding species).

Antenna.—Browish black. Proximal segments of flagellum transverse as in preceding species; next segments at first progressively enlarged and broadened up to VIII or IX, which are the largest, and usually barrel shaped, then narrowed, without perceptible modification of form, up to XI and XII, which are most frequently longer than broad; XIII elongate, slightly narrowed in midportion. Basal black setae distinctly longer than hairs of verticils; longer than those of preceding species, in variable proportions according to origin of specimens. Anomalies: One basal black seta observed once on VII, once on VII and VIII, and twice on X. Verticils of 8–10 hairs, about 1.5 times as long as diameter of segment; when external black seta is lacking on XII, they may number up to 16, and then are often implanted in irregular row, or same with some elements situated beyond this line. Sensory setae: On III, seta opposite sensilla usually present and stronger than other; from IV to X, all slender, of less diameter than that of basal black seta on VI; on XI and XII, generally distinct, rarely fused in single seta; on VI, respective positions of basal black seta and corresponding sensory seta are reversed. External black setae present up to XI (IX–XII), frequently double, as long as hairs of verticils; one time on XIII on one side. As previously remarked, in case this seta is lacking, base of segment is occupied by hyaline hairs; on XIII,

single median black seta present; no anomaly observed.

Palpus.—Segment III black, moderately enlarged in midportion, nearly fusiform. Sensory pit of reduced size, in form of regular truncated cone, not curved on its axis; opening very broad. diameter scarcely less than that of pit; located on anterior face a little nearer mesal face than lateral. IV brown, subcylindrical, and slender, as long or nearly as long as III.

Clypeus.—As in preceding species. One time, one mesal seta less, on one side.

Mesonotum.—Combinations of anterolateral setae according to number of posterolaterals: Three posterolateral setae: (6)×1, (9)×2, (10)×5, (12)×1; four posterolaterals: (7)×1, (9)×1, (11)×1, (12)×1, (17)×1. Variations and frequency of total number of lateral setae for four species of group 2 as follows:

Group 2 species	Frequency of occurrence for indicated number of lateral setae																		
	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21				
<i>knowltoni</i>	15	39	27	11	7	1	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>arnaudi</i>	-	-	1	-	1	2	6	-	2	1	-	-	-	-	1	-	-	-	-
<i>atchleyi</i>	-	-	-	1	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-
<i>vargasi</i> (2 sides)	-	-	-	-	-	1	1	1	1	-	-	-	-	-	-	-	-	-	-

Wing.—Generally of grayish tint, which increases from posterior to anterior margin. Stigma triangular, tip sharp pointed, posterior margin most often concave. Radial cell large;

color more or less brownish according to specimen. Microtrichia enlarged, very distinct. Costal setae 42-63. Variations and frequency for four species of group 2 as follows:

Group 2 species	Frequency of occurrence for indicated number of costal setae																										
	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64					
<i>knowltoni</i>	7	15	23	15	14	12	11	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>arnaudi</i>	-	-	-	-	-	-	-	-	-	-	1	-	-	1	-	4	1	-	2	4	-	1	-	-	-	-	-
<i>atchleyi</i>	-	-	-	-	-	-	-	-	1	-	-	-	1	-	-	-	1	-	-	-	-	-	-	-	-	-	-
<i>vargasi</i>	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-

Legs.—Femora and tibiae dull brown; foretibia not paler at its tip; tarsi brownish, usually with very slight pallor on anterior basitarsus, sometimes on hind basitarsus also. Tarsal spines:

Foreleg: (2)×6, (3)×14, (4)×2, (5)×3. Variations and frequency for four species of group 2 as follows:

Group 2 species	Frequency of occurrence for indicated number of tarsal spines on foreleg							
	1	2	3	4	5	6	7	8
<i>knowltoni</i> ¹	71	110	16	2	-	-	-	-
<i>arnaudi</i> ¹	-	-	6	14	2	3	-	-
<i>atchleyi</i> ²	-	-	1	-	1	3	-	1
<i>vargasi</i> ³	-	4	-	-	-	-	-	-

¹ Midbasitarsus unarmed.

² Midbasitarsus possibly armed.

³ Midbasitarsus armed.

Abdomen.—Two large *spermathecae* similar to those illustrated for non-California specimens of preceding species. Pale spots are less numerous and more extensive, at times forming broad pale region with very irregular contours, resembling contracted scars. Third spermatheca slightly paler than others. Dimensions on holotype: 52×34 , 54×32 , $30 \times 14 \mu$.

Male (fig. 12).—Length of body 1.75–2.50 mm. Length of wing 1.20–1.55 mm. Four specimens examined.

Antenna.—Pubescence present on base of XV, on all the length of XIV, on distal part of XIII, and sometimes on distal part of XII.

Palpus.—Last two segments, respectively, dark brown and pale brown. Sensory pit located at midportion or just before midportion of III. The more III is long, the more IV seems to be short.

Mesonotum.—Combinations of anterolateral setae according to number of posterolaterals (both sides): Two posterolateral setae (3) \times 2; three posterolaterals: One time each with 4, 5, 6, 7, 8, and 9 anterolaterals. Variations and

frequency of total number of lateral setae for known males of group 2 as follows:

Group 2 species	Frequency of occurrence for indicated number of lateral setae										
	5	6	7	8	9	10	11	12			
<i>knowltoni</i>	3	8	4	1	—	—	—	—			
<i>arnaudi</i> (both sides)	2	—	1	1	1	1	1	1			
<i>atchleyi</i> (both sides)	—	—	—	7	8	3	—	—			

Wing.—Pale gray; microtrichia of medium size. Costal setae 13–24. Variations and frequency for known males of group 2 as follows:

Group 2 species	Frequency of occurrence for indicated number of costal setae										
	6	8	10	12	14	16	18	20	22	24	26
<i>knowltoni</i>	4	4	4	3	—	—	—	—	—	—	—
<i>arnaudi</i>	—	—	—	—	1	1	—	1	—	1	—
<i>atchleyi</i>	—	—	—	1	1	5	6	3	1	—	1

Legs.—Femora and tibiae blackish brown; tarsi entirely brown except forebasitarsus yellowish. Basal setae of fifth tarsomere erect and curved, sometimes appearing strictly erect, which does not represent any difficulty as seen in introductory section. Tarsal spines (midbasitarsus unarmed): Foreleg: (1) \times 1, (2) \times 1, (3) \times 2, (4) \times 3, (5) \times 1. Variations and frequency for known males of group 2 as follows:

Group 2 species	Frequency of occurrence for indicated number of tarsal spines on foreleg							
	1	2	3	4	5	6	7	8
<i>knowltoni</i>	9	20	3	—	—	—	—	—
<i>arnaudi</i>	1	1	2	3	1	—	—	—
<i>atchleyi</i> ¹	—	—	—	—	4	11	6	1

¹ Midbasitarsus possibly armed.

Genitalia.—Tergum IX longer than broad; lateral margins thickened distally, their pubescence usually surpassing area of fleshy setose lobes; these lobes well separated from two setae on posterior margin, which are located very close together; on two specimens examined, proximal

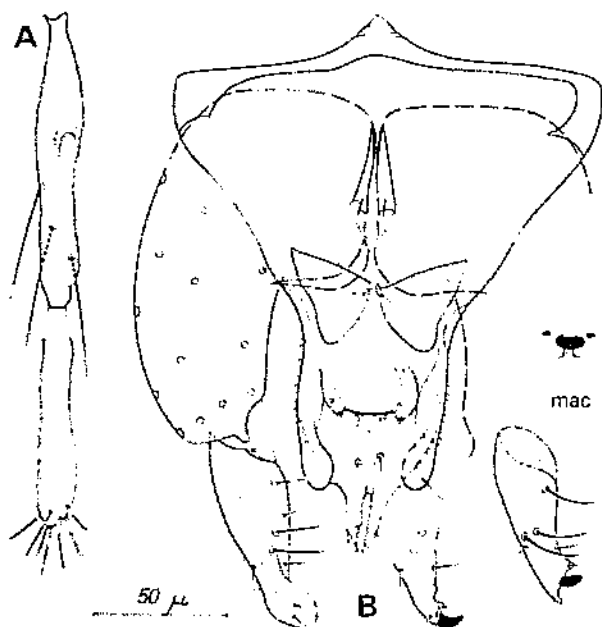


FIGURE 12.—*Leptoconops arnaudi*, n. sp., male: A, Last two segments of right palpus; B, genitalia in ventral view, with tip of dististyle seen in three different orientations, and macules (mac) isolated (arrow shows empty space between two teeth of apical dilation of parameres).

margin of sternum IX with triangular median dilation, whose apex is poorly defined and poorly visible. Dististyle—three hairs of ventral face in basimedial position, proximal one widely separated from others, all strong and rectilinear, and nearly as long as greatest breadth of dististyle. Spatulate spine in form of small, apical black mass, triangular or conical, which is not broadly overlapped, but simply covered by lamelliform expansion of ventral margin, latter rather small. Aedeagus as illustrated. Distal half of parameres directed obliquely, visible in ventral view; on apical dilation proximal tooth, which is also dorsal, is narrower at base than in *L. knowltoni* and on whole is slightly incurved; distal (ventral) tooth is again more slender than dorsal, which it part way crosses; between two is an empty space not found in any other species examined. Macule compact, transverse, and slightly curved, with form badly defined and with indefinite limits; it is flanked on each side and in proximal position by accessory macule of dense texture; also on each side but in distal position, a weak diffuse pigmentation of soft tissue.

Types.—Holotype, female, allotype, male, Bodega Bay, Sonoma County, Calif., 10 Sept. 1964, W. H. Whitsel (Type No. 72230, USNM). Paratypes, 24 females, 50 males (listed in section on Distribution of Species).

Distribution.—California (Sonoma and Ventura County beaches) (fig. 24).

Discussion.—This species is named for Paul H. Arnaud, Jr., California Academy of Sciences, San Francisco, in appreciation of his steady interest and assistance in the study of ceratopogonids.

6. *Leptoconops (Holoconops) atchleyi*, new species

Female (fig. 13).—General color blackish to black, contrasting with absence of all pigmentation on wing. Length of body 1.95–2.10 mm. Length of wing 1.24–1.50 mm. Three specimens examined; variations and frequency reported for comparison with those of *L. arnaldi*.

Antenna.—Black. Segment IV slightly transverse, following segments progressively subglobose, then globose, at XI and XII longer than broad; all nearly same diameter, antenna appearing moniliform; XIII elongated, subcylindrical,

slightly narrowed on its basal third. Basal black setae on IV as long as hairs of verticils; extremely long on V (3.5 times diameter of segment), moderate on VI (2.5 times diameter of segment). Verticils of seven to nine short hairs, scarcely 1.5 times as long as diameter of segment. Sensory setae widely separated in all segments, including XI and XII; on VI (fig. 13, A), respective positions of basal black seta and corresponding sensory seta are reversed; on

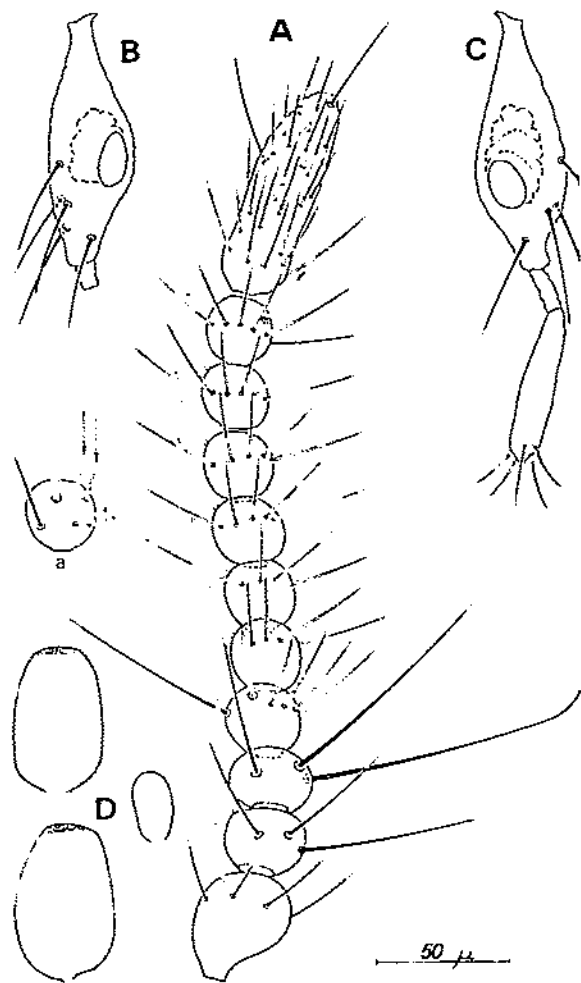


FIGURE 13.—*Leptoconops atchleyi*, n. sp., female: A, Segments III–XIII of antenna, showing greatest part of internal (mesal) face (right) and beginning of external face (left); latter represented by isolated portion (a), showing two small supplementary sensory setae (arrows); B, segment III of right palpus; C, last two segments of left palpus; D, spermathecae. On antennal segment VI, note permutation of basal black seta and corresponding sensory seta.

opposing series, they are always accompanied laterally by two smaller hyaline sensory setae, respectively, implanted at center of rounded pale spot of integument, similar to that of sensory seta (such elements are sometimes observed on certain specimens of different species, but in irregular fashion, on only some segments and only one per segment). External black setae present up to XII or XIII; nearly always double or triple from base of flagellum up to X or XI; on XIII, one median black seta.

Palpus.—Distal two segments blackish; III elongated, broad distally, its shape similar to that of *L. whitseti* and *L. asilomar*. IV slender, proportionately longer than in two species of first group.

Clypeus.—Four setae arranged in usual manner; one lateral seta more, one time.

Mesonotum.—(7+3), (8+3), and (10+3) lateral setae.

Wing.—Entirely hyaline. Stigma triangular, posterior margin rectilinear, and apex sharply pointed; hyaline. Microtrichia punctiform and colorless; scarcely perceptible on posterior margin of wing and more distinct on anterior margin. Costal setae very slightly pigmented, nearly colorless; 38–54.

Legs.—Femora and tibiae blackish; tarsi slightly paler. Tarsal formulas: On each of three specimens examined, one of midbasitarsi is unarmed, but other bears median spinule perfectly developed: Foreleg: (3)×1, (5)×1, (6)×3, (8)×1; midleg: (0)×3, (1)×3.

Abdomen.—Two large spermathecae subequal, elongate ovoid; their surface perfectly smooth as in females of first group, without any trace of diverticulum on head, which is slightly flattened. Head with numerous small spots that are slightly paler than rest of organ and slightly depressed; also numerous spines. Third spermatheca same color as others, without neck. Dimensions: 58×38, 58×32, 26×15μ.

Male (fig. 14).—Body entirely black. Length of body 2.20–2.45 mm. Length of wing 1.45–1.70 mm. Eighteen specimens examined; variations and frequency reported for comparison with those of *L. arnaudi*.

Antenna.—Only one of all American males examined with pubescence present at tip of segment III (see fig. 2); also on IV and V, where it is very difficult to recognize; also at

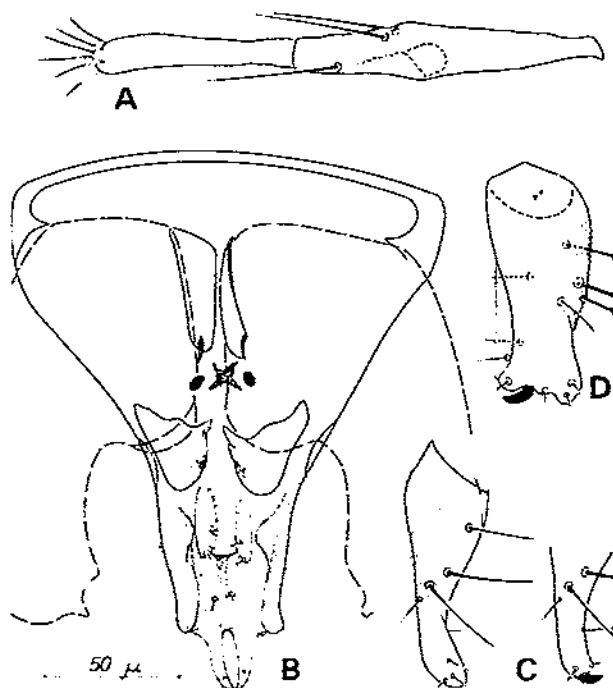


FIGURE 14.—*Leptoconops atchleyi*, n. sp., male: A, Last two segments of right palpus; B, median portion of genitalia; C, right dististyle in ventral view (right, dotted line shows lamelliform expansion supposedly removed); D, left dististyle (slightly flattened) seen from external face.

base of mesal face of XV and on all distal part of XIV.

Palpus.—Last two segments black, very elongate. III may be of form usually observed, or very slender from end to end, with annular dilation limited to area of sensory pit; this located just distad of middle of segment; IV clubbed, distinctly shorter than III. Proboscis black, nearly as long as head height.

