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A NEW SPECIES OF *CLADOCHAETA* COQUILLETT (DIPTERA: DROSOPHILIDAE) AND A NEW RECORD FOR *CLADOCHAETA STURTEVANTI* WHEELER AND TAKADA IN ARIZONA, WITH NOTES ON NATURAL HISTORY

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Abstract.—***Cladochaeta johnsonae*, new species**, is described and figured, including description of larvae and their association with spittlebug (Cercopidae) nymphs. A new record for *Cladochaeta sturtevanti* Wheeler and Takada is reported from Arizona, previously known only from California, Washington, and southwestern Utah.

Key Words: *Cladochaeta,* Drosophilidae, taxomony, Arizona, larvae, spittlebugs, Cercopidae

The genus *Cladochaeta* was erected by the dipterist, D. W. Coquillett (1856–1911) in 1900 for *Cladochaeta nebulosa.* The generic name refers to the single-branched arista of this species. In 1924, J. R. Malloch described *Clastopteromyia* for the eastern North American species *Clastopteromyia inversa,* naming the genus in reference to its association with the cercopid *Clastoptera.* These two generic names were subsequently used synonymously until Wheeler and Takada (1971) recognized *Clastopteromyia* as a junior synonym of *Cladochaeta.* Vilela and Bächli (1990), in a study of type specimens, provided a diagnosis for a monophyletic genus *Cladochaeta,* in which they included 13 described species. Grimaldi and Nguyen (1999) reported over 100 additional new species to the genus and transferred two species from the genus *Diathoneura* to *Cladochaeta.* In the present paper, I describe the adults and immature stages of a new species of *Cladochaeta* and report a new record for *C. sturtevanti* Wheeler and Takada.

MATERIAL AND METHODS

During August 22–25, 1998, and September 12–17, 1999, spittlemasses were surveyed at and in the vicinity of the Southwestern Research Station (SWRS). The station is located near Portal, Arizona, in the Chiricahua Mountains at elevations of roughly 4,500–5,500 ft. (1,372–1,677 m). Vegetation of the area is dominated by oaks (*Quercus* spp.), pinyon pine (*Pinus edulis* Engelmann), juniper (*Juniperus* spp.), and agave and creosote at slightly lower elevations. Spittlemasses with fly larvae or pupae were collected and kept in plastic vials with branch cuttings from the respective host plants. Some fly larvae and spittlebug nymphs were immediately preserved in 70% ethanol and subsequently critical point dried. The remaining immatures were allowed to eclose, were collected, critical point dried, and mounted for study.

Diagnostic measurements of the adult head of *Cladochaeta* were taken as described in Grimaldi and Nguyen (1999) (see Table 1). Overall body length was also mea-

Table 1. Measurements of *Cladochaeta johnsonae* adults (mm).

	ThL	HW	CD	ED	FW	CD/ED	FW/HW
♂	0.971	0.750	0.086	0.361	0.250	0.238	0.333
	0.911	0.742	0.074	0.372	0.225	0.198	0.303
	0.959	0.750	0.090	0.396	0.237	0.227	0.316
	1.125	0.843	0.084	0.407	0.273	0.206	0.323
	0.980	0.770	0.077	0.369	0.249	0.208	0.323
	1.100	0.810	0.099	0.400	0.287	0.247	0.354
	1.023	0.819	0.082	0.408	0.282	0.200	0.344
	1.020	0.706	0.074	0.357	0.215	0.207	0.304
	0.857	0.687	0.071	0.35	0.251	0.203	0.365
	0.858	0.678	0.073	0.338	0.228	0.216	0.336
	0.994	0.813	0.083	0.39	0.273	0.213	0.336
	0.905	0.716	0.077	0.361	0.249	0.213	0.348
	0.791	0.662	0.064	0.349	0.239	0.183	0.361
	0.834	0.679	0.070	0.344	0.254	0.203	0.374
	0.953	0.792	0.074	0.372	0.271	0.199	0.342
Average	0.952	0.748	0.079	0.372	0.252	0.211	0.337
♀	0.912	0.729	0.074	0.349	0.233	0.212	0.319
	0.890	0.725	0.083	0.345	0.243	0.240	0.335
	0.904	0.722	0.070	0.338	0.244	0.207	0.338
	0.809	0.681	0.065	0.323	0.226	0.201	0.332
	0.923	0.739	0.072	0.373	0.232	0.193	0.314
	0.746	0.650	0.068	0.313	0.218	0.217	0.335
	0.839	0.677	0.074	0.338	0.192	0.219	0.284
	0.906	0.765	0.082	0.361	0.250	0.227	0.327
	0.812	0.640	0.070	0.336	0.203	0.208	0.317
	0.914	0.696	0.076	0.358	0.223	0.212	0.320
	0.784	0.616	0.062	0.318	0.208	0.195	0.338
	0.703	0.613	0.062	0.321	0.203	0.193	0.331
Average	0.845	0.688	0.0715	0.339	0.223	0.210	0.324

