

ARTHROPOD FAUNA COHABITING LARVAL BREEDING SITES OF *LEPTOCONOPS FOULKI* CLASTRIER & WIRTH IN THE SANTA ANA RIVER, CALIFORNIA¹

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ABSTRACT. Four principal carabids and several hunting spiders of ca. 125 arthropod species (in 55 families) found in *Leptoconops foulki* Clastrier and Wirth larval breeding habitats may be influential in natural predation judged by respective host-predator density

associations. Highest predator densities were found in the July–October interval, with *Omophron dentatus* LeConte remaining abundant at all seasons. Predator population densities appeared to rise in response to rising gnat larval densities during summer.

INTRODUCTION

The biting gnat, *Leptoconops foulki* Clastrier & Wirth, is a serious annoyance in and adjacent to the Santa Ana River near Riverside, California during post flood years. Normally, the river is confined to a 0.5–1.0 m deep channel with gnat breeding occurring in a band of sloping shoreline that contains adequate soil moisture. Flood waters destroy the river channel and form a broad shallow meandering stream with many moist sand bars favorable for gnat larval development. From this recently disturbed habitat, adult gnat populations develop to

levels as high as 1,813 females per min attacking around the human head (Foulk and Sjogren 1967).

The persistent, diurnal gnat attack of persons entering the river bottom recreational land and of residents nearby stimulated control studies. Field evaluations of larvicides at maximum registered rates for mosquito control by aerial application indicated little effectiveness, and high volume ground applications were only temporarily effective. However, the unstable bog nature of the sand bars would not support all-terrain vehicles with the required high volume insecticide payloads. The adult gnat habit of resting overnight under the surface of dry wind-blown sand adjacent to the larval breeding grounds favored the suppres-

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sion of adult populations by aerial applications to these localized population foci. An extensive insecticide screening program subsequently conducted to determine relative susceptibility of *L. foulki* to available compounds, revealed no significant resistance (Georghiou et al. 1972). However, as chemical cost and resistance problems were ultimately anticipated, alternative control strategies were also initiated. One method employed the use of low biuret urea directed at the larval and pupal breeding habitat near or at the soil surface (Rees et al. 1971), which resulted in over 51% reduction in emergence over 3 field generations, yet produced no harmful effects on several predatory species tested (Legner et al. 1970).

The present study was conducted to characterize the arthropod fauna associated with *L. foulki* egg, larval, and pupal habitats beginning the summer following river flooding in 1970. The objective was to determine qualitatively and quantitatively those arthropods which may exert the greatest impact on immature gnat populations. Other workers have reported several arthropod species as predators of *Leptoconops* (Bacon 1973, Foulk 1968, Legner et al. 1970), but their relative impact was not assessed.

MATERIALS AND METHODS

Three *L. foulki* breeding sites were selected along the Santa Ana River located ca. 3 km apart. The 1st location was southwest of Pedley, California, 2.8 km downstream from the Van Buren Ave. Bridge; the 2nd site was 2 km west of Mira Loma, California and a 3rd site in Norco, 0.2 km south of the Hamner Ave. Bridge on the Granja Vista del Rio Ranch. Experimental plots selected were ca. 0.2 ha. in size, centrally located within the breeding grounds.

Three methods were employed to sample each site to insure representative collection of arthropod forms present. In one method, soil cores were collected by combining three 7.6-cm long by 4.4-cm diam. plugs per sample in plastic bags, 10

samples per site for separation by 23-cm diam. Berlese funnels heated with 40 watt light bulbs. In the 2nd method, 10 additional samples were collected per site for processing by soil flotation, using a saturated solution of $MgSO_4$. Both groups of soil samples were placed in a cool ice chest for transfer to the laboratory where they were processed on the same day as collected.

The 3rd sample method consisted of pit traps constructed from 946-cc polyethylene containers fitted with a 10-cm diam. funnel. A 6.5 cm² Vapona® pest strip was placed in the bottom of each trap to kill captured specimens. Twelve traps were placed at random within the plot each month and left in place for 7 days before collection. All specimens were preserved in 75% ethanol.

Samples were collected monthly, using all 3 methods described from each of the 3 breeding sites, from July through November, 1970 after which the study areas were again inundated by flood water. Sample collection was resumed in January and February, 1971.

More frequent and earlier sampling was made of *L. foulki* larvae using a 2.5 cm diam. core sampler, and of adults using a modified suction machine (Dietrick et al. 1959, Foulk and Sjogren 1967) held at head height (1.8 m) operating 6 min over a distance of 30 m.