Clypeus.—Not distinctive.

Mesonotum.—Combinations of anterolateral setae according to number of posterolaterals: Two posterolateral setae: (6)×1; three posterolaterals: (5)×6, (6)×8, (7)×3.

Wing.—Entirely hyaline, except extreme base of costa, which is slightly brownish. Microtrichia minuscule, scarcely visible. On costa, 12–26 nearly colorless setae of medium length, as in female; setae of anterior margin, beyond stigma and denuded area, entirely colorless, hyaline.

Legs.—Femora and tibiae black; tarsi blackish brown. Basal setae of fifth tarsomere erect

curved. Tarsal formulas (legs missing on several specimens): Foreleg: (5)×4, (6)×11, (7)×6, (8)×1; midleg: (0)×9, (1)×6, (2)×2, (3)×1.

Genitalia.—Ninth tergum and dististyle very close to those of *L. arnaldi*, but without their being entirely identical. Basimedian position of three ventral setae of dististyle not always evident. Distal half of parameres directed obliquely, visible by ventral examination; apical dilation not appearing to differ from that of *L. arnaldi*, except by the teeth, which are larger. Macule of loose texture, limits very imprecise and difficult to define, resembling sometimes that of preceding species, rarely in form of four-pointed star; always flanked on each side and in slightly distal position by large accessory macule, more or less rounded, and extremely dense.

Types.—Holotype, female, allotype, male, Tolenas, Cemeni Hill Rd., 1 mi NE. Fairfield, Solano County, Calif., 8 March 1965, E. Mezger (Type No. 72231, USNM). Paratypes, 1 female, 97 males (listed in section on Distribution of Species).

Distribution.—California (Solano and San Joaquin Counties) (fig. 24).

Discussion.—This species is named for William R. Atchley, Texas Tech University, Lubbock, in recognition of his important and innovative work on the biosystematics of North American Ceratopogonidae.

The female of this species, presenting characters belonging to two groups, resembles the females of *L. whitsei* and *L. asilomar* in the form of the palpus and spermathecae, as well as the presence of one median spine on the midbasitarsus. It is distinguished from them by other characters, opposite and nonequivocal: Presence of only one median black seta on antennal segment XIII; stigma of wing triangular, tip sharp pointed. The male agrees with the general morphology of its proper group (group 2).

**7. *Leptoconops (Holoconops) vargasi*,
new species**

? *Leptoconops kerteszi* Kieffer; Whitsel, 1965: 66 (Carmen Isl., Baja California).

Female (fig. 15).—General color dull brown. Length of body 1.75 mm (holotype) and 2.0 mm.

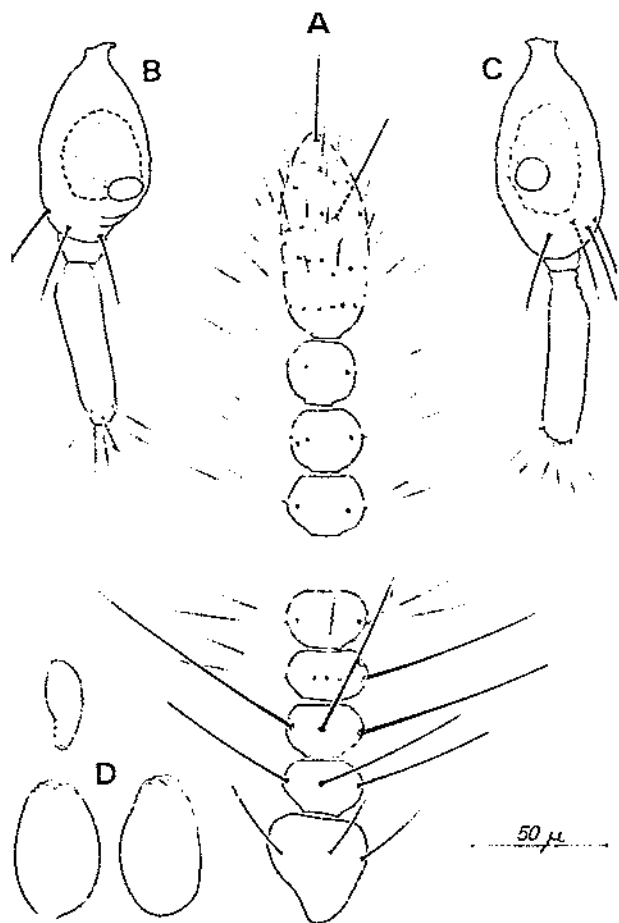


FIGURE 15.—*Leptoconops vargasi*, n. sp., female: A, Segments III-VII and X-XIII of antenna viewed from internal (mesal) face; B, last two segments of right palpus of type in oblique position; C, same segments of left palpus of paratype in horizontal position; D, spermathecae.

Length of wing 1.25 mm (holotype) and 1.3 mm. Two specimens examined; variations and frequency reported for comparison with those of *L. arnaldi*.

Antenna.—Dull brown. Segments IV to VI slightly transverse; following segments imperceptibly elongated up to XII, which may be globose or slightly longer than broad; as in *L. arnaldi* but in much more discrete manner there is a progressive broadening of segments from IV to VIII or IX, followed by narrowing beyond; XIII very slightly swollen in middle. Basal black setae: On IV as long as hairs of verticils; on V and VI extremely long (three times diameter of segment). Verticils of six to nine hairs, about twice as long as diameter of

segment. Sensory setae: On III, two setae present, stronger found on side opposite sensilla; on VI, respective positions of basal black seta and corresponding sensory seta are reversed; on XI, two distinct setae; on XII they are separate on three antennae, fused in a single seta on fourth. External black seta present up to XI, three times; up to XII, one time; when this seta is lacking, base of segment remains bare; on XIII, a single strong median black seta.

Palpus.—Segment III dull brown and similar to that of *L. knowltoni*; IV brown, very much shorter than III, appearing stout.

Clypeus.—Four setae without any distinction in holotype; one lateral seta extra on one side and two on other in paratype.

Mesonotum.—Lateral setae (both sides): (10+3), (8+4), (10+4), (10+5).

Wing.—Brownish gray. Stigma triangular, apex sharp pointed and posterior margin very slightly convex; strongly infuscated. Radial cell rounded in outline. Microtrichia enlarged, much more so approaching anterior margin. Costal setae 43–53.

Legs.—Femora and tibiae blackish brown; foretibia slightly paler on tip; basitarsi brownish yellow on their proximal portions; remainder of basitarsi and all other tarsomeres brownish. Tarsal spines: Foreleg: (2)×4; midleg: (1)×2, (2)×2.

Abdomen.—Two large spermathecae elongate; on head, diverticulum more or less developed, embossed, and marked with small rounded and large scarlike depressions, slightly paler, as well as numerous spines that can scarcely be seen. Third spermatheca, same color as others, and proportionately longer than in other species examined; without neck. Dimensions on holotype: 54×32, 50×30, 35×14μ.

Types.—Holotype, female, San Quintin, Baja California, Mexico, 16–18 February 1965, A. M. Barnes, from ears of man (Type No. 72232, USNM). Five female paratypes (listed in section on Distribution of Species).

Distribution.—Mexico (Baja California) (fig. 24).

Discussion.—This species is named for Luis Vargas, for many years our leading authority on medical entomology in Mexico, in recognition of his important work on Mexican Ceratopogonidae.

From the presence of a single median black seta on antennal segment XIII and the form of the alar stigma, this species belongs to the second group of species narrowly defined. It constitutes an anomaly, as in the preceding species, by the presence of median spines on the midbasitarsus. The form of the palpus resembles that of *L. knowltoni*, from which the species is separated by the presence of these tarsal spines, as well as by their larger size, more lateral setae on the mesonotum, more costal setae, and by the coloration of the wing.

3. *Leptoconops (Holoconops) andersoni*, new species

Female (fig. 16).—General color blackish. Measurement of body impossible. Length of wing about 1.0 mm. Two specimens examined.

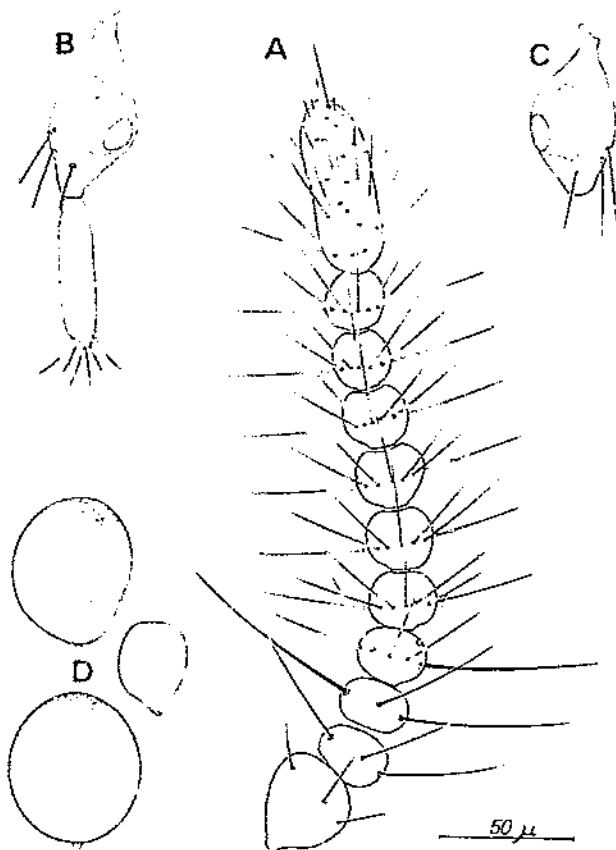


FIGURE 16.—*Leptoconops andersoni*, n. sp., female: A, Antenna viewed from internal (mesal) face; B, last two segments of right palpus, ventral view; C, segment III of left palpus, ventral view; D, spermathecae (upper one slightly deformed).

Antenna.—Blackish. Proximal segments slightly broadened from IV to VI, then slightly narrowed and lengthened until XII; XIII cylindrical, tip rounded. Basal black setae of medium thickness and relatively long on IV (as long as hairs of verticils); stronger than preceding on V and VI and fairly long (about twice diameter of segment). Verticils of 8–11 hairs, about twice as long as segment diameter. Sensory setae: On III, very slender and present on both sides; elsewhere scarcely stronger than hairs of verticils; broadly separated on XI and XII; respective positions of basal black seta on VI and of corresponding sensory seta have been investigated on five specimens; it has not been possible to define them precisely five times; for other five times they are seen to be reversed regularly. External black seta of medium length, present up to XI or XII; when lacking on XII, base of segment remains bare; on XIII, no median black seta.

Palpus.—Stout. Segment III blackish like antenna; globosely enlarged except at extreme base, which forms short petiole. Sensory pit in form of truncated cone, occupying great part of segment and extending equally toward base and apex; opening of large diameter, located on mesal face. IV paler and shorter than III.

Clypeus.—Two mesal setae very close together and distinctly distad of two lateral setae, but this arrangement may also be found in other species of group 3.

Mesonotum.—Black. Lateral setae: (5+3) and (6+3).

Wing.—Very slight brownish gray tint. Stigma little darker; although a "broad" type, it is less broad than in species of group 1, and its apex is also less broadly rounded. Microtrichia enlarged, prominent. Costal setae 31–38.

Legs.—Entirely blackish, except ventral face of forebasitarsus, which is slightly paler; on forebasitarsus, hairs of ventral margin extremely strong, possibly causing confusion with spines. Tarsal formulas: Foreleg: (1)×1, (3)×1, (4)×1, (5)×1; midleg: (1)×1, (2)×1, (3)×1, (4)×1.

Abdomen.—Two large spermathecae highly pigmented; equal and of same form, regularly ovoid. Head rounded and smooth, without any form of diverticulum; marked with sparse, slightly paler dots grouped in cap. Third sper-

matheca elongate ovoid; of same color as others; proportionately (like that of *L. vargasi*) longer than in other species studied; without neck at base. Dimensions: 74×54, 74×54, 48×32μ.

Types.—Holotype, female, Hopland, Mendocino County, Calif., University of California Field Station, 18 May 1973, E. T. Schmidtman, from calf at top of East Canyon (Type No. 72233, USNM). Paratypes, six females (listed in section on Distribution of Species).

Distribution.—California (Mendocino County, valley of Russian River) (fig. 25).

Discussion.—This species is named for John R. Anderson, University of California at Berkeley, in recognition of his important work on ceratopogonid feeding habits and disease transmission.

From its general characteristics (stigma of wing rounded at tip, median spines present on midbasitarsus, spermathecae without diverticulum), this species should belong to the first group of species in the broad sense, but the absence of median black setae on antennal segment XIII places it in the third group, where it constitutes an anomaly that separates it immediately from all the rest of the group. The anomaly would be the same if characters of the antenna had placed it in the second group. It is possible but highly improbable that a specimen of *L. andersoni* might be considered a specimen actually belonging to the first group, but with both antennae anomalous by the simultaneous absence of the two median black setae on each of the 13th segments. In this eventuality it would be separated from *L. americanus*, *whitseti*, and *asilomar* by its small size, the characteristic form of the palpus, the absence of necks on the two large spermathecae, and the important relative length of the third spermatheca; also from the two last species by the smaller number of setae on the mesonotum and costa.

9. *Leptoconops (Holoconops) sublettei*, new species

Leptoconops kerteszi Kieffer; Jones, 1965: 217 (Weld County, Colo.; biting sheep); Jones, 1967: 462 (Weld County, Colo.; biting sheep).

Female (fig. 17).—General color pale brown. Length of body about 1.7 mm. Length of wing

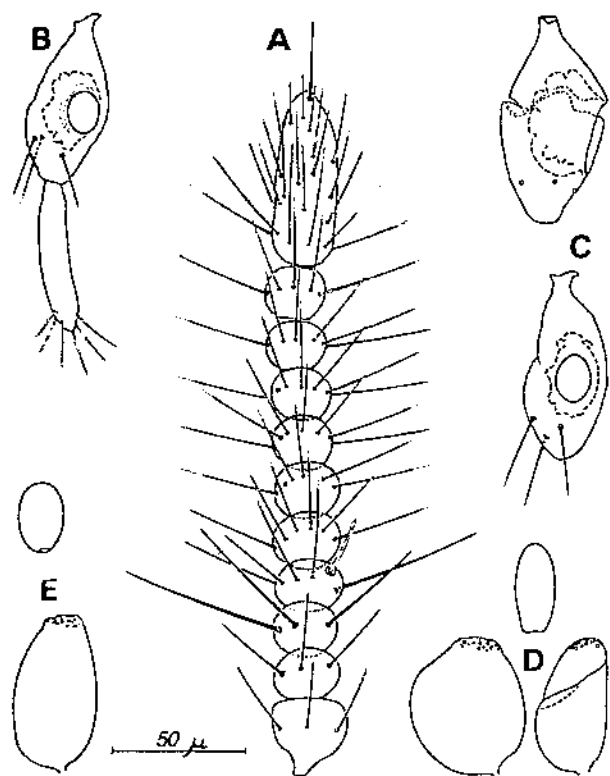


FIGURE 17.—*Leptoconops sublettei*, n. sp., female: A, Antenna viewed from internal (mesal) face; B, last two segments of right palpus, ventral view; C, segment III of right palpus of two paratypes in lateral view (above, flattened by cover glass) and ventral view; D, spermathecae; E, spermathecae of paratype.

0.8–1.0 mm. Variations and frequencies noted on 12 specimens; reported for comparison with those of *L. foulki*.

Antenna.—Segments slightly transverse and without important change of form from IV to XII; VII and VIII slightly enlarged, latter sometimes globose; XIII subcylindrical, slightly narrowed in midportion. Basal black setae of medium length (2.5 times diameter of segment); on VI, respective positions of this seta and corresponding sensory seta are reversed. Verticils with seven to nine short hairs (1.5 times as long as diameter of segment). Sensory setae: On III that which is opposed to sensilla strong, other very weak; displaced on VI. External black seta present up to X or XI; when lacking, base of segment remains bare; on XIII, median black seta lacking; verticils usually of four to five hairs on each of faces; subapical black seta longer than diameter of segment.

Palpus.—Segment III brown; moderately broad on its ventral face, very slightly laterally; lateral face slightly depressed in midportion. Sensory pit in shape of slender truncated cone, directed transversely, without any outline of retort-shaped neck; opening almost half as large as basal breadth, very large with diameter proportionately greater than that of following species. IV very narrowly brown at base, progressively paler distally, cylindrical, slightly shorter than III.

Clypeus.—Without basal setae; four distal setae nearly in straight line, but their spacing variable.

Mesonotum.—Combinations of anterolateral setae according to number of posterolaterals: Two posterolateral setae: (7)×1; three posterolaterals: (5)×1, (6)×5, (8)×3.

Wing.—Entirely hyaline. Stigma triangular, tip sharp pointed. Radial cell ellipsoidal, well formed. Microtrichia weak, poorly pigmented and poorly visible posteriorly, more apparent toward anterior margin of wing. Costal setae 25–40.