ThL = Thorax Length, HW = Head Width, CD = Cheek Depth, ED = Eye Depth, FW = Face Width.

sured for adult cercopids. To study the mating behaviors of these flies, some flies were maintained in culture using standard instant *Drosophila* medium (Carolina Biological Supply Company). Virgin females were kept separate from males. Several days after eclosing, a single virgin female was introduced to a single male in a plastic vial and observed up to one hour. Genitalia of males and females were dissected and mounted on microscope slides using techniques described by Grimaldi (1987). Mouthparts of larvae were obtained through dissection of specimens as well as from puparia. Select fly larvae and spittlebug nymphs were sputter coated with gold/palladium for study by scanning electron microscopy (SEM). Electromicrographs were also taken of heads of male and female *Cladochaeta* adults. All SEM's were taken with a Hitachi S4700 Field Emission SEM. Morphological terminology follows Grimaldi and Nguyen (1999). All specimens are deposited in the American Museum of Natural History (AMNH).

Results

Individuals of *Cladochaeta* associated with spittlebugs were found on golden rabbitbrush (*Chrysothamnus nauseosus* Britton). Based on dissected male genitalia, the flies associated with cercopids on this plant were identified as *C. sturtevanti,* which had not previously been reported in Arizona. Previous collections of this species have mostly been from California, with a few in-

dividuals from Washington and southern Utah. Eleven male and ten female flies were collected during the first collection period. The *Chrysothanmus* cercopids were identified as *Clastoptera lineatocollis* Stål (Doering, 1928). The spittlemass produced by this species of cercopid was very frothy and usually contained only a single nymph. Approximately 30% of the spittlemasses contained either a *Cladochaeta* larva or pupa. Occasionally, two pupae were found within the same spittlemass. Fly pupae were found in locations varying from within the spittlemass, generally at the edge, to distant of the spittlemass by as much as a centimeter, generally lodged in the node of a small branch apical to the spittlemass. The cercopids were rather small (3.97 mm body length). In several cases, apparently moribund nymphs of this species were found close to a fly pupa, which has never been observed for other *Cladochaeta,* even *C. inversa* (Grimaldi and Nguyen 1999).

Immature stages of a new species of *Cladochaeta* also were associated with spittlebugs on wild grape (*Vitis arizonica* Engelmann). Three females and nine males of this new *Cladochaeta* species were reared to adults and collected during the first visit to SWRS. Eleven females and 11 males were collected during the secong collecting period. The wild grape spittlebugs were small (3.66 mm average body length) and keyed out to a species of *Clastoptera* between *lawsoni* Doering and *arizonana* Doering (Doering 1928). These spittlebugs were found only on wild grape and never on *Chrysothamnus.* They produced a very mucilaginous spittlemass, which almost always contained fly larvae. The *Cladochaeta* larvae were observed crawling through the jelly-like portion of the grape spittlemasses more often than those found in *Chrysothamnus* spittlemasses. However, many larvae were also found attached to nymphs (Fig. 1). These spittlemasses harbored aggregations of up to 50 nymphs, many of which were early instars.

Attempts at maintaining *Cladochaeta* in culture were largely unsuccessful. Males survived up to two weeks but females usually died after a few days. It appeared that these females did not eat any of the instant *Drosophila* medium since their abdomens were shrunken. No results were recorded for the mating behavior of this *Cladochaeta.* When introduced into the same vial, males and females ignored one another and usually remained apart and groomed themselves. Individuals of both sexes, however, were observed to move their wings in a fashion similiar to that reported by Spieth (1952: 454–455) for *Chymomyza.* No movement of the forelegs was observed.