RESULTS AND DISCUSSION

At least 125 arthropod species were found in association with the breeding habitat of *L. foulki*, as revealed by the 3 collection methods (table 1), the pit trap yielding the greatest number of species. However, 4 carabid species, *Brachinus costipennis* Motschulsky, *Bradycellus nitidus* Dejean, *Omophron dentatus* LeConte, and *Stenolophus comma* Dejean, comprised 84.5% of the total number of individual insect specimens collected (table 1). The relative densities of 17 principal arthropod species trapped in pit traps is shown in table 2 for each of the 7 collec-

Table 1. Predatory and scavenger arthropods found associated with the biting gnat, *Leptoconops foulki* Clastrier & Wirth, in the Santa Ana River, California during 7 monthly surveys from July 1970 to February 1971.

Species	No. Sites Present	Samples Found ¹	Relative Abundance in Pit Traps (%) ²
Insecta			
Coleoptera			
Anthicidae			
<i>Anthicus</i> spp.	2	S	—
Carabidae			
<i>Agonum funebris</i> Dejean	3	P	0.15
<i>Agonum punctiforme</i> Say	1	P	0.01
<i>Amara littoralis</i> Mannerheim	1	P	<0.01
<i>Amara</i> sp. prob. <i>stupidus</i> LeConte	3	P	0.10
<i>Amara</i> sp. "A"	1	F	—
<i>Amara</i> sp. "B"	2	P	0.07
<i>Amara</i> sp. "C"	1	P	<0.01
<i>Anisodactylus californicus</i> Dejean	3	P	0.95
<i>Apristus laticollis</i> LeConte	2	P	0.12
<i>Bembidion obliquulum</i> LeConte	1	P	<0.01
<i>Brachinus costipennis</i> Motschulsky	3	F,P	5.07
<i>Bradycellus nitidus</i> Dejean	3	F,P,S	23.95
<i>Calathus ruficollis</i> Dejean	1	P	0.04
<i>Calosoma cancellatum</i> Escholtz	1	P	<0.01
<i>Chlaenius obsoletus</i> LeConte	1	P	<0.01
<i>Chlaenius sericeus viridifrons</i> Escholtz	2	P	0.04
<i>Chlaenius tricolor</i> Dejean	3	P	0.07
<i>Chlaenius variabilipes</i> Escholtz	3	P	0.04
<i>Dyschirius aratus</i> LeConte	2	F,P,S	0.16
<i>Elaphropus renoica</i> Casey	2	F,P,S	0.71
<i>Harpalus bicolor</i> Fab.	2	P	0.18
<i>Notiobia purpurascens</i> Bates	3	P	0.26
<i>Omophron dentatus</i> LeConte	3	F,P,S	50.67
<i>Platynus brunneomarginatus</i> Mannerheim	1	P	<0.01
<i>Pterostichus lustrans</i> LeConte	2	P	0.04
<i>Pterostichus</i> nov. sp.	1	F	—
<i>Scarites subterraneus</i> Fab.	2	P	0.05
<i>Stenolophus anceps</i> LeConte	2	P	0.04
<i>Stenolophus comma</i> Dejean	3	P,S	4.82
<i>Stenolophus flavipes</i> LeConte	3	P	0.21
Chrysomelidae			
<i>Chaetocnema denticulata</i> Illiger	1	P	<0.01
<i>Diabrotica undecimpunctata undec.</i> Mannerheim	1	P	<0.01
<i>Disonychia latiovittata</i> Hatch	2	F,P	0.14
<i>Longitarsus</i> sp.	1	P	<0.01
Cicindelidae			
<i>Cicindela haemorrhagica</i> LeConte	2	P	0.06
<i>Cicindela oregona</i> LeConte	3	P	0.10
Cucujidae			
<i>Cryptolestes</i> sp.	1	S	—