Legs.—Femora brown; tibiae slightly paler, broadly yellowish at tip on anterior leg. On all legs, first two tarsomeres yellowish, distal three slightly brownish. Tarsal formulas: Foreleg: (1)×3, (2)×17, (3)×2, (4)×1; midleg: Unarmed, except one specimen that bears one median spine on one side and three on other, and two specimens with one spine on one side.

Abdomen.—Two large spermathecae rather variable and deformed in numerous gravid examples; most often of same form as in species of second group, one of them being strongly swollen at base. Third spermatheca slightly less pigmented than other two, and generally less elongated than on holotype. Dimensions: 50×40, 50×30, 35; 15μ.

Male (fig. 18).—General color pale brown. Length of body about 1.5 mm. Length of wing 0.85–0.95 mm. Four specimens examined.

Antenna.—Some elements of pubescence rarely at tip of segment XIV.

Palpus.—Coloration similar to that of female. Sensory pit located at middle or just before middle of segment III.

Clypeus.—Four distal setae equidistant and disposed in straight line.

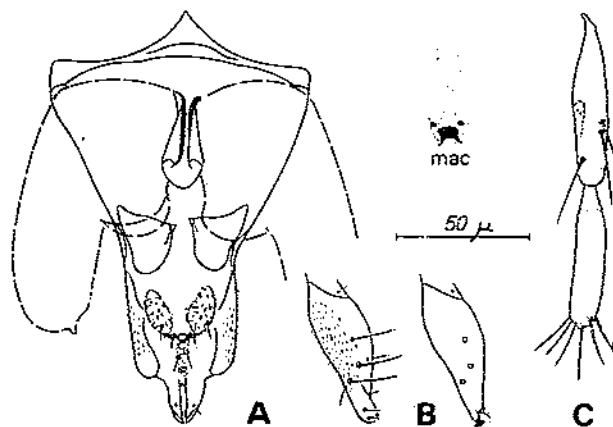


FIGURE 18.—*Leptoconops sublettei*, n. sp., male: A, Genitalia in ventral view; B, dististyle (right, dotted line shows lamelliform expansion supposedly removed); C, last two segments of left palpus. (mac, macules)

Mesonotum.—Lateral setae: $(3+3) \times 3$ and $(4+3) \times 1$.

Wing.—Entirely hyaline; microtrichia as in female; 6–10 costal setae.

Legs.—Coloration similar to that of female. Basal setae on fifth tarsomere long and doubly curved, nearly decumbent. Tarsal formulas: Foreleg: $(1) \times 3$ and $(2) \times 4$; midleg: Unarmed.

Genitalia.—With general characters described for second and third groups, namely, ninth tergum without conspicuous process on dorsal face; two setae of posterior margin very close together and far removed from fleshy setose lobes. In *L. sublettei*, ninth tergum is elongated and broadly surpasses tips of basistyles; submedian processes of posterior margin maintaining at their base general direction of tergum, but then moderately and progressively curved toward ventral face on their distal portions; proximal margin of ninth sternum presenting mesad a process more or less apparent according to its orientation and degree of compression of preparation. Dististyle with three ventral setae in median position. Lamelliform expansion of ventral margin poorly developed and just barely overlapping spatulate spine; tubercle located at tip of dorsal margin normally visible on ventral examination. Apical dilation of parameres with proximal tooth obtuse, not digitiform. Macule loose, more or less transversely elongated; accessory macule of medium size, poorly visible.

Types.—Holotype, female, Sinton, Tex., summer 1963, R. S. Cook (Type No. 72234, USNM). Paratypes, five females, same data as holotype.

Distribution.—Arizona, California, Colorado, Montana, Nebraska, New Mexico, North Dakota, Oklahoma, Texas, Wyoming (fig. 25).

Discussion.—This species is named for James E. Sublette, Eastern New Mexico University, Portales, in appreciation of his long friendship and in recognition of his extensive contributions to the study of Nearctic Diptera, especially of the Southwestern States.

The four males described, the only ones available when the description was first prepared, are associated, respectively, with females collected at Imperial Dam, Imperial County, Calif., (two females, three males), and Bosque del Apache, Socorro County, N. Mex., 18 July 1965, W. R. Atchley (two females, one male). But the females, which agree well with the definition of the species, differ in certain details, such as the greater length of the hairs of the verticils or the form of the spermathecae, and are themselves assigned to *L. sublettei* with very slight reservation. Subsequent to the preparation of the description, we obtained a good series of this species, which was collected in Weld County, Colo., including males as well as females. This series agrees well with the description here and confirms our association of the sexes and our concept of the species. Because these males are from Colorado, somewhat removed from the Texas type locality, we prefer not to designate a male allotype.

10. *Leptoconops (Holoconops) foulki*, new species

Leptoconops kerteszi Kieffer; Ryckman, 1961: 405 (Imperial County, Calif.; notes on feeding on jack-rabbit ears); ? Murray, 1966: 36 (Tulare County, Calif.); Foulk, 1967: 424 (Santa Ana River, Calif.; feeding habits, bloodmeal size); Sjogren and Foulk, 1967: 394 (Santa Ana River, Calif.; colonization; feeding habits; larval biology); Foulk, 1968: 223 (Norco, Calif.; adult resting behavior); Rees et al., 1969: 29 (in part, Utah, biology and control); Rees and Winget, 1970: 121 (Little Mountain, Weber County, Utah; biology; control); Legner et al., 1970: 633 (Santa Ana River, Calif.; control of larvae); Georgiou et al., 1972: 205 (Santa Ana River, Calif.; insecticides for adult control).

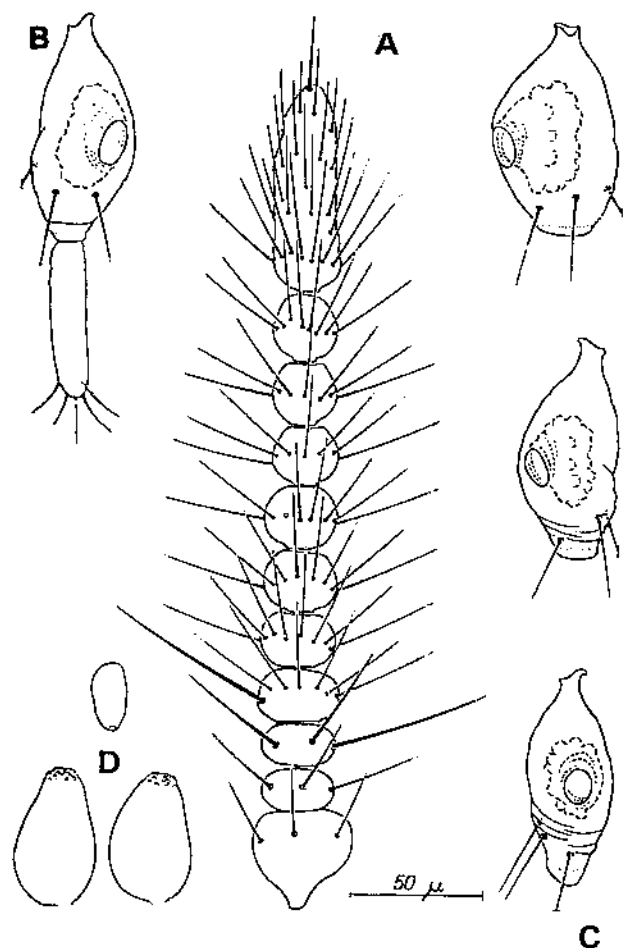


FIGURE 19.—*Leptoconops foulki*, n. sp., female: A, Antenna viewed from internal (mesal) face; B, last two segments of right palpus, ventral view; C, from top to bottom, segment III of left palpus in lateral view, same in oblique view slightly depressed, segment III of right palpus in ventral view slightly depressed; D, spermathecae.

Female (fig. 19).—General color blackish brown. Length of body 1.20–1.70 mm. Length of wing 0.90–1.10 mm. Variations and anomalies noted on 40 specimens.

Antenna.—Segment IV transverse and often very small; following at first rapidly enlarged up to VI or VII, which are largest of flagellum, then progressively narrowed up to XI or XII, which are slightly longer than broad; XIII cylindrical, slightly narrowed in midportion. Basal black setae: On IV scarcely longer than diameter of segment; on V and VI scarcely 2.5 times this diameter. Variations: Absence of basal black seta

on VI, nine times; on two sides, one time. Verticils with hairs short (about 1.5 times diameter of segment) but numerous (8–12, and up to 16 on XII, where they are often arranged in irregular row). Sensory setae: On III that which is opposite sensilla strong, other weak and often doubled by another still weaker seta; on VI situated in line with others (no exception has been observed in material examined) External black seta shorter than hairs of verticils, present up to IX or XI; in case it is lacking, base of segment remains bare; on XIII, no median black seta (present once on single side); subapical black seta nearly as long as diameter of segment; at base of lateral face five to six hyaline hairs of irregular verticils.

Palpus.—Segment III dark brown, similar to that of preceding species, with lateral face slightly depressed at middle, but larger and more swollen ventrally. Sensory pit voluminous; appearing in direct view in shape of flattened, truncated cone, very broad at base and of low height, and slightly inclined toward tip of segment; examined in oblique or lateral position, pit appears asymmetrical and very slightly cornuate near its opening; latter is of much smaller diameter than base of pit, but still large. IV brown proximad, progressively paler up to its tip; cylindrical or slightly clubbed; shorter than III.

Clypeus.—Normally without basal setae; four distal setae nearly in straight line, two mesal setae being closer to each other than to corresponding lateral seta. Variation: One lateral seta extra, six times; one mesal seta less, three times. Supplementary lateral seta may be implanted a variable distance from normal seta, and in extreme cases resembles a basal seta; one may recognize it to a certain extent by its size, which is comparable to that of seta which it duplicates. A true basal seta has, however, been observed four times on specimens forming a part of a normal series and exhibiting themselves all the characters of the species.

Mesonotum.—Combinations of anterolateral setae according to number of posterolaterals: Three posterolateral setae: (5)×12, (6)×14, (7)×6, (8)×4, (9)×2, (10)×1; four posterolaterals: (6)×1. Variations and frequency of total number of lateral setae for species of group 3 as follows:

Group 3 species	Frequency of occurrence for indicated number of lateral setae						
	7	8	9	10	11	12	13
<i>sublettei</i>	-	1	6	-	3	-	-
<i>foulki</i>	-	12	14	7	4	2	1
<i>reesi</i>	1	15	27	22	1	1	-
Species C (both sides) ..	-	1	1	-	-	-	-

Wing.—Very pale gray. Stigma triangular with sharp-pointed tip; more or less tinted with brown. Microtrichia of medium size and moder-

ately pigmented, more apparent near anterior margin. Costal setae 21–41. Variations and frequency for species of group 3 as follows:

Group 3 species	Frequency of occurrence for indicated number of costal setae										
	22	24	26	28	30	32	34	36	38	40	42
<i>sublettei</i>	-	-	1	1	5	1	1	1	1	1	-
<i>foulki</i>	1	1	1	-	3	7	8	9	2	3	3
<i>reesi</i>	-	2	5	8	10	17	11	7	5	2	-
Species C (both sides)	-	-	-	1	1	-	-	-	-	-	-

Legs.—Femora and tibiae dark brown; foretibia very slightly pale at tip; tarsi uniformly pale brown except forebasitarsus pale on its basal half. Tarsal formulas: Foreleg: (1)×20, (2)×48, (3)×5, (4)×5; midleg: One time on single specimen, one median spine on one side and one rather poorly formed spine on other. Variations and frequency for species of group 3 as follows:

Group 3 species	Frequency of occurrence for indicated number of tarsal spines on foreleg				
	0	1	2	3	4
<i>sublettei</i>	-	3	17	2	1
<i>foulki</i>	-	20	48	5	5
<i>reesi</i>	2	53	65	15	1
Species C	-	1	1	-	-

Abdomen.—Two large spermathecae subequal and resembling those of group 2; ovoid, more or less elongate or saclike; provided at base with short neck, often eccentric. At head numerous small pale depressions, centered with implantation of a "spine." Third spermatheca very lightly pigmented, without particular characters. Dimensions: 48×29, 45×29, 25×13μ.

Male (fig. 20).—General color blackish. Length of body 1.50–1.90 mm. Length of wing 0.90–1.35 mm. Variations noted on 30 specimens.

Antenna.—Pubescence present on distal portion of XIV.

Palpus.—Last two segments with coloration as in female. Sensory pit relatively broad, located at middle or just after middle of III; segment IV at first slightly narrowed, then more or less club shaped and slightly shorter than III.

Clypeus.—Four distal setae equidistant and situated in straight line.

Mesonotum.—Combinations of anterolateral setae, always with three posterolaterals: (2)×1, (3)×6, (4)×11, (5)×7, (6)×2. Variations and frequency of total number of lateral setae for known males of group 3 as follows:

Group 3 species	Frequency of occurrence for indicated number of lateral setae				
	5	6	7	8	9
<i>sublettei</i>	-	3	1	-	-
<i>foulki</i>	1	6	11	7	2
<i>reesi</i>	-	1	1	-	-

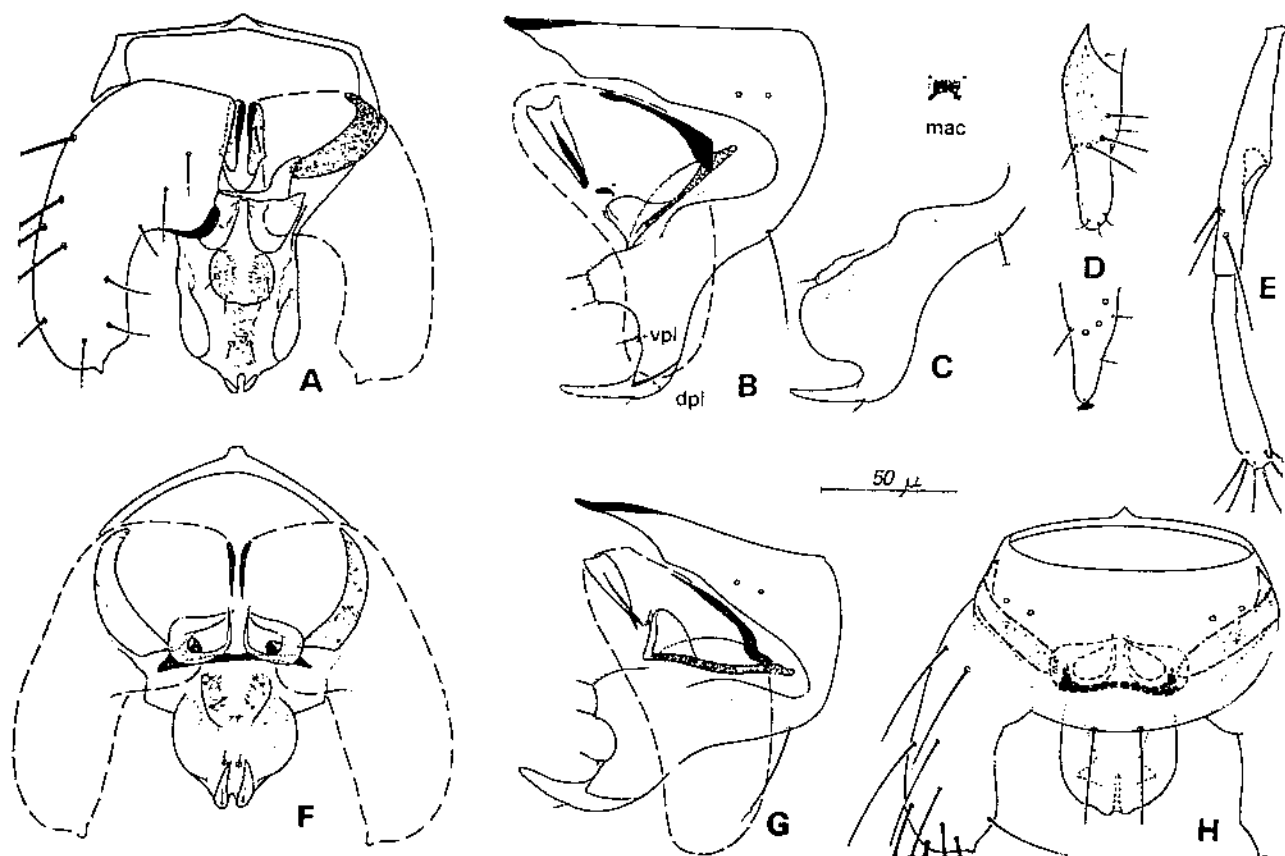


FIGURE 20.—*Leptoconops foulki*, n. sp., male: Genitalia in normal state of extension (A, B) and in state of contraction (F–H): A, F, Genitalia (without dististyles) in ventral view; B, G, same in lateral view, lateral margin of tergum IX supposedly removed; C, latter shown isolated; H, genitalia contracted in dorsal view; D, right dististyle in ventral view (below, dotted line shows its tip with lamelliform expansion supposedly removed); E, last two segments of right palpus. (dpl, dorsal plate; mac, macules; vpl, ventral plate)

Wing.—Hyaline; microtrichia similar to those of female. Costal setae 8–17. Variations and frequency for known males of group 3 as follows:

Group 3 species	Frequency of occurrence for indicated number of costal setae						
	6	8	10	12	14	16	18
<i>sublettei</i>	1	1	2	—	—	—	—
<i>foulki</i>	—	2	5	7	6	4	1
<i>reesi</i> (1 specimen)	—	—	—	1	—	—	—

Legs.—Color similar to that of female; tip of foretibia most often brown like the rest, rarely paler and then narrowly so. Basal setae of fifth tarsomere somewhat variable in this species;

most often curved erect and short, but on certain specimens or on certain tarsomeres one of them may be distinctly longer and slightly decumbent (doubly curved). To avoid all error of interpretation it is necessary to examine all the tarsomeres. Tarsal formulas (midleg unarmed): Foreleg: (1)×7, (2)×29, (3)×17, (4)×4. Variations and frequency for known males of group 3 species (foreleg) as follows:

Group 3 species	Frequency of occurrence for indicated number of tarsal spines on foreleg			
	1	2	3	4
<i>sublettei</i>	3	4	—	—
<i>foulki</i>	7	29	17	4
<i>reesi</i>	—	3	1	—

Genitalia.—May exhibit two different aspects according to whether they are in normal state of extension or in unusual state of contraction. In second case, nature of which escapes us, genitalia appear to be "closed" by contraction of ventral face, tergum IX forming a hinge in its narrowest part. These two "states" do not result from conditions of slide preparation, because both have been observed on undissected males preserved in the same vial of alcohol, before any other manipulation.