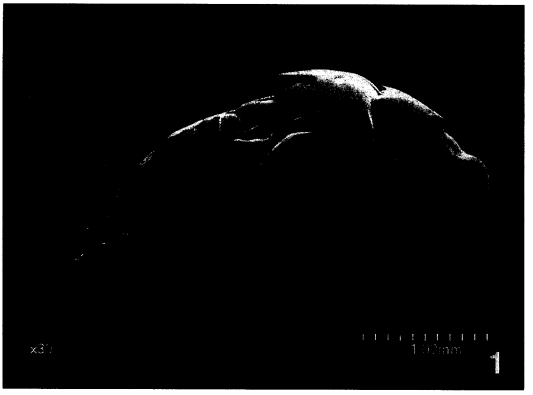
Systematics

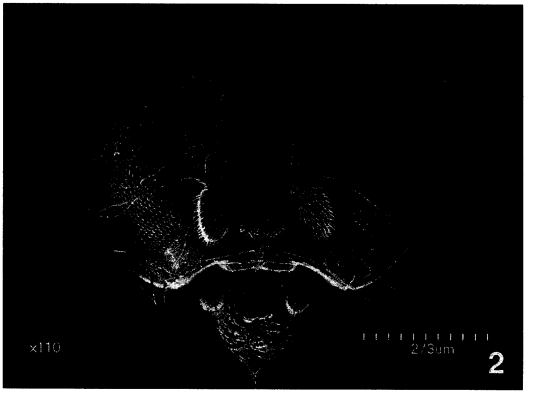
Cladochaeta johnsonae Nguyen, new species

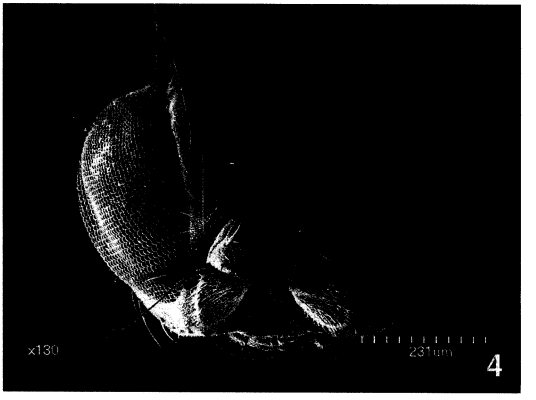
(Figs. 1–17)

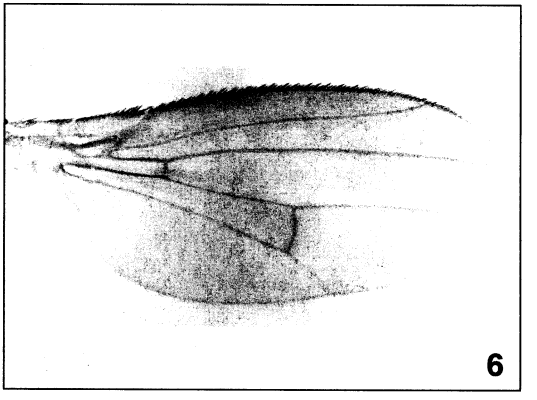
Diagnosis.—Thorax dark yellow to brown with darker areas laterally. Abdomen with light yellow pattern in a V-shape anteriorly; brown to black posteriorly. Male genitalia similar to *Cladochaeta mystaca* Grimaldi and Nguyen (see Discussion). Male with long and convergent vibrissae having tips that intertwine to form one full spiral. Male antenna with pedicel having a medially projecting, long, fingerlike lobe with numerous setulae at the apex. Differs from *C. mystaca,* which has a brush of longer setae on smaller pedicel lobes.