Table 1. Continued

Species	No. Sites Present	Samples Found ¹	Relative Abundance in Pit Traps (%) ²
Curculionidae			
<i>Hypera brunneipennis</i> Boheman	2	P	0.08
<i>Hypera</i> sp. prob. <i>bicolor</i> Fab.	2	F	—
<i>Listroderes obliquus</i> Klug	2	P	0.04
<i>Rhynchaenus</i> sp.	1	F	—
<i>Sphenophorus venatus</i> (Say)	1	P	<0.01
Baridinae Genus sp.	1	P	<0.01
Dermestidae			
<i>Dermestes maculatus</i> DeGeer	1	S	—
<i>Trogoderma sternale</i> Jayne	1	S	—
Elateridae			
<i>Aeolus mellillus mellillus</i> (Say)	1	P	<0.01
<i>Conoderus amplipollis</i> (Gyllenhal)	3	P	0.06
Heteroceridae			
<i>Heterocerus</i> sp.	3	F,P,S	0.08
Hydrophyllidae			
<i>Chaetarthria</i> sp. prob. new	1	P	0.03
<i>Tropisternus columbianus</i> Brown	1	P	0.02
<i>Tropisternus ellipticus</i> (LeConte)	2	P	0.04
Lathridiidae			
<i>Lathridius crenatus</i> LeConte	1	P	0.01
<i>Melanophthalma</i> sp.	1	P	0.01
Limnichidae			
<i>Eulimnichus californicus</i> (LeConte)	1	F,P,S	0.08
Phalacridae			
<i>Stilbus</i> sp.	2	F,P	0.29
Ptiliidae			
<i>Ptenidium</i> sp.	3	F,S	—
Scarabaeidae			
<i>Aphodius lividus</i> (Olivier)	1	P	0.01
Scolytidae			
<i>Xyleborus saxeseni</i> (Ratzeburg)	3	S	—
Silphidae			
<i>Silpha ramosa</i> Say	2	P	0.70
Sphaeriidae			
<i>Sphaerius politus</i> Horn	1	P	0.04
Staphylinidae			
<i>Apocellus sphaericollis</i> Say	1	P	0.01
<i>Bledius</i> sp.	3	F,P,S	0.01
<i>Carpelimus</i> sp.	3	F,S	—
<i>Platystethus americanus</i> Erichson	3	P	0.01
<i>Philonthus lecontei</i> Horn	1	P	0.01
<i>Scopaeus</i> sp.	1	F	—
<i>Thinobius</i> sp.	3	F,P,S	0.01
Tenebrionidae			
<i>Phloeodes diabolicus</i> LeConte	2	P	0.02
<i>Ulus</i> sp.	1	P	0.03
Misc. Families	3	F,P,S.	3.93
Collembola			
Genus sp.	3	F,S	—
Dermaptera			
Labiduridae			
<i>Labidura riparia</i> (Pallas)	3	P	0.56

Table 1. Continued

Species	No. Sites Present	Samples Found ¹	Relative Abundance in Pit Traps (%) ²
Diptera			
Ceratopogonidae			
<i>Culicoides</i> sp.	1	S	—
<i>Forcipomyia</i> spp.	1	F	—
<i>Leptoconops foulki</i> Clastrier & Wirth	3	F	—
Chironomidae			
Genus sp.	3	F	—
Chloropidae			
<i>Meromyza</i> sp.	1	S	—
<i>Siphonella neglecta</i> Beck	1	P	<0.01
Dolichopodidae			
Genus sp.	3	P	0.06
Ephydriidae			
<i>Atissa pygmaea</i> (Haliday)	2	F,P	0.14
<i>Psilopa olga</i> Cresson	3	P	0.10
Helomyzidae			
<i>Ecoptomera</i> sp.	1	P	<0.01
Milichiidae			
<i>Desmometopa m-nigrum</i> (Zetterstedt)	1	P	<0.01
Phoridae			
<i>Megaselia</i> sp.	3	F,P	0.43
Psychodidae			
Genus sp.	1	S	—
Sarcophagidae			
<i>Hilarella hilarella</i> (Zetterstedt)	1	P	<0.01
<i>Helicobia rapax</i> (Walker)	2	P	0.02
<i>Ravinia lherminieri</i> (Robineau-Desvoidy)	2	P	0.02
<i>Sarcophaga</i> sp.	1	P	<0.01
Sepsidae			
<i>Saltella sphondylii</i> (Schrank)	1	P	<0.01
Sphaeroceridae			
<i>Leptocera</i> sp.	1	P	0.05
Stratiomyidae			
<i>Nemotelus</i> sp.	2	F	—
Tachinidae			
<i>Peleteria</i> sp.	1	P	<0.01
Tethinidae			
<i>Pelomyia coronata</i> (Loew)	1	P	<0.01
Embioptera			
Genus sp.	2	S	—
Homoptera			
Cicadellidae			
<i>Dikraneura</i> sp.	1	P	<0.01
<i>Draeculacephala minerva</i> Ball	1	P	<0.01
<i>Helochara delta</i> Oman	2	P	0.02
<i>Texanamus spatulatus</i> (Van Duzee)	2	P,S	0.05