Normal state, in extension: Tergum IX slightly longer than broad and slightly surpassing tips of basistyles; lateral margins much expanded distally, two submedian processes of posterior margin bent at right angles from base, two fleshy setose lobes much removed from two setae of same margin; proximal margin of sternum IX presenting in midportion a process of variable form, more or less noticeable according to its orientation and degree of flattening of slide. Dististyle with three ventral setae in median position; first rather weak, other two much stronger; hyaline seta, which is almost in line with preceding ones, is found most often in strictly ventral position because of very slight mesal rotation of dististyle. Lamelliform expansion of ventral margin poorly developed, just barely overlapping spatulate spine and pubescent up to vicinity of apical setae; tubercle located at tip of dorsal margin usually hidden under spatulate spine on ventral examination because of rotation already mentioned. Distal half of parameres in oblique position; apical dilation of usual form, with two teeth distinct, long and drawn out digitiform, distal tooth more or less broadly crossing proximal one. Aedeagus and macule as shown in illustration; accessory macules extremely reduced and possibly escaping notice.

State of contraction differs from preceding as follows: Tergum IX projects ventrally, appearing short and globular; fleshy setose lobes are erected to maximum, ventral plate (of median pigmented band) is then seen in direct view on all its length and no longer appears in form of transverse bar. Distal halves of parameres close themselves on basal halves and take a direction perpendicular to axis of genitalia; orientation of apical dilation is then seen reversed, appearing in very different aspect from that described

here, and quite characteristic. When genitalia in state of contraction are viewed from dorsal side, this aspect of apical dilations is maintained, but most often that of rest of genitalia is deeply modified and not recognizable.

Types.—Holotype, female, allotype, male, Santa Ana, Orange County, Calif., Santa Ana River Flood Channel, McFadden Bridge, 27 October 1966, J. Shanafelt (Type No. 72235, USNM). Paratypes, 66 females, 19 males (all from California, listed in section on Distribution of Species).

Distribution.—California, Montana, Nevada, Oregon, Utah (fig. 25).

Discussion.—This species is named for Joseph D. Foulk, National Sanitation Consultants, San Francisco, Calif., in recognition of his important studies of *Leptoconops* biology in southern California.

11. *Leptoconops (Holoconops) reesi*, new species

Leptoconops kerteszi Kieffer; Rees and Smith, 1950: 9 (N. Salt Lake City, Utah; annoyance; breeding places; control); Knowlton and Fronk, 1950: 113 (in part, Utah records); Rees and Smith, 1952: 49 (N. Salt Lake City, Utah; breeding places; biology; control); Curtis, 1957: 18 (British Columbia, biting man); Rees, 1958: 741 (N. Salt Lake City, Utah; control); Rees et al., 1969: 29 (in part, Utah, biology, control); Rees et al., 1972: 15 (in part; Beck's Hot Springs, N. Salt Lake City, Utah; breeding places; control).

Female (fig. 21).—General color pale brown. Length of body 1.30–1.85 mm. Length of wing 0.85–1.05 mm. Variations and anomalies noted on 70 specimens; reported for comparison with those of *L. foulki*.

Supraorbital setae.—One median seta extra, one time; four setae extra, one time; one seta less, two times.

Antenna.—Segments IV–VI transverse, practically same diameter on all their length and with flat articular surfaces, appearing subcylindrical; on following ones, distal articulation is scarcely modified, whereas proximal face takes progressively form and dimensions usually observed; VII and VIII usually little enlarged; IX–XII slightly narrower than preceding, XII remaining transverse, rarely globular or subglobular; XIII rather variable in form, most often enlarged in midportion. Basal black setae:

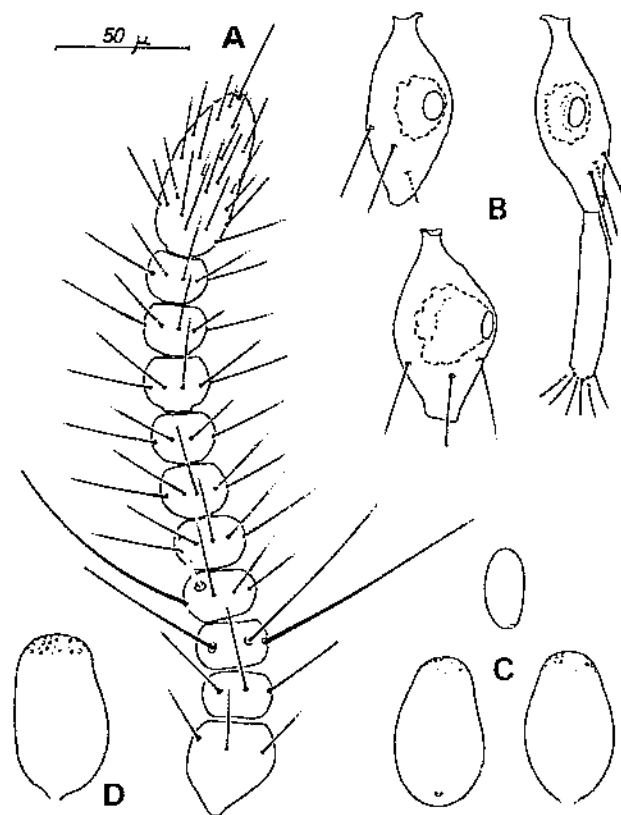


FIGURE 21.—*Leptoconops reesi*, n. sp., female: A, Antenna viewed from internal (mesal) face; B, last two segments of left palpus, ventral view (right), third segment of right palpus seen in two different orientations (left); C, spermathecae of holotype in slightly oblique position; D, spermatheca of paratype.

On IV nearly as long as hairs of verticils; on V and VI long or very long (from 2.5 to nearly four times diameter of segment), strong and rather often flexuous; displaced on VI. Variations: Basal black seta absent on VI, three times; black seta present on VII, one time. Hairs of verticils short (1.5 times diameter of segment), four to six in number (exceptionally seven or eight on one or two segments). Sensory setae: On III, present on two sides, of same size and rather slender; otherwise as strong as basal black setae; on VI, sensory seta is displaced, very rarely in same alignment as others and then in unilateral fashion. External black seta present up to X or XI; often double, rarely triple; in case it is lacking, base of segment remains bare; on XIII, no median black seta; subapical black seta long and strong. Variations: One median

black seta present, three times; one external black seta, two times; one subapical black seta extra, one time.

Palpus.—Segment III dark brown; mainly and symmetrically swollen on middle of ventral face; lateral face not depressed and whole slightly fusiform. Sensory pit resembling that of two preceding species, but small and as deep as broad; most often also in regular cone whose axis would be perpendicular to that of segment; opening narrow, usually situated in axis of pit; rarely preceded by trace of retort-shaped neck, scarcely visible. IV brown at base, progressively paler up to its tip, nearly as long as III.

Chypeus.—Bearing most often on basal portion one to three setae half as long and as strong as four distal setae, latter equidistant from each other; two mesal setae always located distad of two laterals; all these setae may present numerous variations, which are now reported. Basal setae, number and frequency: (0)×14, (1)×27, (2)×25, (3)×4; lateral setae: (1-1)×42, (1-2)×14, (2-2)×9, (2-3)×3, (3-3)×2; mesal setae: (1-1)×69, (1-2)×1. Variations of basal setae and distal setae appear to be independent of each other.

Mesonotum.—Combinations of anterolateral setae, with three posterolaterals on all specimens examined: (4)×1, (5)×15, (6)×27, (7)×22, (8)×1, (9)×1.

Wing.—Hyaline. Stigma triangular, tip sharp pointed; sometimes slightly brownish. Radial cell well formed, ellipsoidal. Microtrichia nearly colorless at base of wing and posteriorly, but more and more pigmented toward anterior margin and wing tip. Costal setae 24-40.

Legs.—Femora and tibiae brown; foretibia broadly yellowish at tip; all basitarsi, and also frequently second tarsomere to a variable degree, yellowish; rest of tarsi light brown. Tarsal formulas: Foreleg: (0)×2, (1)×53, (2)×65, (3)×15, (4)×1; midleg: One median spine present on one side, four times.

Abdomen.—Two large spermathecae elongated and basally without any distinction, except perhaps neck rather long and often eccentric. On distal part they are much less narrowed than in preceding species described, diverticulum appearing as a subcylindrical formation that prolongs body of spermatheca and whose head, more or less flattened, bears pale spots and poorly visible

spines; however, numerous variations are observed. Third spermatheca much paler than the others and of usual form, without neck at base. Dimensions (two large ones slightly oblique): 56×34 , 56×34 , $30 \times 14 \mu$.

Male.—Two specimens only, associated with a female collected at Rio Chama, N. Mex., may possibly represent the male sex of this species. They are unfortunately both crushed by the cover glass and furnish only a limited number of characters:

General color pale brown. Length of body about 1.50 mm. Length of wing 1.10 mm.

Antenna.—Segment XIV narrowly pubescent at tip.

Palpus.—Sensory pit located at middle of segment.

Clypeus.—Without basal setae; distal setae in straight line.

Mesonotum.—Lateral setae (3+3) and 4+3).

Wing (only 1 specimen).—Costal setae 11.

Legs.—Coloration similar to that of female. Basal setae of fifth tarsomere erect curved. Tarsal formulas: (2) \times 3 and (3) \times 1.

Genitalia.—Tergum IX with general characters of groups 2 and 3. Dististyle—ventral setae in median position. Lamelliform expansion of ventral margin just overlapping spatulate spine. Remainder of genitalia taxonomically not usable.

Color of legs therefore provides at this time the only way of separating these two males from those of *L. foulki*.

Types.—Holotype, female, Timpie, Tooele County, Utah, 17 April 1934, G. F. Knowlton and W. L. Thomas, "very annoying to man" (Type No. 72236, USNM). Paratypes, 41 females, all collected in eastern Tooele County, Utah (listed in section on Distribution of Species).

Distribution.—Colorado, Idaho, New Mexico, Utah, Wyoming; Canada (British Columbia, Saskatchewan) (fig. 25).

Discussion.—This species is named in memory of the late Don Rees, University of Utah, Salt Lake City, in recognition of his important contributions to the study of the biology and control of *Leptoconops* in the Salt Lake City area.

One female collected by R. C. Bechtel at Rogers Springs, Clark County, Nev., 1,500 ft, 23 April 1971, is very similar to *L. reesi* but differs in the presence of a pair of strong black setae on the

front, as well as in small differences in the alignment of lateral sensory seta VI on the antenna and the structure of the spermathecae, and is thought probably to represent a distinct species. Because it is known only from a unique specimen and because of its overall similarity to *L. reesi*, we prefer not to name it at this time but present the following description and an illustration (fig. 22).

12. *Leptoconops* (*Holoconops*) Species C

Female (fig. 22).—General color blackish brown. Length of body 1.4 mm. Length of wing 0.9 mm. A single specimen examined, whose chaetotactic formulas are reported with those of *L. foulki*.

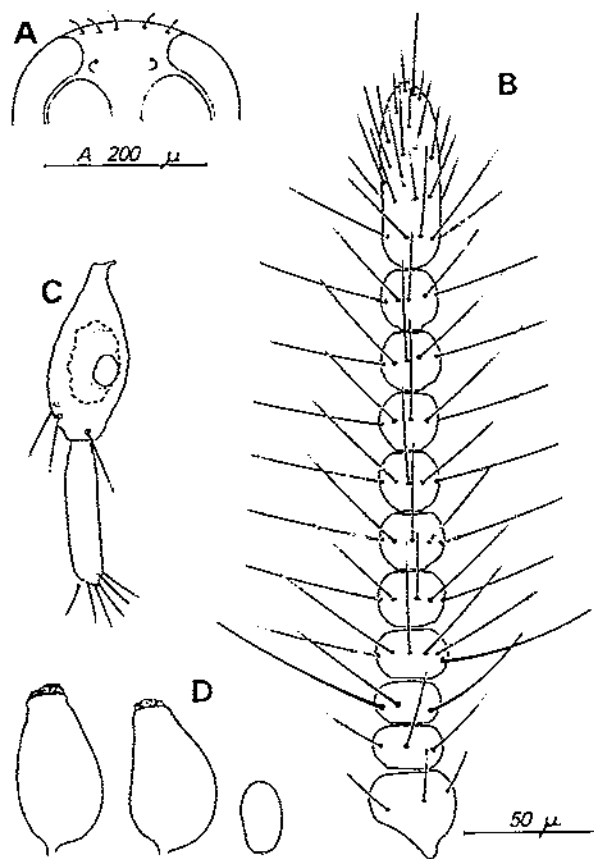


FIGURE 22.—*Leptoconops* species C, female: A, Dorsal half of head, showing two frontal setae (one supplementary median supraorbital seta); B, antenna seen from internal (mesal) face; C, last two segments of right palpus in ventral view; D, spermathecae.

Supraorbital setae.—One median extra on one side. *Front* with long, strong, black seta on each side, at level of angle formed by lower margin of eyes with upper margin of antennal depression.

Antenna.—Blackish brown. Segments IV and V transverse, articular surfaces broad and flat, but not subcylindrical as in preceding species: VI–VIII longer and broader and largest of flagellum; following ones progressively narrower, and all longer than broad; XIII elongate, cylindrical, slightly narrowed in midportion. Basal black setae: On IV small; on V and VI long and strong (up to three times diameter of segment). Verticils more than twice as long as diameter of segment, numbering five to six, possibly up to seven to eight on XII. Sensory setae weak and of the same quality on both sides of III; long, strong, not displaced on VI, but arranged in two regular series up to X; fused in single hypertrophied seta on XI and XII. External black setae long and strong, present up to XII; XIII without median black seta; usual verticils of four to five hairs at base of mesal and lateral faces; subapical black seta longer than diameter of segment.

Palpus.—Segment III dark brown, of same form as in *L. foulki*, with lateral face slightly depressed in middle; axis of pit appearing very much more strongly inclined toward tip of segment. IV light brown at base, progressively

paler up to apex; cylindrical and shorter than III.

Clypeus.—Distal setae equidistant and nearly in straight line; also with two basal setae weaker than distal ones.

Mesonotum.—Blackish. Combinations of lateral setae on both sides: (5+3) and (6+3).

Wing.—Very light gray. Stigma triangular, posterior margin slightly convex and tip sharp pointed; not brown, but of a gray more evident than on rest of wing. Radial cell extremely reduced, ellipsoidal, and well formed. Microtrichia weak and moderately pigmented. Costal setae 28–29.

Legs.—Femora and tibiae dark brown; foretibia slightly paler at tip; tarsi uniformly pale brown, except forebasitarsus, which is yellowish. Tarsal formulas: Foreleg: (1)×1 and (2)×1; midleg: Unarmed.

Abdomen.—Two large spermathecae strongly pigmented, elongated, and without distinction on basal part; distal portion progressively narrowed and ending in constriction followed by expansion, which altogether gives impression of an amphora. Diverticulum, extremely reduced in size and marked with wrinkles, spots, and spines, would represent stopper of this amphora. Third spermatheca very much paler than others, without neck. Dimensions: 64×34, 60×34, 28×15μ.

Distribution.—Nevada.