Description.—*Head:* Eyes with very sparse, short pilosity. In male, antenna with pedicel with fingerlike lobe having numerous, long setulae; setulae very thick at apex; lobe almost equal in length to flagellomere I (Figs. 2, 3). Female without modified pedicel (Fig. 4). Flagellomere I dark brown to black in both sexes. Arista with 3 dorsal branches (Fig. 5); one ventral branch between d-3 and apical fork; ventral branch equal in length to d-3; branches of apical fork about 0.5 length of d-3. Frons brownish yellow; interfrontal setulae of about equal length to anterior reclinate orbital setae but thinner. Proclinate setae about same









Figs. 1–6. *Cladochaeta johnsonae*. 1, Cercopid nymph with attached larva. 2, Head of male. 3, Detail of male antennae, showing modified pedicels. 4, Head of female. 5, Arista. 6, Wing.

length as posterior reclinate orbital setae; anterior reclinate setae about 0.5 length of proclinates. Postocellar setae medium to small and convergent. Face medium tan and flat; cheeks yellow and of moderate depth. In male, vibrissae long, very fine, and convergent, forming spiral; in female, thicker and without spiral. Proboscis and palps yellow.

Thorax: Scutellum yellow; scutum generally yellowish with darker areas in posterior and lateral portions. Anterior scutellar setae large and convergent; apical scutellar setae cruciate and slightly shorter than an-

terior scutellars. Anterior dorsocentral setae about 0.5 length of posterior dorsocentrals. Legs light yellow. Forefemur with row of 4 stiff dorsolateral setae and row of 3 ventrolateral setae; in female dorsolateral setae of same thickness as in male but slightly shorter; hindfemur of both sexes without prominent setae. Wing hyaline with diffuse infuscation along costal edge down to past R_{4+5}; infuscation darkest around costal edge towards but not reaching apex of wing (Fig. 6); very slight clouding of x-vein dm-cu; venation and shape as in *C. mystaca*. Haltere light yellow.

Abdomen: Tergites I–III yellow medially, brown laterally; tergites IV–VII uniformly brown. Sternites yellow; lighter yellow in female. Female terminalia (Fig. 7): Apical tergite narrow and without setae; simpe inverted U-shaped. Apical sternite sclerotized; base flared into 2 lateral arms curving anteriorly and downwards; tip of sternite undivided, projecting posteriorly, with 12 small setae. Male genitalia (Fig. 8) very similar to *C. mystaca* (Grimaldi and Nguyen 1999, fig. 64) with following differences: Cercus larger and triangular shaped; epandrium height about 1.5× width vs. being equal; tapering in distal ends of epandrium more pronounced; each half of epandrium with row of 6–7 setae vs. having 5 setae; distal third of paraphyses much broader; apices of paraphyses without noticable knob.

Type material.—Holotype ♂, ARIZONA: Cochise Co., vicinity of Portal. 5000–5500 ft. VIII/20–25/98. Reared from cercopids on wild grape. Nguyen and Grimaldi, colls. (AMNH). Paratypes, same data as holotype (2 ♀, 2 ♂) (AMNH).

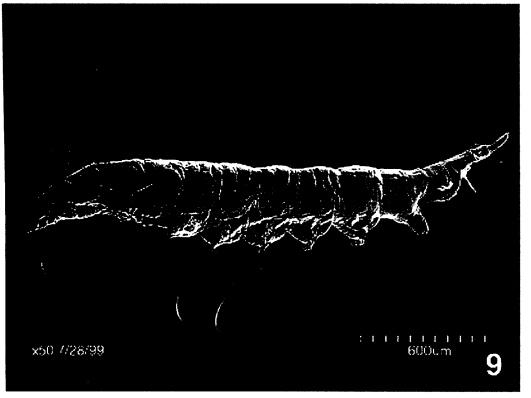
Other specimens examined.—ARIZONA: Cochise Co., near Portal, 5,000–5,500 ft. IX/13–21/99. Reared from cercopids on wild grape. T. Nguyen, coll. (11 ♀, 11 ♂) (AMNH). Same data as holotype (1 ♀, 6 ♂) (AMNH).