Table 1. Continued

Species	No. Sites Present	Samples Found ¹	Relative Abundance in Pit Traps (%) ²
Hymenoptera			
Braconidae			
<i>Aspilota</i> sp.	1	P	<0.01
Cynipidae			
Genus sp.	1	S	—
Diapriidae			
<i>Trichopria</i> sp.	3	P	0.04
Eulophidae			
<i>Pnigalio</i> sp.	1	F	—
Formicidae			
<i>Formica</i> sp.	1	P	<0.01
<i>Iridomyrmex humilis</i> (Mayr)	1	P	<0.01
<i>Solenopsis</i> prob. <i>molesta</i> (Say)	1	S	—
<i>Solenopsis xyloni</i> McCook	1	P	0.03
Pompilidae			
Genus sp.	3	P	0.61
Scelionidae			
<i>Calotelea marlattii</i> (Ashmead)	2	P	0.04
<i>Idris</i> sp.	2	S	—
Sphecidae			
<i>Clypeadon</i> sp.	1	P	<0.01
<i>Liris aequalis</i> (Fox)	1	P	<0.01
<i>Liris argentata</i> (P.de B.)	1	P	<0.01
<i>Lyroda subita</i> Say	1	P	0.12
<i>Oxybelus californicus</i> Boheman & Schlinger	2	P,S	0.02
<i>Plenoculus</i> sp.	1	P	<0.01
Tiphidae			
<i>Methocha</i> sp.	1	P	<0.01
Isoptera			
Kalotermitidae			
<i>Incisitermes minor</i> (Hagen)	1	P	<0.01
Orthoptera			
Gryllidae			
<i>Gryllus</i> spp.	3	F,P	0.10
<i>Neonemobius mormonius</i> (Scudder)	2	P	0.05
Tetrigidae			
<i>Paratettix mexicanus</i> (Sauss.)	3	F,P	0.24
Tridactylidae			
<i>Tridactylus</i> sp. prob. <i>minutus</i> Scudder	3	F,P,S	0.02
Thysanoptera			
Thripidae			
<i>Chirothrips</i> sp. nr. <i>mexicanus</i> Crawford	1	S	—
Thysanura			
Genus sp.	2	S	—
Arachnida			
Araneida			
Misc. hunting species	3	F,P,S	—

¹ F = flotation, P = pit traps, S = soil core.² relative abundance of insects averaged over all 7 sample intervals; Arachnida not included.

Table 2. Relative abundance per 10-cm diam. pit trap of predatory and scavenger arthropods found in *Leptaconops foulki* breeding habitats in the Santa Ana River, California during 7 monthly surveys in the 7/14/70-2/16/71 interval (principal species present).

Species	Mean No. / replicate & \bar{s}_x							
	7/14/70	8/18/70	9/15/70	10/15/70	11/16/70	1/14/71	2/16/71	
Coleoptera								
Carabidae								
<i>Agonum funebris</i> Dejean	$\bar{x} = 0.28$ $\bar{s}_x = 0.09$	0	0	0.03	0	0	0	
<i>Anisodactylus californicus</i> Dejean	1.14	—	—	0.03	—	—	—	
<i>Brachinus costipennis</i> Motschulsky	0.23	0.78	0.03	0.03	0	0.11	0	
<i>Bradycellus nitidus</i> Dejean	9.20	0.20	0.03	0.03	—	0.05	—	
<i>Dyschirius aratus</i> LeConte	3.46	0.28	0.25	0.25	0.08	0.11	0	
<i>Notiobia purpurascens</i> Bates	7.75	0.09	0.10	0.09	0.05	0.05	—	
<i>Omophron dentatus</i> LeConte	12.61	20.17	5.14	5.14	7.03	0.31	0.08	
<i>Stenolophus comma</i> Dejean	1.89	2.25	4.65	1.24	1.73	0.13	0.05	
<i>Cicindelidae</i>	0.31	0.06	0	0	0	0	0	
<i>Cicindela oregona</i> LeConte	0.14	0.04	—	—	—	—	—	
<i>Heteroceridae</i>	0.06	0.03	0.36	0.14	0	0	0	
<i>Heterocerus</i> sp.	0.04	0.03	0.12	0.06	—	—	—	
<i>Labiduridae</i>	70.64	0.69	0.50	13.94	13.89	9.33	1.78	
<i>Labidura riparia</i> (Pallas)	7.23	0.22	0.15	3.39	3.92	1.51	0.56	
<i>Dolichopodidae</i>	8.72	1.11	0.11	0.06	0.03	0.03	0.03	
<i>Genus</i> sp.	1.39	0.37	0.05	0.04	0.03	0.03	0.03	
Diptera								
<i>Dermaptera</i>	0.11	0	0	0.03	0	0	0	
<i>Labiduridae</i>	0.05	—	—	0.03	—	—	—	
<i>Labidura riparia</i> (Pallas)	0.07	0	0	0.03	0	0	0.06	
<i>Dolichopodidae</i>	0.05	—	—	0.03	—	—	0.04	
<i>Genus</i> sp.	0.19	0.03	0.03	0	0.06	0	0	
<i>Dolichopodidae</i>	0.09	0.03	0.03	—	0.04	—	—	