DISTRIBUTION OF SPECIES

(Figs. 23–25)

Arizona

L. knowltoni.—Pima Co., Organ Pipe Cactus Natl. Monument, Williams Spring, 14.ii.1970, P. H. Arnaud, Jr. (CAS) (with reservations)—4 females.

L. sublettei.—Coconino Co., Sedona, Oak Creek Canyon, 29.vi.1953, W. W. Wirth—1 male.

British Columbia

L. reesi.—Dog Creek, 22.vi.1955, L. G. Curtis (CNC)—5 females.

California

L. americanus.—Inyo Co., Death Valley, Furnace Creek, iii.iv.1962, R. Soroker and J.

Poll, riding stable on golf course (BVC)—2 females. Inyo Co., Death Valley, Furnace Creek, 14.iv.1962, R. H. Whitsel (with reservations)—4 females. Inyo Co., Death Valley, Harmony Borax works, 14.iii.1962, R. Soroker and J. Poll (BVC)—9 females. Inyo Co., Furnace Creek Ranch, 1.iv.1969, G. Grodhaus, biting man at tennis courts (BVC)—2 females. Inyo Co., Lone Pine, 10.iv.1966, R. H. Whitsel (SMC) (also see *L. foulki* and *L. knowltoni*)—1 female. Inyo Co., Lone Pine, Goodale Creek, 3.iv.1953, H. B. Leech (CAS)—1 female, 3 males. Inyo Co., Resting Springs, Tecopa, 23.iv.1955, J. N. Belkin (UCLA)—2 females. Lassen Co., E. shore Eagle Lake, 30.ix.1972, E. T. Schmidtman, ex calf

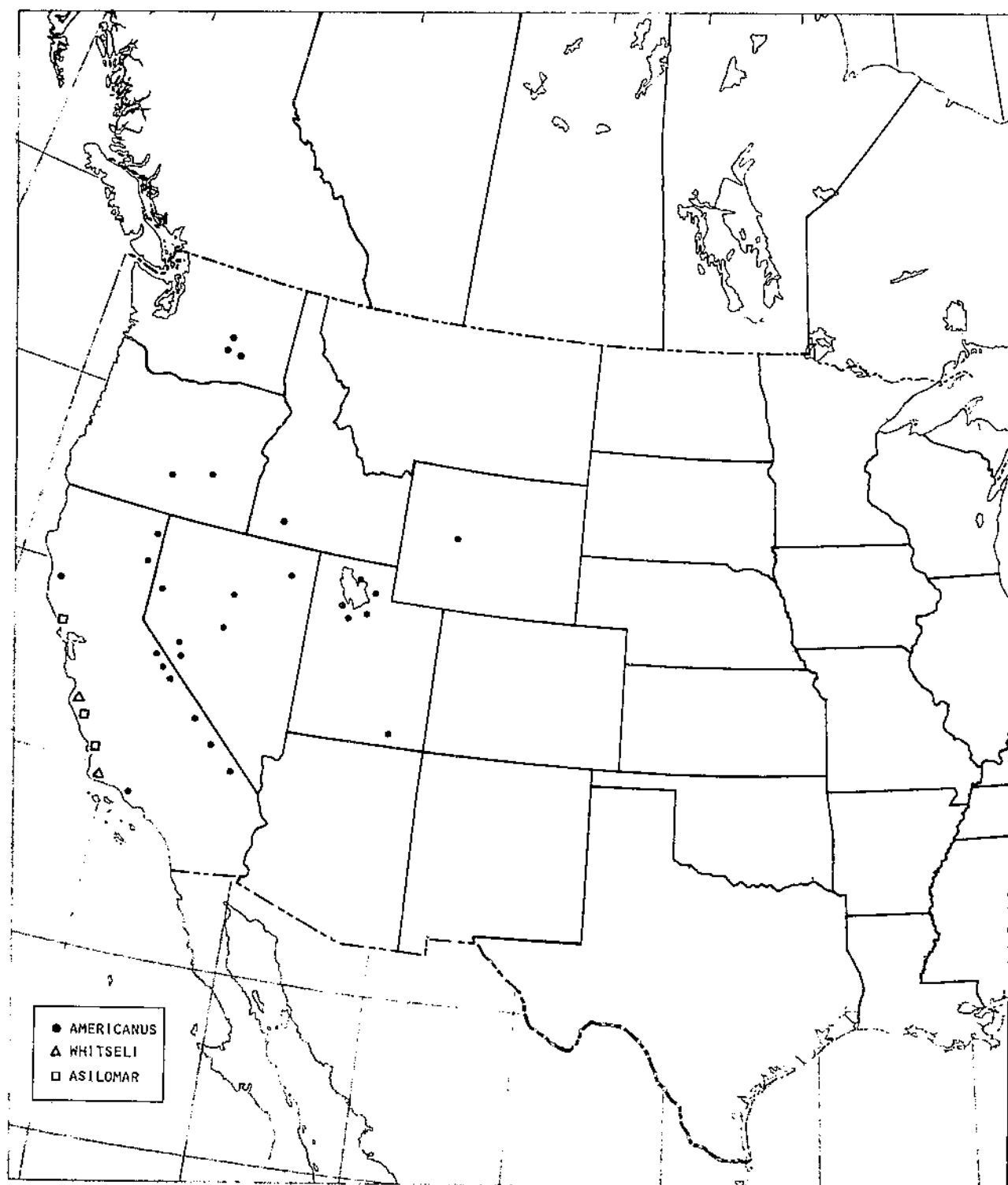


FIGURE 23.—Distribution of species of *Leptoconops kerteszi* complex group 1 in western North America.

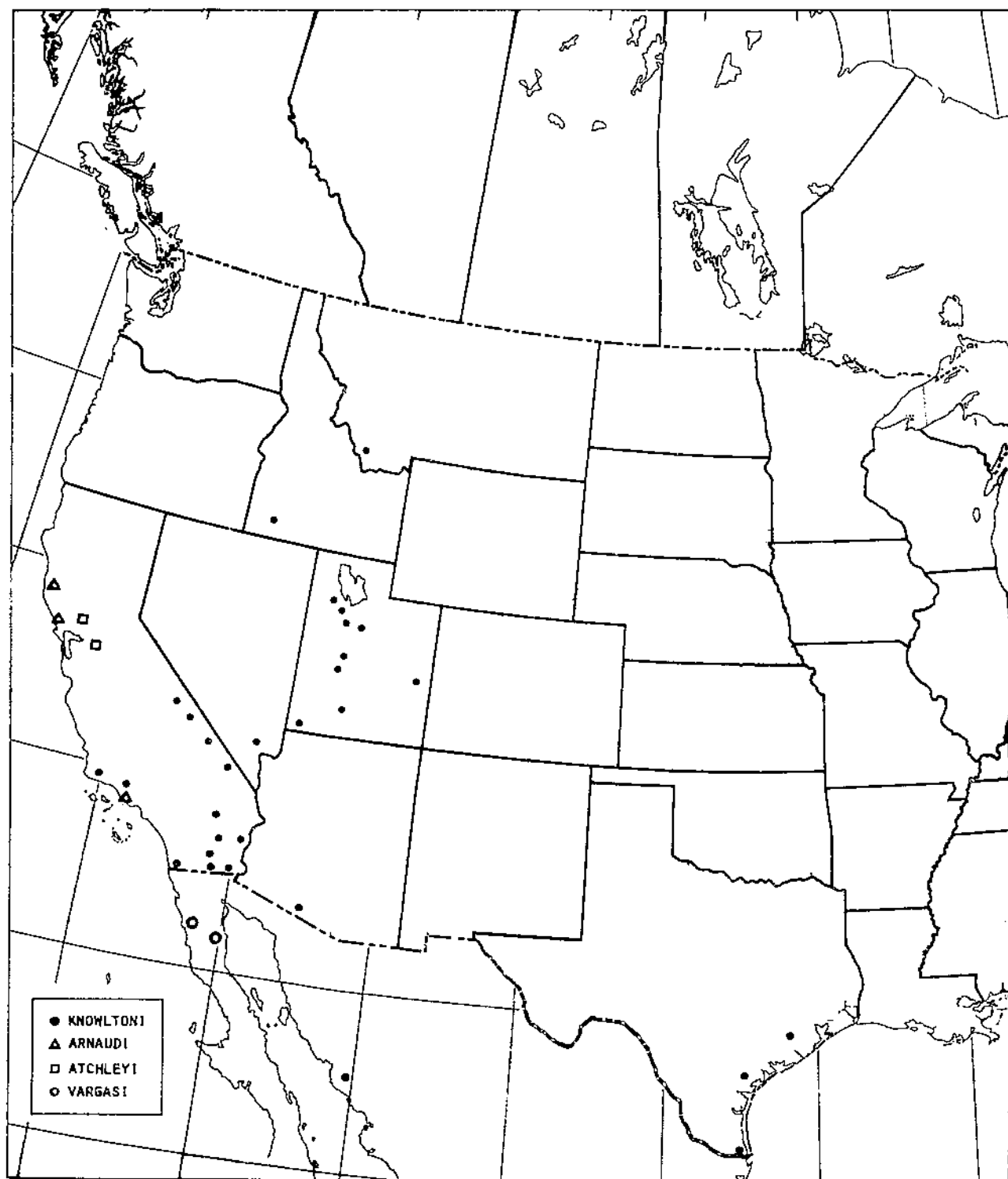


FIGURE 24.—Distribution of species of *Leptoconops kerteszi* complex group 2 in western North America.

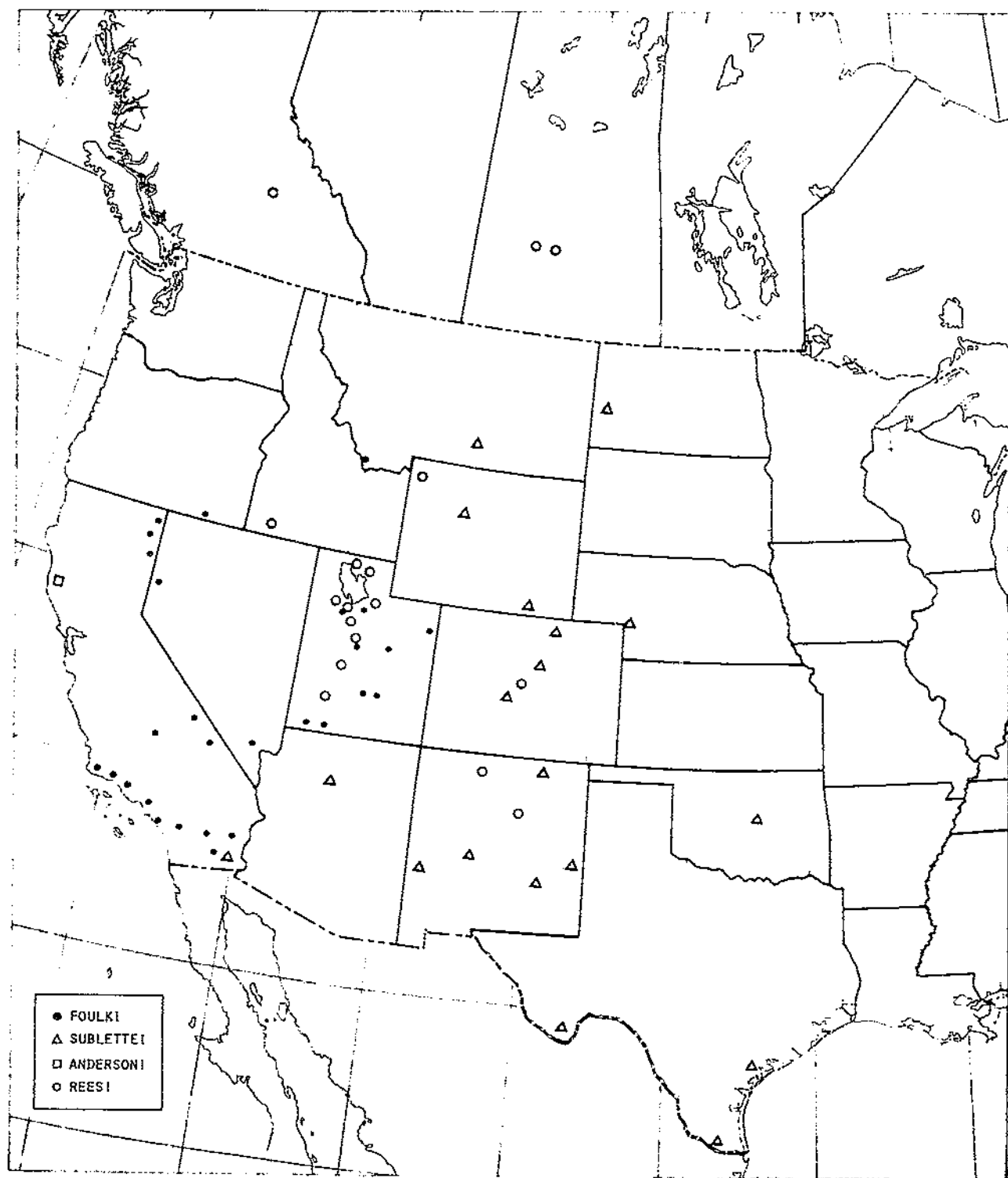


FIGURE 25.—Distribution of species of *Leptoconops kerteszi* complex group 3 in western North America.

(ETS)—7 females. Mendocino Co., Hopland Field Station, 17.iv, 15.22.v.1964, 1.vi.1965, J. R. Anderson, ex ears of deer (UCB) (see also *L. andersoni*)—1 female. Mendocino Co., Hopland Field Station, 25.iv, 12,18.v.1973, E. T. Schmidtman, ex calf (ETS) (also see *L. andersoni*)—12 females. Modoc Co., Alturas, v.1949, H. H. Welsh, ex rabbit—3 females. Modoc Co., Davis Creek, 10.vi.1949, W. Jellison and G. Kohls—12 females. Modoc Co., Willow Creek, 15.v.1948, W. W. Wirth, biting man 4 p.m. (UCB) (also see *L. foulki*)—6 females. Mono Co., Bodie, 21.v.1965, R. E. Doty (BVC)—6 females. Mono Co., 1.5 mi W. Bodie, 21.vi.1965, R. E. Doty, biting (BVC)—30 females. Mono Co., 4.4 mi N. Bodie, 8,375 ft elev., 23,24.vi.1965, R. E. Doty, moist sand at edge of ditch (BVC) (1 pupa with reservations)—3 females, 15 larvae, 30 pupae. Mono Co., Bridgeport, 7.vi.1948, W. W. Wirth (UCB)—1 female. Mono Co., Huntoon Creek, 7.vi.1948, W. W. Wirth—1 female. Mono Co., Leevining, 18.v.1966, H. Johnson, biting (BVC)—1 female. Mono Co., E. side Mono Crater, 17.v.1961, R. Soroker and E. Lusk, biting man (BVC)—11 females. Mono Co., Mono Crater, 17.v.1961, R. Soroker (BVC)—7 females. Mono Co., Mono Lake, 7.vi.1948, W. W. Wirth, lake margin (UCB)—1 male. Mono Co., Mono Lake, 3.viii.1974, M. S. Mulla (off man) (MM)—5 females. Mono Co., Mono Lake, 9.viii.1965, Adams and Mulla (MM)—2 females. Mono Co., Mono Lake, 20.vi.1965, R. H. Whitsel (SMC)—6 females. Mono Co., Mono Lake, 22.vi.1965, R. E. Doty and J. P. Clarke (BVC)—55 females. Mono Co., Mono Lake, 3 mi N. Leevining, 22.vi.1965, R. E. Doty (BVC)—1 female. San Bernardino Co., Death Valley, Saratoga Springs, 19.iii, 23.iv, 27.v.1955, Belkin and McDonald (UCLA) (2 females with reservations) (also see *L. knowltoni*)—6 females. San Bernardino Co., Death Valley, 5 mi NW. Saratoga Springs, 28.iii.1972, J. D. Pinto (UCR) (also see *L. knowltoni*)—1 female. Ventura Co., 4 mi E. Fillmore, 19.vi.1969, D. L. Rohe and J. Neri, biting (BVC) (also see *L. knowltoni*)—1 female.

L. andersoni.—Mendocino Co., Hopland Field Station, 17.iv, 15.22.v.1964, 1.vi.1965, J. R. Anderson, ex ears of deer (UCB) (also see *L. americanus*) (paratypes)—6 females. Mendocino Co., Hopland Field Station, 18.v.1973,

E. T. Schmidtman, ex calf (ETS) (also see *L. americanus*) (holotype)—1 female.

L. arnaudi.—Marin Co., 5 mi N. Alpine Lake, no date, M. S. Mulla (MM)—5 females, 3 males. Marin Co., 0.5 mi N. Alpine Lake, ii.iv.1961, R. Garcia (BVC)—2 males. Marin Co., Lily Lake, near Alpine Lake, 19.v.1969, M. F. Knudsen (BVC)—5 females. Sonoma Co., Bodega Bay, vi,viii.1933, S. B. Freeborn (paratypes)—2 females, 1 male. Sonoma Co., Bodega Bay, 30.vii.1948, W. W. Wirth, swarming near shore (paratypes)—2 females, 26 males. Sonoma Co., Bodega Bay, 30.vi.1962, M. S. Mulla, swarming (males) and off man (females) (MM) (paratypes)—9 females, 9 males. Sonoma Co., Bodega Bay, 10.ix.1964, R. H. Whitsel (SMC) (holotype female, allotype male, paratypes)—10 females, 6 males. Sonoma Co., Bodega Bay, 16.iv.1969, R. Schoepner (SMC) (paratypes)—2 females, 9 males. Ventura Co., Point Mugu, 17.viii.1949, J. N. Belkin (UCLA)—11 females, 12 males. Ventura Co., Point Mugu, 1.vii.1962, R. R. Sanders (UCLA)—1 female.