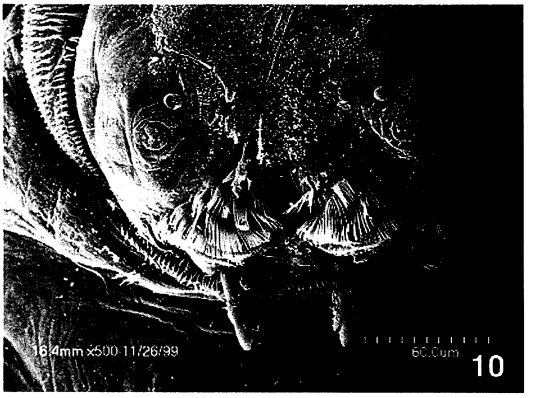
Etymology.—Named for Christine A. Johnson, a colleague at AMNH and veteran researcher at SWRS.

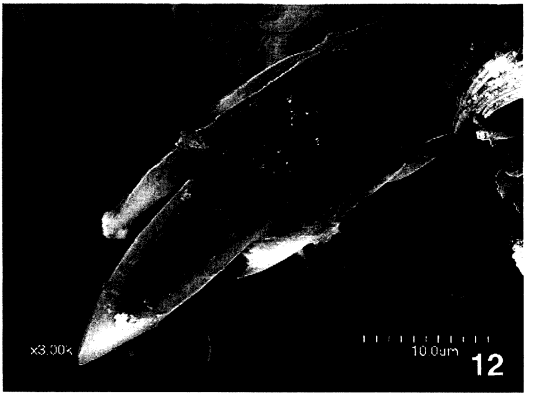
Third instar larva (Figs. 9–17).—Amphineustic; anterior spiracle with 3 filaments. Head small (Fig. 10); antenna and maxillary palp complex as in other drosophilids. Oral cavity small and round. Oral lamellae in 10–12 transverse rows with long, thin fringes; 3 rows anterior to oral cavity; 1 vertical row of lamellae flanking either side of oral cavity (Fig. 11). Mandible entirely sclerotized, small and hooked with 1 prominent tooth and 3 smaller ones posterior to apical hook on both ventral edges (Fig. 12); teeth form a groove on ventral surface of each mandible (Fig. 13). Anterior portions of cephalopharyngeal skeleton, including hypopharynx, heavily sclerotized; hypopharyngeal sclerite moderately sclerotized; dorsal and ventral cornu not sclerotized (Fig. 14). Six pairs of prolegs, each with crochet of 25–30 sharp, hooked spinules in 3–4 rows; spinules of first row pointing anteriorly, those of remaining rows pointing posteriorly (Fig. 15). Pair of fingerlike and apparently eversible structures lateral to anus (Fig. 16) (probably same structures found in *C. inversa* by Grimaldi and Nguyen 1999, fig. 167c). Posterior spiracles on telescoping trunk about 1.5× length of everted spiracular tubes; spiracular tubes separated and eversible (Fig. 17). Spiracular plate with 3 spiracular openings. Spiracular hairs reduced as in other *Cladochaeta* larvae examined (Grimaldi and Nguyen 1999: 292).

Discussion

Cladochaeta johnsonae is placed in the *sororia* species group (Grimaldi and Nguyen 1999: 92) and is closely related to *C. mystaca* based on remarkably similar structures in the male genitalia, particularly of the paraphyses. Both species also have modified pedicels and unusual oral vibrissae (for flies). Despite these similarities, the differences in the modified pedicels of *C. johnsonae* and *C. mystaca* are striking enough to justify separate species. This is also consistent with the subtle differences in the male genitalia of these two species. McAlpine (1976) suggested that spiral vi-