	0.22	0	0	0	0	0	0	0	0
	0.09	—	—	—	—	—	—	—	—
Ephydriidae									
<i>Psilopa olga</i> Cresson									
Phoridae									
<i>Megaselia</i> sp.	0.86	0	0	0	0	0	0	0	0
	0.29	0.06	—	—	—	—	—	—	—
Hymenoptera									
Pompilidae									
Genus sp.	0.75	0.39	0.17	0	0.03	0.03	0.03	0.03	0
	0.24	0.12	0.06	—	—	—	—	—	—
Orthoptera									
Tetrigidae									
<i>Paratettix mexicanus</i> (Sauss.)	0.42	0.03	0.06	0	0.03	0.03	0.03	0	0
	0.17	0.03	0.04	—	—	—	—	—	—
ARACHNIDA (Misc. Araneida)									
	3.78	1.11	1.25	0	0.44	0.44	0	0	0
	0.61	0.20	0.22	—	0.13	0.13	—	—	—

tion intervals. Higher densities were generally associated with the July to October period for most species; but *O. dentatus* remained comparatively numerous at later collection dates (table 2). These results also emphasize different predatory species from those assessed earlier (Legner et al. 1970). Several undetermined species of hunting spiders were moderately abundant during the 1st 3 sample months (table 2). The abundance of *L. foulki* larvae (table 3) and adults (table 4) was not significantly correlated, but adult densities approached their peak and progressively subsided in early June (table 4).

Table 3. Number of *Leptoconops foulki* Clastrier & Wirth larvae per 2.5-cm diam. soil core over 6 km of Santa Ana River habitat.

Collection Date	Avg. No. <i>L. foulki</i> larvae	\bar{sx}
1/14/70	7.3	1.5
2/19/70	8.9	3.0
3/13/70	4.3	1.2
4/15/70	4.1	1.5
5/15/70	5.1	0.6
7/29/70	5.9	1.7
8/18/70	14.8	9.7
9/28/70	8.4	3.1
10/26/70	6.4	1.8
11/19/70	6.0	1.7
12/19/70	1.1	0.6
1/21/71	0.4	0.2

Most of the fauna associated with this habitat would not be expected to influence densities of *L. foulki* to any great extent, either competitively or predatorily, by virtue of its scarcity. However, predation by the 4 carabids and especially *O. dentatus* may be significant and could contribute to the natural decline in *L. foulki* density. The rise of such predator populations appeared correlated with increasing gnat larval densities during summer (tables 2 and 3), and with secondary surges of adults in October and November (tables 2 and 4).

The results suggest a role for such predators in gnat abatement, with the host pupa by virtue of its exposure at the

Table 4. Total number adult *Leptoconops foulki* Clastrier & Wirth collected over 30 m at head with modified D-Vac (Foulk & Sjogren 1967) operating 6 min.

Collection Date	Avg. No. <i>L. foulki</i> adults	$\bar{s}\bar{x}$
4/23/70	108.5	27.2
5/8/70	205.5	72.5
5/12/70	224.5	113.2
5/22/70	185.3	100.3
5/30/70	2308.8	1584.3
6/10/70	3580.0	1350.1
6/25/70	1560.7	477.3
7/17/70	821.1	310.3
9/24/70	91.0	20.1
10/22/70	168.8	46.5
11/23/70	509.3	266.2
12/7/70	35.7	31.2
1/19/71	25.0	0.6
2/5/71	63.6	29.7

surface of the soil (Rees et al. 1971) probably being most vulnerable. Although initiatives to enhance predator activity could result in further reduced gnat densities, ignoring predators and the possible adverse impact of control practices on them, might produce unwanted gnat increases.

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