L. asilomar.—Marin Co., Dillon Beach, 24.iii.1968, G. Grodhaus, biting, dune area (BVC)—1 female. Monterey Co., $\frac{3}{4}$ mi S. Asilomar, 14,21.ii.1964, R. Doty (BVC) (paratypes)—5 females, 4 males, 4 larvae, 8 pupae. Monterey Co., $\frac{3}{4}$ mi S. Asilomar, 5.iii.1964, B. Keh, B. Markos, and R. E. Doty, from sandy beach (BVC) (paratypes)—3 females, 4 males, 3 larvae, 12 pupae. Monterey Co., $\frac{3}{4}$ mi S. Asilomar, 10,12.iii.1964, R. E. Doty, reared (BVC) (paratypes)—1 female, 40 larvae, 14 pupae. Monterey Co., $\frac{3}{4}$ mi S. Asilomar, 25.iii.1964, R. E. Doty, emergence trap (BVC) (paratypes)—40 females, 15 males. Monterey Co., $\frac{3}{4}$ mi S. Asilomar, 20.iii.1964, R. E. Doty, reared (BVC) (holotype female, allotype male, paratypes)—15 females, 15 males, 2 larvae, 5 pupae. Monterey Co., $\frac{3}{4}$ mi S. Asilomar, 30.iv.1964, R. E. Doty (BVC) (paratypes)—2 females. Monterey Co., $\frac{3}{4}$ mi S. Asilomar, 13.v, 5.vi.1964, R. E. Doty (BVC) (paratypes)—7 females, 3 males. Monterey Co., Asilomar, 1.ix.1945, 1.x.1946, 11.vii.1957, A. L. Melander (paratypes)—5 females. Monterey Co., 2 mi S. Asilomar, 20.v.1965, R. Doty and J. Foulk, biting man (paratypes)—1 female. Monterey Co., Asilomar, 19.iii.1964, R. Doty and B. Markos,

reared ex damp sand (paratypes)—1 female, 1 pupa. Monterey Co., Del Monte, 23.30.xii.1963, 16.i, 2.iii.1964, R. E. Doty (BVC) (paratypes)—3 females, 2 males, 1 larva. Monterey Co., Monterey Peninsula Country Club, 23.viii.1961, H. Laughery (BVC) (paratypes)—2 females. Monterey Co., Pacific Grove, 14.ii.1964, R. E. Doty (BVC) (paratypes)—2 females. Monterey Co., 1.5 mi SE. Pacific Grove, 30.iii.1966, R. E. Doty, biting (BVC) (paratypes)—6 females. San Luis Obispo Co., Oso Flaco Lake, 23.vi.1948, W. W. Wirth—3 females, 2 males.

L. atchleyi.—San Joaquin Co., Diablo Mts., 10 mi SW. Tracy, 1,000 ft, 23.iv.1973, E. T. Schmidtman, ex calf in creekbed (ETS)—13 females. Solano Co., Tolenas, 1 mi NE. Fairfield, Cemeni Hill Rd., 8.iii.1965, E. Mezger (BVC) (holotype female, allotype male, paratypes)—2 females, 98 males.

L. foulki.—Imperial Co., 8 mi W. Davis Lake, 28.iii.1955, Ryckman, Lee, and Spencer, ex *Lepus* ear—2 females. Imperial Co., Hot Mineral, 25.iv.1953, 3.ii.1954, J. N. Belkin (UCLA) (also see *L. knowltoni*)—23 females, 2 males. Imperial Co., Hot Mineral, 30.iii.1965, D. D. Linsdale and R. H. Soroker (BVC) (also see *L. knowltoni*)—15 females. Inyo Co., Lone Pine, 10.iv.1966, R. H. Whitsel (SMC) (also see *L. americanus*, *L. knowltoni*)—2 females. Lassen Co., Susanville, 26.v.1933, ex jackrabbit—2 females. Los Angeles Co., Elizabeth Lake Camp, 28.iii.1953, W. McDonald (UCLA) (also see *L. knowltoni*)—1 female. Modoc Co., Cedar Creek, Cedarville, 15.v.1948, W. W. Wirth, swept ex willows—11 females, 13 males. Modoc Co., Cedarville, 15.v.1948, W. W. Wirth, creek margin—5 females, 5 males. Modoc Co., Dismal Swamp, 15.iii.1948, W. W. Wirth—2 females. Modoc Co., Willow Creek, 15.v.1948, W. W. Wirth, biting 4 p.m. (UCB) (also see *L. americanus*)—2 females. Monterey Co., Greenfield, Salinas River, vii.1959, D. Jamieson (BVC)—5 females, 4 males. Orange Co., Alyso Canyon, x. 1952, J. N. Belkin (UCLA) (paratypes)—23 females. Orange Co., Santa Ana River bottom, 27.x.1966, R. E. Doty (BVC)—2 larvae, 6 pupae. Orange Co., Santa Ana River, 4.5 mi N., 3 mi E. Orange, 10.vi.1960, J. Poll; 14.vi.1960, D. L. Rohe (BVC) (paratypes)—2 females. Orange Co., Santa Ana River Flood Channel, McFadden Bridge, 27.x.1966, J. Shanafelt and J. D. Foulk (UCR)

(holotype female, allotype male, paratypes)—11 females, 11 males. Orange Co., Santa Ana River, Peralto St., 2 mi E. Anaheim, 11.13.xi.1959, J. G. Shanafelt (BVC) (paratypes)—20 females. Orange Co., Santa Ana River, Yorba St., 23.v.1960, J. G. Shanafelt (BVC) (paratypes)—2 females. Orange Co., Santa Ana River, Yorba St., 31.v.1960, H. Magy and J. Poll (BVC) (paratypes)—4 females, 3 males. Riverside Co., Indian Wells, 24.iv.1953, J. N. Belkin, at light (UCLA)—1 female. Riverside Co., Mecca, v.1962, M. S. Mulla (MM) (also see *L. knowltoni*)—1 male. Riverside Co., Norco, Santa Ana River Valley, 26.viii.1965, J. D. Foulk, swarming (males), around man's head (females) (paratypes)—5 females, 5 males. Riverside Co., Norco, 27.x.1965, J. D. Foulk, suction trap (UCR) (paratype)—1 male. Riverside Co., Norco, 5.vi.1970, L. Luna (UCR)—5 females. Riverside Co., Palm Desert, 23.vii.1969, S. Frommer, light trap (UCR)—1 female, 3 males. Riverside Co., Rubidoux sewage disposal plant, 21.viii.1969, S. Frommer and J. Sublette (UCR)—1 female. Riverside Co., Thousand Palms, 25.iii.1955, W. R. M. Mason (CNC)—1 male. Riverside Co., Thousand Palms Canyon, 21.iii.1954, J. N. Belkin (UCLA)—2 females. San Bernardino Co., Santa Ana River, 31.v.1974, L. Lacey (MM)—3 females, 3 males. Santa Barbara Co., Cuyama Ranch, 22.iv.1966, R. L. Nelson, carbon dioxide trap (RLN) (also see *L. knowltoni*)—8 females. Santa Barbara Co., Guadalupe, 23.vi.1948, W. W. Wirth, at Umbelliferae flowers (also see *L. whitseli*)—4 males. Santa Barbara Co., Sisquoc River Canyon, 12.v, 1.15.viii.1972, E. T. Schmidtman, ex calf (ETS)—15 females. Tulare Co., Success Lake, E. of Porterville, 12.vi.1960, 28.ii.1961, D. J. Womeldorf (BVC)—3 females. Ventura Co., Santa Paula, 10.vii.1948, Welsh and Jellison, ex *Lepus* ear—2 females.

L. knowltoni.—Imperial Co., Brawley, 26.xi.1959, E. I. Schlinger, vacuum (UCR) (paratype)—1 female. Imperial Co., Hot Mineral, 30.iv.1952, J. N. Belkin (UCLA) (paratype)—1 female. Imperial Co., Hot Mineral, 25.iv.1953, 3.ii.1954, J. N. Belkin (UCLA) (paratypes) (also see *L. foulki*)—23 females, 2 males. Imperial Co., Hot Mineral, 30.iii.1965, D. D. Linsdale and R. H. Soroker (BVC) (paratypes) (also see *L. foulki*)—15 females. Imperial Co.,

Palo Verde, 7.iv.1949, W. W. Wirth (UCB)—1 female, 1 male. Imperial Co., foot of mountains W. of Salton Sea, 23.vii.1952, Leech and Green (CAS) (paratype)—1 female. Imperial Co., Westmoreland, 19.v.1965, M. S. Mulla, suction trap (MM)—1 female, 1 male. Inyo Co., Death Valley, Ashford Mill, 7.iv.1962, M. S. Mulla (MM)—3 females. Inyo Co., Death Valley, Furnace Creek, 14.iv.1962, R. H. Whitsel (SMC)—1 female. Inyo Co., Fish Slough, 10 mi E. Bishop, 5.vi.1967, J. C. Hall (UCR)—1 female. Inyo Co., Furnace Creek Ranch, 1.iv.1969, G. Grodhaus, biting man near drainage ditch from golf course (BVC)—6 females. Inyo Co., Lone Pine, 10.iv.1966, R. H. Whitsel (SMC) (also see *L. americanus* and *L. foulki*)—1 female. Inyo Co., Panamint Mts., iv.1891 (through C. V. Riley)—1 female. Inyo Co., Resting Springs, 7.iv.1962, M. S. Mulla, biting man (MM)—4 females. Lassen Co., Pine Creek, 24.v.1950, H. P. Chandler (CAS)—1 female. Los Angeles Co., Elizabeth Lake Camp, 28.iii.1953, W. McDonald (UCLA) (also see *L. foulki*)—1 female. Riverside Co., Blythe, 20.vii. 1947, J. W. MacSwain, light trap (UCB) (paratype)—1 female. Riverside Co., Dos Palmas, 4.iv.1962, M. S. Mulla, swarming (MM) (paratype)—1 female. Riverside Co., Dos Palmas, 18.v.1966, M. T. Ali (MM) (paratype)—1 male. Riverside Co., Mecca, 17.iv.1956, v.1962, M. S. Mulla (MM) (paratypes) (also see *L. foulki*)—12 females, 3 males. Riverside Co., Mecca, 13.iv.1965, J. Doyen (UCB) (paratypes)—2 females. Riverside Co., Mecca, 13.iv.1965, C. Slobodchikoff (UCR) (paratypes)—3 females. Riverside Co., Salton Sea, north shore, 10–15.ix.1964, J. D. Foulk, emergence trap (UCR) (holotype female, allotype male, paratypes)—4 females, 7 males; same, 26.v.1965 (paratype)—1 male. Riverside Co., Salton Sea, north shore, 14.ix.1964, J. D. Foulk, ex rabbit ear (UCR) (paratypes)—3 females. Riverside Co., Salton Sea State Park, 13.viii.1964, J. D. Foulk, light trap (UCR) (paratypes)—1 female, 5 males. San Bernardino Co., Crowder Canyon, 24.v.1966, J. D. Foulk, swarming above head of man (UCR)—3 females. San Bernardino Co., Death Valley, Saratoga Springs, 19.iii, 23.iv, 27.v.1955, Belkin and McDonald (UCLA) (also see *L. americanus*)—6 females. San Bernardino Co., Death Valley, 5 mi NW. Saratoga Springs, 28.iii.1972, J. D.

Pinto (UCR) (also see *L. americanus*)—7 females. San Diego Co., San Diego, 25.iii.1916, H. G. Dyar—2 females. Santa Barbara Co., Cuyama Ranch, 22.iv.1966, R. L. Nelson, carbon dioxide trap (RLN) (also see *L. foulki*)—3 females. Tulare Co., Success Dam, S. Fork Tule River, 30.iv.1962, G. Campbell (BVC)—1 female. Ventura Co., 4 mi E. Fillmore, 19.vi.1969, D. L. Rohe and J. Neri, biting (BVC) (also see *L. americanus*)—1 female.

L. sublettei.—Imperial Co., Imperial Dam, 28.vi.1954, W. A. McDonald, at light (UCLA) (with slight reservation)—2 females, 3 males.

L. whitseli.—Monterey Co., Pebble Beach, Del Monte Property, 11.viii.1964, R. Schoepner, reared (SMC) (allotype male, paratypes)—5 males, 50 larvae, 46 pupae. Monterey Co., Pebble Beach, Del Monte Property, 23.ix.1964, R. H. Whitsel (SMC) (holotype female, paratypes)—117 females. Santa Barbara Co., Guadalupe, 23.vi.1948, W. W. Wirth, at Umbelliferae flowers (also see *L. foulki*)—4 males.

Colorado

L. americanus.—Alamosa Co., Great Sand Dunes Natl. Monument, 25.viii.1968, F. G. Andrews—1 female.

L. reesi.—Park Co., Lake George, 18.vi, T. D. A. Cockerell, annoying to man—1 female.

L. sublettei.—Denver Co., Aurora, 4.v.1946, M. T. James—3 females. Weld Co., 27.vi.1950, V. I. Miles, magpie nest—4 females, 1 male. Weld Co., Hudson, vi–viii.1964, L. R. Ertle, sheep bait trap (RHJ)—400 females, 10 males.

Idaho

L. americanus.—Owyhee Co., ranch 5 mi SW. Bruneau, 12.ix.1973, R. H. Jones, ex sheep (RHJ)—4 females.

L. knowltoni.—Owyhee Co., ranch 5 mi SW. Bruneau, 26.viii.1973, R. H. Jones, ex sheep (RHJ) (also see *L. reesi*)—1 female.

L. reesi.—Owyhee Co., ranch 5 mi SW. Bruneau, 26.viii.1973, R. H. Jones, ex sheep (RHJ) (also see *L. knowltoni*)—15 females.

Mexico

L. knowltoni.—Sinaloa, 14 mi S. Los Mochis, 6.ii.1964, P. A. Rauch (CAS)—1 female, 14 males.

L. vargasii.—Baja California, 26 mi S. San Felipe, 15.iv.1965, Cavagnaro, Ross, and Vesterby

(CAS) (paratype)—1 female. Baja California, San Quintin, 16-18.ii.1965, A. M. Barnes, ex ear of man (BVC) (holotype, paratypes)—5 females.

Montana

L. foulki.—Beaverhead Co., 8.vi.1937, R. R. Parker (also see *L. knowltoni*)—3 females.

L. knowltoni.—Beaverhead Co., 8.vi.1937, R. R. Parker (also see *L. foulki*)—1 female.

L. sublettei.—Yellowstone Co., Billings, 3.v.1906, H. G. Dyar—2 females. Yellowstone Co., Billings, 31.viii.1966, R. H. Jones, biting sheep (RHJ)—1 female.

Nebraska

L. sublettei.—Keith Co., Paxton, 2.vi.1938, H. O. Schroeder—3 females, 2 males.

Nevada

L. americanus.—Elko Co., Wells, near Angel Lake, 7,500 ft, 17.vi.1952, E. I. Schlenger (UCD)—3 females, 5 males. Esmeralda Co., Chiatovich Creek, 6,500 ft, 18.vi.1970, R. C. Bechtel, biting man (RCB)—6 females. Lander Co., Battle Mtn., 7.vii.1953, C. B. Philip, ex rabbit—1 female. Lander Co., Spencer's Hot Springs, 9.ix.1972, R. C. Bechtel, ex man (RCB)—7 females. Mineral Co., Hawthorne, 17.vi.1964, A. Morrill—22 females, 23 males. Mineral Co., N. end Walker Lake, 4,150 ft, 19.iv.1971, R. C. Bechtel, ex man (RCB)—27 females. Washoe Co., Steamboat, 13.v.1917, H. G. Dyar—1 female. ? County, 15 mi E. Herlong, 2.vii.1974, E. T. Schmidtmann, carbon dioxide trap (ETS)—2 females.

L. foulki.—Clark Co., Las Vegas, 15.iv.1930, D. E. Fox—1 female. Clark Co., Las Vegas, 26.iii.1931, E. W. Davis—2 females. Clark Co., Rogers Spring, 1,500 ft, 23.iv.1971, R. C. Bechtel (RCB) (also see *L. knowltoni*, *L. species C*)—1 female. Washoe Co., Gerlach, 1.v.1970, E. R. Lukens, biting man (RCB)—21 females.