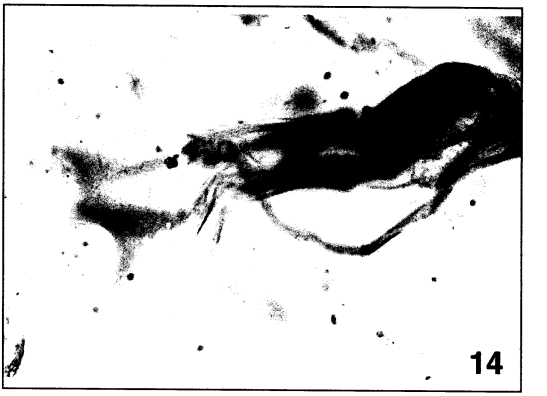


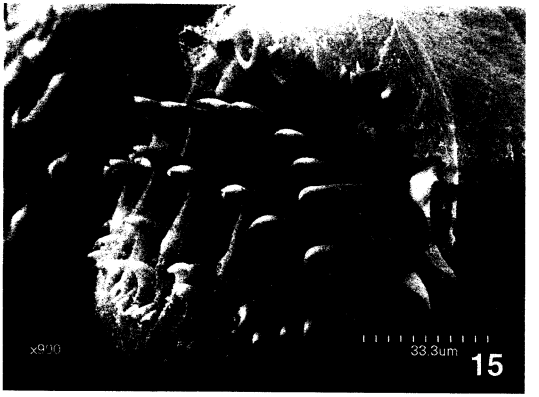


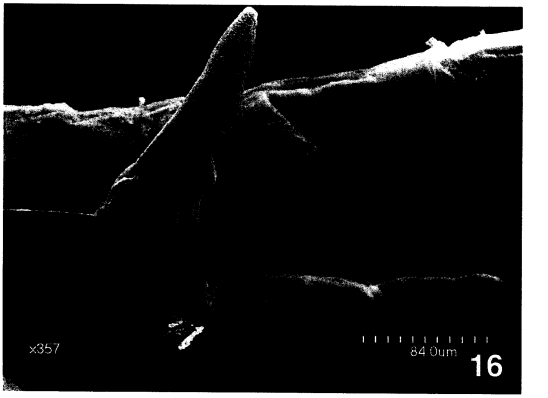
Figs. 7–12. *Cladochaeta johnsonae*. 7, Female terminalia, lateral view. 8, Male genitalia, posterior view. 9, Habitus of third-instar larva. 10, Head of larva. 11, Oral cavity of larva, showing oral lamellae. 12, Detail of larval mouth hook.

brissae reported in some male clusiid flies may be used in combat. It is unclear whether this is the case in these two *Cladochaeta* species.

During the second collecting period, no *C. sturtevanti* larvae nor their associated cercopids were found. This is probably due to the later collecting date during this period. Both *C. sturtevanti* and *C. johnsonae* were restricted to their respective host cercopids and plants. In only one instance during the second collecting period, four fly larvae were collected from cercopids on an unidentified vine (possibly an introduced







Figs. 13–16. *Cladochaeta johnsonae*. 13, Ventral view of larval mandibles, showing teeth and ventral grooves. 14, Larval cephalopharyngeal skeleton. 15, Detail of proleg, showing crochet of hooks. 16, Everted para-anal organs. 17, Posterior spiracles.

species) next to a large stand of wild grape. This vine had many spittlemasses of cercopids of apparently the same species as those on wild grape. Only one of these spittlemasses contained any fly larvae. Of the fly larvae collected from this plant, only a single female eclosed and was indentified as *C. johnsonae*. The remaining larvae died and were lost. The presence of *Cladochaeta* on this different plant may be a chance occurrence due to the proximity of its usual host plant. A more thorough examination of

the plants in this area will determine if *C. johnsonae* is restricted to cercopids on wild grape.

The morphology of *C. johnsonae* third-instar larvae suggests an intermediate state between parasitic and saprophagous lifestyles. The oral lamellae of *C. johnsonae* are more numerous and developed than in other described *Cladochaeta* larvae and are closer to those of known saprophagous drosophilids (Grimaldi and Nguyen 1999, fig. 170). These lamellae, however, do not converge as strongly into the oral cavity as in other sparophagous flies. The mandibles of *C. johnsonae* are rather blunt and bear teeth. These teeth and ventral grooves on the mandibles are strikingly similar to those of a saprophagous ephydrid reported to live in spittlemasses of *Tomaspis inca* Guérin-Méneville in Costa Rica (Grimaldi and Nguyen 1999: 293). However, *C. johnsonae* does possess only a partially sclerotized cornu of the cephalopharyngeal skeleton. In saprophagous species the cornu is heavily sclerotized. The common observation of *C. johnsonae* larvae attached to spittlebug nymphs also indicates a parasitic lifestyle. These aspects of the morphology of *C. johnsonae* larvae may suggest a facultatively spaprophagous lifestyle and possible switching between true parasitism and saprophagy in this species. This probably explains why *C. johnsonae* larvae were found often crawling freely within spittlemasses, a habit which was not seen frequently in *C. sturtevanti* larvae.

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