L. knowltoni.—Clark Co., Rogers Spring, 1,500 ft, 23.iv.1971, R. C. Bechtel (RCB) (also see *L. foulki*, *L. species C*)—2 females.

L. species C.—Clark Co., Rogers Spring, 1,500 ft, 23.iv.1971, R. C. Bechtel (RCB) (also see *L. foulki*, *L. knowltoni*)—1 female.

New Mexico

L. reesi.—Rio Arriba Co., Rio Chama, 9.viii.1965, W. R. Atchley, at light (WRA)—1 female. San Miguel Co., Las Vegas Hot Spring, 18.viii, H. S. Barber—4 males.

L. sublettei.—Catron Co., 5 mi E. Glenwood, 24.vi.1953, W. W. Wirth—1 female. Chaves Co., Roswell, 8.v.1913, A. G. Hammon, "bloodsucking"—1 female. Colfax Co., Maxwell, 1.ix.1915, C. K. Wildermuth—2 females. Roosevelt Co., Arch Salt Lake, 24.v.1969, W. W. Wirth, biting man 9 a.m.—6 females. Socorro Co., Bosque del Apache, 18.vii.1965, W. R. Atchley (WRA) (with slight reservation)—2 females, 1 male.

North Dakota

L. sublettei.—Billings Co., Mikkelson, 13.ix.1929, G. C. Wheeler—1 female.

Oklahoma

L. sublettei.—Canadian Co., El Reno, 14.vi.1963, R. M. Ahring—1 female.

Oregon

L. americanus.—Harney Co., Denio, 29.vi.1953, A. B. Gurney (also see *L. foulki*)—2 females. Harney Co., Wrights Point, 12 mi S. Burns, 23.v.1963, K. Goeden (KG)—9 females, 21 males. Harney Co., 23.vi.1967, G. Hickman, from golden eagle's nest—1 female. Lake Co., 2 mi E. Lakeview, 1.viii.1968, Goeden and Westcott, light trap (KG)—1 female.

L. foulki.—Harney Co., Denio, 29.vi.1953, A. B. Gurney (also see *L. americanus*)—3 females.

Saskatchewan

L. reesi.—Jansen, 10.vi.1913, T. N. Willing, troublesome about face in sun (CNC)—5 females.

Texas

L. knowltoni.—Aransas Co., Aransas Wildlife Refuge, 22.iv.1956, W. W. Wirth, biting man in a.m.—3 females. Cameron Co., Port Isabel, 17-18.vii.1971, R. H. Jones, on horse (RHJ)—4 females. Kleberg Co., Baffin Bay, 31.v.1964, B. McDaniel, biting man—3 females. Nueces Co., Padre Island, 13 mi S. of N. Causeway, 28.v.1952—1 female.

L. sublettei.—Brewster Co., Glen Springs, Big Bend Natl. Park, 7.v.1956, R. H. Jones (RHJ)—1 female. Brewster Co., Rio Grande Village, Big Bend Natl. Park, 19.iii.1976, W. E. Steiner, at light—2 males. Houston Co., 5 mi NW. Grapeland, 3.viii.1968, R. E. Woodruff, light trap (UF)—2 females. San Patricio Co., Sinton, summer 1963, R. S. Cook (holotype, paratypes)—6 females. San Patricio Co., Welder Wildlife Refuge, 1963, W. Samuel, ex ears of deer—4 females. Starr Co., Rio Grande City, 28.vi.1959, V. H. Lee, biting man—1 female.

Utah

L. americanus.—Box Elder Co., Locomotive Springs, Curlew Valley, 24.iv.1934, Knowlton and Rowe (USU) (also see *L. knowltoni*)—1 female. Millard Co., Black Rock, 7.iv.1934, G. F. Knowlton (USU)—4 females. Millard Co., Greenwood, 25.v.1956, G. F. Knowlton, biting man (USU) (also see *L. reesi*)—2 females. Salt Lake Co., Antelope Island Road, 24.v.1969, R. N. Winget (UU) (also see *L. reesi*)—58 females. Salt Lake Co., Garfield, 22.v.1953, 29.iv.1954, G. F. Knowlton (USU) (also see *L. foulki*, *L. reesi*)—2 females. Salt Lake Co., Saltair, 23.v.1969, K. Nielson (UU)—2 larvae, 2 pupae. Salt Lake Co., Salt Lake, 26.vi, H. S. Barber, "biting devilishly" (lectotype)—2 females. Salt Lake Co., Salt Lake City, 1.v.1928, W. W. Jones (UCB)—1 female. Salt Lake Co., University of Utah lab. colony (UU) (collected in Tooele Co., near Lake Point by P. G. Lawyer)—50 females. San Juan Co., Canyonlands Natl. Park, 15.vi.1969, S. Romney, around man (UU)—10 females, 3 males. Tooele Co., Dolomite, 17.iv.1934, Knowlton and Thomas (USU) (also see *L. knowltoni*)—1 female. Tooele Co., S. end Great Salt Lake, vi.1969, R. Nielson and D. Rees (UU)—1 female. Tooele Co., S. end Great Salt Lake, vii.1969, P. G. Lawyer (UU)—5 females, 3 males, 2 larvae. Tooele Co., Lake Point, 5.v.1948, 17.v.1950, G. F. Knowlton (USU) (also see *L. foulki*)—9 females. Tooele Co., Skull Valley, 17.iv.1934, Knowlton and Thomas (USU) (also see *L. reesi*)—34 females. Tooele Co., Stansbury Isl., 18.vi.1952, E. I. Schlinger (UCB)—7 females. Tooele Co., Timpie, 17.iv.1934, Knowlton and Thomas, annoying to man (UU) (also see

L. reesi)—42 females. ? County, Flux, 19.v.1933, 2.iv.1934, Knowlton and Thomas, flying and biting (USU) (also see *L. knowltoni*, *L. reesi*)—36 females.

L. foulki.—Carbon Co., Price, Price River, 10.vi.1974, W. L. Grogan, swept (WLG)—1 female. Garfield Co., Escalante, 1.viii.1958, R. H. Jones, light trap (RHJ)—6 females. Juab Co., Nephi, 12.v.1948, G. F. Knowlton (USU)—4 females. Kane Co., Cottonwood Creek, 26.v.1970, L. Nielson and H. Arnell, biting (UU)—5 females. Salt Lake Co., Garfield, 22.v.1953, 29.iv.1954, G. F. Knowlton (USU) (also see *L. americanus*, *L. reesi*)—1 male. Tooele Co., Lake Point, 5.v.1948, 17.v.1950, G. F. Knowlton (USU) (also see *L. americanus*)—1 female, 2 males. Uintah Co., Dinosaur Natl. Monument, Split Mtn., 10.vii.1968, W. R. Atchley, biting man (WRA)—1 female. Washington Co., Bloomington, 22,25.v.1974, W. L. Grogan, at light (WLG) (also see *L. knowltoni*)—15 females. Washington Co., St. George, 17.vii.1956, G. F. Knowlton, light trap (USU)—1 female. Washington Co., St. George, Santa Clara River, 24.v.1974, W. L. Grogan, at light (WLG) (also see *L. knowltoni*)—9 females. Wayne Co., Capitol Reef Natl. Monument, 22.vii.1968, W. R. Atchley, biting man (WRA)—6 females. Wayne Co., Loa, 21.vii.1955, G. F. Knowlton, at Umbelliferae (USU)—75 females. Weber Co., Salt Creek Refuge, North Little Mtn., v.1969, R. N. Winget, biting (UU)—4 females.

L. knowltoni.—Box Elder Co., Locomotive Springs, Curlew Valley, 24.iv.1934, Knowlton and Rowe (USU) (also see *L. americanus*)—6 females. Grand Co., Hartley Dome, 13.viii.1958, W. L. Nutting, at light—1 male. Millard Co., Deseret, 17.vi.1948, Knowlton, Wood, and Allred, annoying man (USU)—11 females. Millard Co., 8 mi SW. Kanosh, 24.v.1938, G. F. Knowlton (USU)—187 females. Tooele Co., Dolomite, 17.iv.1934, Knowlton and Thomas (USU) (also see *L. americanus*)—6 females. Tooele Co., Grantsville, 17.iv.1934, Knowlton and Thomas, around man (USU)—1 female, 1 male. Utah Co., 8 mi N. Genola, no date, Knowlton and Dorst, biting (USU)—10 females. Washington Co., Bloomington, 22,25.v.1974, W. L. Grogan, at light (WLG) (also see *L. foulki*)—3 females.

Washington Co., St. George, 20.vi.1950, G. F. Knowlton (USU)—1 male. Washington Co., St. George, Santa Clara River, 24.v.1974, W. L. Grogan, at light (WLG) (also see *L. foulki*)—2 females, 2 males. ? County, Flux, 19.v.1933, 2.iv.1934, Knowlton and Thomas (USU) (also see *L. americanus*, *L. reesi*)—2 females. ? County, Indian Creek, Scarp Ranch, 1.v.1949, Knowlton and Thornley, biting man (USU)—30 females.

L. reesi. — Box Elder Co., Blue Creek, 19.iv.1934, G. F. Knowlton and J. A. Rowe (USU)—30 females. Box Elder Co., cement plant 5 mi N. Brigham City, v. 1969, Penrose and Thatcher (UU)—1 female. Box Elder Co., Golden Spike Duck Club, 1969, Penrose and Thatcher, biting man (UU)—4 females. Box Elder Co., Penrose, 14.iv.1934, Knowlton and Rowe (USU)—24 females. Iron Co., Little Salt Lake, NNW. of Parowan, 21.v.1969, L. Ogden and F. Harmston, biting man (UU)—1 female. Juab Co., 12 mi N. Scipio, junction Sevier River and Hwy. 91, 20.v.1969, Harmston and Ogden, biting man (UU)—23 females. Millard Co., Greenwood, 25.v.1956, G. F. Knowlton, biting man (USU) (also see *L. americanus*)—6 females. Salt Lake Co., Antelope Island Road, 23.v.1969, R. N. Winget (UU) (also see *L. americanus*)—2 females. Salt Lake Co., Garfield, 22.v.1953, 29.iv.1954, G. F. Knowlton (USU) (also see *L. americanus*, *L. foulki*)—1 female. Salt Lake Co., Salt Lake City, v.1948, D. M. Rees (UU)—6 females, 2 males. Salt Lake Co., Salt Lake City, 16.iv.1949 (BVC)—2 females, 2

males. Tooele Co., Erdat, 2.v.1952, G. F. Knowlton (USU)—3 females. Tooele Co., Grantsville, 17.vi.1949 (BVC)—2 females. Tooele Co., Mills Junction, 17.v.1952, G. F. Knowlton (USU) (paratypes)—5 females. Tooele Co., Skull Valley, 17.iv.1934, Knowlton and Thomas (USU) (paratypes) (also see *L. americanus*)—19 females. Tooele Co., Timpie, 17.iv.1934, Knowlton and Thomas, annoying to man (USU) (holotype, paratypes) (also see *L. americanus*)—18 females.

Washington

L. americanus.—Adams Co., Othello, Lower Crab Creek, 4.ix.1950, M. Bacon (WSU)—2 females. Adams Co., Othello, Wildlife Refuge, 22.vi.1964, W. A. Rowley (WSU)—12 females. Grant Co., Ephrata, 16.viii.1950, M. Bacon (WSU)—2 females. Grant Co., O'Sullivan Dam, vii, viii.1950, M. Bacon (WSU)—24 females. Grant Co., O'Sullivan Dam, vii, viii.1954, 1955, H. G. Davis (WSU)—4 females.

Wyoming

L. americanus.—Fremont Co., 10 mi S. Shoshoni, 11.vii.1969, R. J. Lavigne (WYO)—100 females.

L. reesi.—Yellowstone Natl. Park, Old Faithful, 27.vi.1922, H. G. Dyar—6 females. ? County, Mill Creek, 22.vi.1938, ex *Cynomys*—3 females.

L. sublettei.—Albany Co., Laramie, 17.vi.1947, D. G. Denning, light trap—2 females, 2 males. Hot Springs Co., Thermopolis Hot Spring, 13.vi.1969, W. W. Wirth—1 female.

SUMMARY

Using characters that had proved successful in differentiating three species of the *Leptoconops kerteszi* complex in southern Europe and seven others in North Africa, a critical study was made of the species that had gone under the name of *L. kerteszi* in western North America. *L. kerteszi* does not occur in North America, but 11 species are recognized, described, and illustrated: *L. americanus* Carter, originally described from Great Salt Lake, Utah, and the following 10 new species: *andersoni*, *arnaudi*, *asilomar*, *atchleyi*, *foulki*, *knowltoni*, *reesi*, *sublettei*, *vargasi*, and *whitseli*. These species fall in three taxonomic groups, which share common characters of the fe-

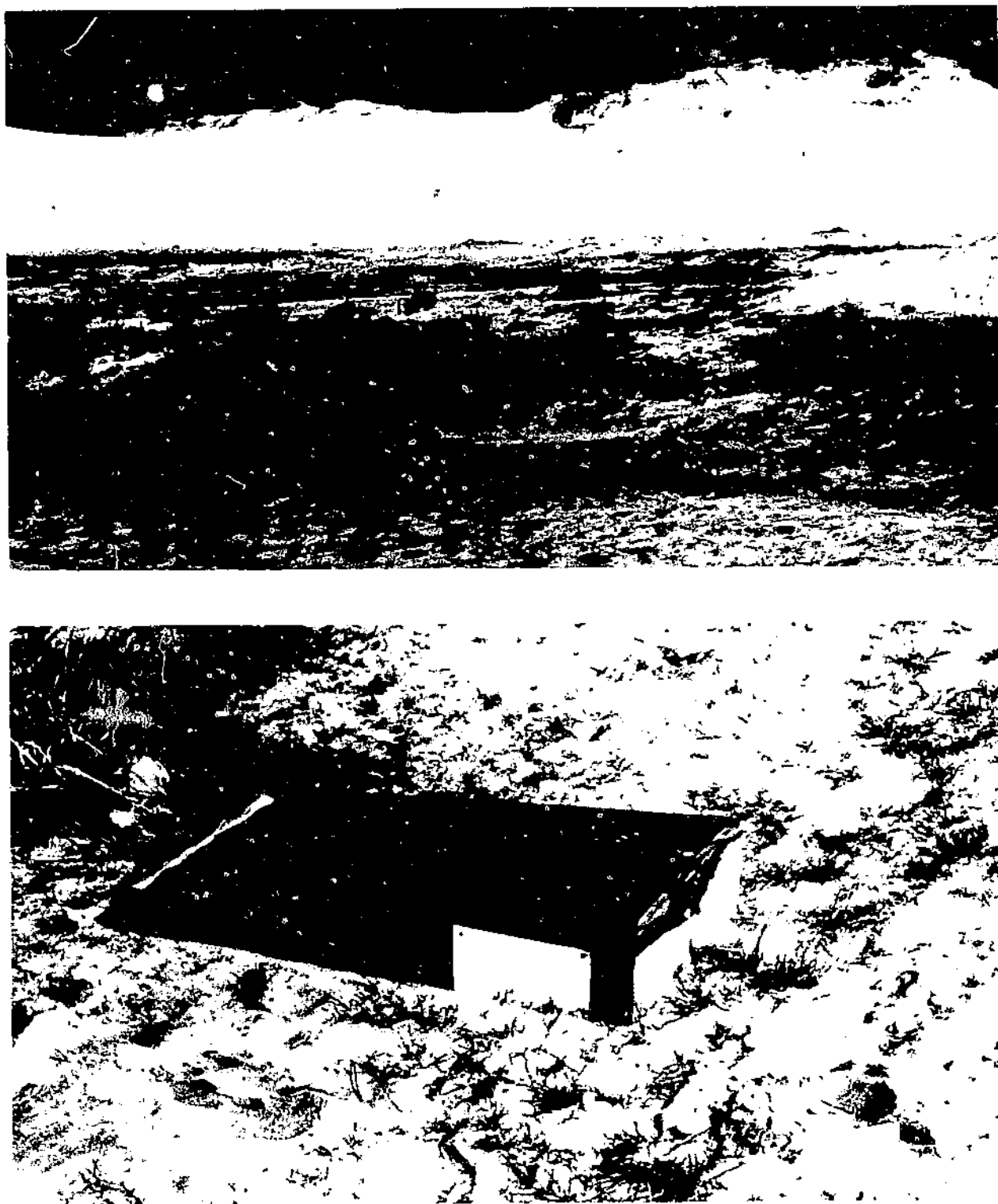
male antenna and wing and of the male tarsi and genitalia. In each group are one or more common and widespread species and several species of restricted distribution. Further biological study will be necessary to determine specific details of larval habitats and female biting habits. Females of this complex are often extremely annoying bloodsucking pests in coastal or desert regions, and the immature stages have been found usually in wet soil in depressions near lakes, ponds, streams, springs, or coastal lagoons, generally under conditions of considerable alkalinity or salinity.

LITERATURE CITED

- AUSTEN, E. E.
1921. A CONTRIBUTION TO KNOWLEDGE OF THE BLOOD-SUCKING DIPTERA OF PALESTINE, OTHER THAN TABANIDAE. *Bul. Ent. Res.* 12: 107-124, 1 plate.
- BACON, M.
1953. A STUDY OF THE ARTHROPODS OF MEDICAL AND VETERINARY IMPORTANCE IN THE COLUMBIA BASIN. *Wash. Agr. Expt. Sta. Tech. Bul.* 11, pp. 1-40.
- BETTINI, S., and FINIZIO, E.
1968. LEPTOCONOPS IRRITANS NOE NEL GROSSE-TANO: PROBLEMI DI LOTTA. *Riv. di Parasitol.* 29: 33-47.
- MAJORI, G., FINIZIO, E., and PIERDOMINICI, G.
1969a. RICERCHE SUI CERATOPOGONIDI NEL GROSSE-TANO: NOTA I. IDENTIFICAZIONE DEI FOCOLAI DI LEPTOCONOPS IRRITANS NOE, 1907. *Riv. di Parassitol.* 30: 227-238.
- MAJORI, G., FINIZIO, E., and PIERDOMINICI, G.
1969b. RICERCHE SUI CERATOPOGONIDI NEL GROSSE-TANO: NOTA II. IDENTIFICAZIONE DEI FOCOLAI DI LEPTOCONOPS BEZZII, NOE, 1907. *Riv. di Parassitol.* 30: 239-242.
- MAJORI, G., FINIZIO, E., and PIERDOMINICI, G.
1969c. RICERCHE SUI CERATOPOGONIDI NEL GROSSE-TANO: NOTA III. OSSERVAZIONI SULLA BIOLOGIA DELLE ALATE DI LEPTOCONOPS IRRITANS E LEPTOCONOPS (HOLOCONOPS) KERTESZI. *Riv. di Parassitol.* 30: 311-318.
- BOESEL, M. W.
1948. HOLOCONOPS IN THE WESTERN LAKE ERIE REGION (DIPTERA: HELEIDAE). *Ohio Jour. Sci.* 48: 69-72.
- CARTER, H. F.
1921. A REVISION OF THE GENUS LEPTOCONOPS, SKUSE. *Bul. Ent. Res.* 12: 1-28.
- CLAUSTRIER, J.
1972. DESCRIPTION DE LA LARVE ET DE LA NYMPHE DE LEPTOCONOPS (HOLOCONOPS) KERTESZI KIEFFER, 1908 (DIPTERA, CERATOPOGONIDAE). *Ann. de Parasit. Humaine et Compar.* 47: 309-324.
1973. LE GENRE LEPTOCONOPS, SOUS-GENRE HOLOCONOPS DANS LE MIDI DE LA FRANCE (DIPT. CERATOPOGONIDAE). *Soc. Ent. de France Ann. (N.S.)* 9: 895-920.
- 1974a. LEPTOCONOPS (HOLOCONOPS) LAOENSIS N. SP. DU SUD-EST ASIATIQUE (DIPTERA, CERATOPOGONIDAE). *Nouvelle Rev. Ent.* 4: 71-74.
- 1974b. LEPTOCONOPS (PROLEPTOCONOPS) HUTSONI N. SP., N. SG. DU SAHARA ALGERIEN SEPTENTRIONAL (DIPTERA, CERATOPOGONIDAE). *Parassitologia* 16: 231-238.
- 1975a. DESCRIPTION DE QUELQUES MALES D'HOLOCONOPS (DIPT., CERATOPOGONIDAE). *Soc. Ent. de France Ann. (N.S.)* 11: 587-607.
- 1975b. LE GENRE LEPTOCONOPS, SOUS-GENRE HOLOCONOPS EN AFRIQUE DU NORD (DIPTERA, CERATOPOGONIDAE). *Inst. Pasteur d'Algérie, Arch.* 50-51 (1972-73): 23-52.
- RIoux, J. A., and DESCOURS, S.
1961. NOTES SUR LES CERATOPOGONIDES XII.—CERATOPOGONIDES DU NORD-TCHAD. *Inst. Pasteur d'Algérie, Arch.* 39: 49-98.
- COLLUZZI, M.
1967. SULLA PRESENZA IN ITALIA DI LEPTOCONOPS KERTESZI KIEFFER (DIPTERA, CERATOPOGONIDAE). *Riv. di Parassitol.* 28: 43-46.
- CURTIS, L. C.
1957. OCCURRENCE OF LEPTOCONOPS KERTESZI KIEFFER (DIPTERA: CERATOPOGONIDAE) IN BRITISH COLUMBIA. *Brit. Columbia Ent. Soc. Proc.* 53: 18.
- EBELING, W.
1975. URBAN ENTOMOLOGY. 645 pp. Univ. Calif. Div. Agr. Sci., Los Angeles.
- ESSIG, E. O.
1926. INSECTS OF WESTERN NORTH AMERICA. 1035 pp. Macmillan Co., New York.
- FOULK, J. D.
1966a. DRAINAGE OF A DESERT SPRING CREEK FOR CONTROL OF LEPTOCONOPS KERTESZI (DIPTERA: CERATOPOGONIDAE). *Mosquito News* 26: 230-235.
- 1966b. A FLOWER-POT EMERGENCE TRAP FOR LEPTOCONOPS KERTESZI. *Jour. Econ. Ent.* 59: 225-226.
1967. BLOOD MEAL SIZE OF LEPTOCONOPS KERTESZI (DIPTERA: CERATOPOGONIDAE). *Mosquito News* 27: 424.
1968. THE RESTING BEHAVIOR OF THE DESERT CERATOPOGONID, LEPTOCONOPS KERTESZI. *Jour. Med. Ent.* 5: 223-229.
1969. ATTACK ACTIVITY OF TWO SPECIES OF GNATS IN SOUTHERN CALIFORNIA. *Ent. Soc. Amer. Ann.* 62: 112-116.
- and SJOGREN, R. D.
1967. A COLLECTION DEVICE FOR LEPTOCONOPS KERTESZI (DIPTERA: CERATOPOGONIDAE) BITING GNATS. *Jour. Med. Ent.* 4: 281-283.
- FREEBORN, S. B., and ZIMMERMAN, E. C.
1934. THE MALES OF LEPTOCONOPS TORRENS, TNS., AND L. KERTESZI, KIEFF. *Bul. Ent. Res.* 25: 257-262.

- GEORGHIOU, G. P., SJOGREN, R. D., and BARKLEY, J.
1972. EFFECTS OF ORGANOPHOSPHORUS, CARBAMATE AND ORGANOCHLORINE INSECTICIDES ON LEPTOCONOPS KERTESZI (KIEFFER) (DIPTERA: CERATOPOGONIDAE). Mosquito News 32: 205-208.
- HARANT, H., and BRUNEL, D.
1950. SUR LES LEPTOCONOPS S. LATO (DIPT. HELEIDAE) DU MIDI MEDITERRANEEN. Vie et Milieu 1: 240-242.
- HOWELL, C. J.
1970. ENTOMOLOGIESE BERIGTE. So. African Vet. Med. Assoc. Jour. 41: 71-74.
- JONES, R. H.
1961. SOME OBSERVATIONS ON BITING FLIES ATTACKING SHEEP. Mosquito News 21: 113-115.
1965. EPIDEMIOLOGICAL NOTES: INCIDENCE OF CULICOIDES VARIIPENNIS IN AN OUTBREAK OF BLUETONGUE DISEASE. Mosquito News 25: 217-218.
1967. EPIDEMIOLOGICAL NOTES: TWO BLUETONGUE EPIZOOTICS. Mosquito News 29: 461-464.
- POTTER, H. W., and RHODES, H. A.
1972. CERATOPOGONIDAE ATTACKING HORSES IN SOUTH TEXAS DURING THE 1971 VEE EPIDEMIC. Mosquito News 32: 507-509.
- KIEFFER, J. J.
1908. DESCRIPTION D'UNE ESPECE NOUVELLE DE CHIRONOMIDES D'EGYPTE. Hungarici Natl. Hist.-Nat. Mus. Ann. 6: 576-577.
- KNOWLTON, G. F., and FRONK, L. E.
1950. SOME LOCALITY RECORDS OF UTAH HELEIDAE. Kans. Ent. Soc. Jour. 23: 113-114.
- and KARDOS, E. H.
1951. UTAH HELEIDAE. Kans. Ent. Soc. Jour. 24: 163.
- KRIVOSHEINA, N. P.
1962. THE PRE-IMAGINAL STAGES OF LEPTOCONOPS (HOLOCONOPS) BOREALIS GUTZ. AND THE SYSTEMATIC POSITION OF THE GROUP LEPTOCONOPS (DIPTERA, NEMATOCERA). Zool. Zhur. 41: 247-251 [In Russian, English summary.]
- LANGERON, M.
1913. MYCTEROTYPUS LAURAE. DESCRIPTION D'UNE VARIETE NOUVELLE (M. LAURAE, VAR. PENETI). Arch. Parasitol. 16: 282-301.
- LEGNER, E. F., SJOGREN, R. D., and WILES, J. T.
1970. EFFECTS OF LOW BIURET UREA ON NATURAL POPULATIONS OF HIPPELATES COLLUSOR (TOWNSEND) and LEPTOCONOPS KERTESZI (KIEFFER). Mosquito News 30: 633-640.
- MACFIE, J. W. S.
1943. CERATOPOGONIDAE (DIPTERA) FROM EGYPT. Roy. Ent. Soc., London. Proc. Ser. B: Taxonomy 12: 145-159.
1947. CERATOPOGONIDAE FROM THE ANGLO-EGYPTIAN SUDAN. Roy. Ent. Soc., London. Proc. Ser. B: Taxonomy 16: 69-78.
- MAJORI, G., BERNARDINI, F., BETTINI, S., and others.
1971. RICERCHE SUI CERATOPOGONIDI NEL GROSSE-TANO. NOTA V: CARATTERISTICHE GEOLOGICHE DEI FOCOLAI DI LEPTOCONOPS SPP. Riv. di Parassitol. 32: 277-291.
- BETTINI, S., FINIZIO, E., and PIERDOMINICI, G.
1970. RICERCHE SUI CERATOPOGONIDI NEL GROSSE-TANO. NOTA IV: IDENTIFICAZIONE DEI FOCOLAI DI LEPTOCONOPS (HOLOCONOPS) KERTESZI KIEFFER, 1908. Riv. di Parassitol. 31: 279-284.
- MAYER, K.
1934. DIE METAMORPHOSE DER CERATOPOGONIDAE (DIPT.). Arch. f. Naturgesch. N.F. 3: 205-288.
- MEILLON, B. DE, and HARDY, F.
1953. NEW RECORDS AND SPECIES OF BITING INSECTS FROM THE ETHIOPIAN REGION—IV. Ent. Soc. South. African Jour. 16: 17-35.
- MULLA, M. S.
1958. UNUSUAL OCCURRENCE OF L. KERTESZI. Calif. Vector Views 5: 55.
- MURRAY, W. D.
1966. COOPERATIVE WORK HELPS MULTI-TARGETED DELTA MAD ACHIEVE URBAN-RURAL CONTROL. Pest Control 34 (9): 30, 34, 36.
- OKADA, T.
1954. NOTE ON SOME BITING MIDGES OF INNER MONGOLIA, NORTH CHINA, MANCHURIA, AND KOREA (DIPTERA, HELEIDAE). Jap. Jour. Appl. Zool. 19: 1-7.
- REES, D. M.
1958. REPORT ON THE RESULTS OF CONTROL METHODS APPLIED TO BITING GNATS IN THE VICINITY OF SALT LAKE CITY, UTAH (DIPTERA: CERATOPOGONIDAE). 10th Internatl. Cong. Ent. Proc. 3: 741-744.
- COLLETT, G. C., and LAWYER, P. G.
1972. REPORT ON THE CONTROL OF THE BITING GNAT LEPTOCONOPS KERTESZI KIEFFER IN THE VICINITY OF SALT LAKE CITY, UTAH. Utah Mosquito Abatement Assoc. 24th Ann. Mtg. Proc. (1971): 15-17.
- COLLETT, G. C., and WINGET, R. N.
1969. THE LEPTOCONOPS PROBLEM IN UTAH. Utah Mosquito Abatement Assoc. 22d Ann. Mtg. Proc. (1969): 29-30.
- LAWYER, P. G., and WINGET, R. N.
1971. COLONIZATION OF LEPTOCONOPS KERTESZI KIEFFER BY ANAUTOGENOUS AND AUTOGENOUS REPRODUCTION (DIPTERA: CERATOPOGONIDAE). Jour. Med. Ent. 8: 266-271.
- and SMITH, J. V.
1950. EFFECTIVE CONTROL METHODS USED ON BITING GNATS IN UTAH DURING 1949 (DIPTERA: CERATOPOGONIDAE). Mosquito News 10: 9-15.

- _____ and SMITH, J. V.
1952. CONTROL OF BITING GNATS IN NORTH SALT LAKE CITY, UTAH (DIPTERA: HELEIDAE). Mosquito News 12: 49-52.
- _____ and WINGET, R. N.
1970. CURRENT INVESTIGATIONS IN UTAH OF THE BITING GNAT LEPTOCONOPS KERTESZI. Mosquito News 30: 121-127.
- _____ WINGET, R. N., and LAWYER, P. G.
1970. STUDIES IN UTAH OF THE BITING GNAT LEPTOCONOPS KERTESZI KIEFFER (DIPTERA: CERATOPOGONIDAE). Univ. Utah Cent. Environ. Biol. Rpt. 1:1-40.
- RIOUX, J. A., and DESCOUS, S.
1965. DETECTION DU BIOTOPE LARVAIRE DE LEPTOCONOPS (HOLOCONOPS) KERTESZI KIEFFER, 1908 (DIPTERA—CERATOPOGONIDAE) DANS LE "MIDI" MEDITERRANEEN. Ann. de Parasitol. Humaine et Compar. 40: 219-229.
- _____ DESCOUS, S., and JUMINER, B.
1964. UNE NOUVELLE STATION DE LEPTOCONOPS (HOLOCONOPS) KERTESZI KIEFFER, 1908 (DIPTERA, CERATOPOGONIDAE) EN TUNISIE. Inst. Pasteur de Tunis, Arch. 41: 153-155.
- RYCKMAN, R. E.
1961. PARASITIC CERATOPOGONIDAE AND SIMULIIDAE (DIPTERA) FROM IMPERIAL COUNTY, CALIFORNIA. Jour. Parasitol. 47: 405.
- SJOGREN, R. D., and FOULK, J. D.
1967. COLONIZATION STUDIES OF LEPTOCONOPS KERTESZI BITING GNATS. Mosquito News 27: 394-397.
- SMITH, L. M., and LOWE, H.
1948. THE BLACK GNATS OF CALIFORNIA. Hilgardia 18: 157-183.
- THORPE, W. H.
1931. MISCELLANEOUS RECORDS OF INSECTS INHABITING THE SALINE WATERS OF THE CALIFORNIA DESERT REGIONS. Pan-Pacific Ent. 4: 145-153.
- WEISS, A.
1912. MYCTEROTYPUS LAURAE, N. SP., CHIRONOMIDE NOUVEAU DU SUD TUNISIEN. Inst. Pasteur de Tunis, Arch. 1912, pp. 24-31, 3 pl.
- WHITSEL, R. H.
1965. A NEW DISTRIBUTION RECORD AND AN INCIDENCE OF MERMITHID NEMATODE PARASITISM FOR LEPTOCONOPS KERTESZI KIEFFER (DIPTERA: CERATOPOGONIDAE). Mosquito News 25: 66-67.
- _____ and SCHOEPPNER, R. F.
1965. THE ATTRACTIVENESS OF CARBON DIOXIDE TO FEMALE LEPTOCONOPS TORRENS TNS., AND L. KERTESZI KIEFF. Mosquito News 25: 403-410.
- WIRTH, W. W.
1951. A NEW BITING MIDGE OF THE GENUS LEPTOCONOPS FROM FLORIDA, WITH NEW RECORDS OF OTHER AMERICAN SPECIES (DIPTERA, HELEIDAE). Ent. Soc. Wash. Proc. 53: 281-284.
- _____ 1952. THE HELEIDAE OF CALIFORNIA. Univ. Calif. Pubs. Ent. 9: 95-266.
- _____ and ATCHLEY, W. R.
1973. A REVIEW OF THE NORTH AMERICAN LEPTOCONOPS (DIPTERA: CERATOPOGONIDAE). Tex. Tech. Univ. Grad. Studies No. 5: 1-57.



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FIGURE 26.—Habitat of *Leptoconops asilomar*, n. sp., and *L. whitelyi*, n. sp., at Pebble Beach, Asilomar, Monterey County, Calif.: Above, general view of habitat; below, soil habitat with emergence trap in place. (Courtesy of R. F. Schoepner.)

END