BREEDING SITES OF SOME *CULICOIDES* SPECIES (DIPTERA, CERATOPOGONIDAE) IN ISRAEL

Y. BRAVERMAN,[1] R. GALUN [2] AND M. ZIV

ABSTRACT. Natural and artificial breeding places of 15 *Culicoides* species in Israel are described. Of them only *C. circumscriptus*, *C. puncticollis*, *C. schultzei* and *C. pallidipennis* were observed in large numbers. The other species of *Culicoides* possibly develop in breeding places that are completely different in their characteristics, and their requirements may be more specific.

Culicoides were found in almost every type of breeding place described in the literature.

INTRODUCTION

The limited work done on *Culicoides* in Israel by Austen (1921), Vimmer (1932) and Macfie (1933) was taxonomic only and limited to the random collection of insects and their identification. Recently this list of species was enlarged by Callot *et al.* (1969).

No work on the biology and ecology of the *Culicoides* species in Israel has been conducted. Therefore this study was undertaken to typify the breeding sites of *Culicoides* according to environmental data collected at natural and artificial breeding places. In addition, the importance of the temporary breeding sites for the reproduction of *Culicoides* was assessed.

METHODS AND MATERIALS

The survey was carried out from 1968–1971 mainly during the dry seasons of the year. A constant amount of mud was taken from each breeding site and the larvae and pupae were removed by the flotation method of Dyce and Murray (1966). This method was suitable for most of the species except for *C. pallidipennis* as the pupae of this species are not able to float on the surface of the water (Nevill, 1968). Therefore, in addition to the flotation method, two types of emergence traps were used as described by Braverman (1970) Rice *et al.* (1971) and Braverman & Galun (1973).

The artificial breeding sites were created at the Veterinary Institute and consisted of various small containers filled with a mixture of soil and cow manure, and artificial puddles created from different combinations of soil, manure and other additives, most of which were layered with double sheeted polyethylene plastic.

The abiotic parameters were measured by the following methods:

pH—In the beginning the pH was determined by pH indicator paper (Whatman–BDH Indicator papers Poole, England), subsequently by a portable pH meter, Electrofact Nuberger, Type Nr: 40 AI (Amersfoort, Holland).

Dissolved oxygen—In the beginning the chemical method of Burke (1962) was used. Subsequently it was measured with a YSI model 54 oxygen meter (Yellow Spring, Ohio, U.S.A.).

Electrical conductivity—At the beginning a resistance bridge, model BTM 8 (Zimmerman—Kass Ltd., Israel) was used. Subsequently a conductivity meter Type CDM 2c No. 121351 (Radiometer, Copenhagen) was also used.

Chlorides—At the beginning, the American Public Health Association (Anon, 1965) chemical method was used. Afterwards, a chloridometer model 4–2008 (Buchler Instruments Inc., Fort Lee, N.J., U.S.A.) was used.

Temperature—A thermometer F 1733

[1] Kimron Veterinary Institute P.O.B. 12, Bet Dagan, Israel.

[2] Israel Institute for Biological Research P.O.B. 19, Ness Ziona, Israel.

TABLE 1. Types of breeding sites of *Culicoides* species in Israel.

Species	Puddles: Dripping water	Puddles: Installations sewage	Drainage channels	Sewage channels	Water reservoirs	Streams	Winter rainpools	Wet rich soils organic matter	Water saturated loose soils	Tree holes	Artificial breeding places
circumscriptus	+	+	+	+	+	+	+	+	..	..	+
puncticollis	+	+	..	+	+	+	+	..	..	..	+
schultzei	+	+	+	+	..	..	..	+	..	+	+
pallidipennis	+	..	+	+	..	..	..	+	+	..	+
cataneii	..	..	+	..	..	..	..	+	..	..	+
kirovabadicus	..	..	..	..	..	..	..	..	..	..	+
obsoletus (Gr.)	..	..	..	..	..	..	..	+	..	..	..
praetermissus	..	..	..	..	..	..	..	..	..	..	+
coluzzii	..	..	+	..	..	+	..	..	..	..	..
newsteadi	..	..	..	..	..	..	..	..	..	..	+
longipennis	..	..	..	..	..	+	..	..	..	..	..
lailae	..	..	..	..	..	..	..	+	..	..	..
haranti	..	..	..	..	..	..	..	..	..	+	..
semimaculatus	..	..	..	..	..	..	..	..	..	+	..
begueti	..	..	..	..	..	..	..	..	..	+	..

RI 1257 (Weston Daystrom, Inc., Newark, N.J., U.S.A.) was used. In one of the artificial breeding places, a Rustrak temperature recorder model 2133 B (Gutton Industries, Inc., Manchester, N.H., U.S.A.) was used.

The data on the species found in the various breeding sites were compared with that obtained from the suction light trapping stations set up in the Yezreel Valley coastal plain and northern Negev.

RESULTS AND DISCUSSION

The number of positive samples in this study was 302. The types of breeding sites of the *Culicoides* species found are given in table 1. The abiotic environmental parameters of these sites are tabulated in tables 2–3. A detailed description of each species is given under separate headings.

C. circumscriptus Kieffer. The total number of samples in which this species was found was 223 and in 45 of which it was dominant. This species multiplies throughout the year, and was trapped in suction light traps at all the trapping stations in considerable numbers.

This is a plastic species with adaptability to a wide range of environmental conditions and was thus obtained from samples of most biotopes. It was generally found in breeding sites rich in organic matter but it was also possible to find it in puddles in dune sand. Generally when the breeding places become richer in organic matter and poorer in oxygen, such as sewage channels, this species becomes exclusive. In a number of cases the species was found to breed in wet soil rich in organic matter but lacking surface water. It was also found in completely shaded puddles. When this species was dominant the accompanying *Culicoides* species were: *C. puncticollis, C. schultzei, C. pallidipennis, C. cataneii* and *C. kirovabadicus.*

C. puncticollis Becker. The total number of samples in which this species was found

TABLE 2. General range of abiotic parameters of *Culicoides* breeding places in Israel.

Species	Water temp. ° C	Mud temp. ° C	Water pH	Dissolved oxygen in water-p.p.m. (% saturation)	Water temp. at oxygen measurement	E.C.* of water at 25° C-millimhos per cm	Chlorides in water meq/L
circumscriptus	6–36	6–37	5.8–11.8	0–26.8 (0–303)	22–28	0.15–9.13	1.3–43
puncticollis	6–35	7–37	5.8– 9.8	0–>20 (0–>243)	26–28	0.23–4.8	2.6–73.4
schultzei	7–35	7–34	5.9–10.2	0–20.9 (0–268)	18–29	0.23–2.38	1.5–30.2
pallidipennis	9–35	5–35	7.0– 9.6	0–20.9 (0–268)	29–30	0.23–9.13	2.6–7.9
cataneii	7–37	7–31	7 – 9.6	1.1–20.9 (13–268)	29–29	0.23–2.07	0.8–7.9
kirovabadicus	15–35	17–32	5.8– 8.8	0–13.1 (0–175)	18–31	0.65–3.66	3.2–21.4
praetermissus	19–28	19–28	8.0– 8.4	3.4–14.1 (36–158)	19–22	0.23–0.45	6.5
coluzzii	31	30	7.9	...	...	...	...
obsoletus (gr).	..	14–29	...	...	...	...	...

* Electrical Conductivity.

TABLE 3. Abiotic parameters of *Culicoides* breeding places in which the species was dominant.

Species	Water temp. ° C	Mud temp. ° C	Water pH	Dissolved oxygen in water-p.p.m. (% saturation)	Water temp. at oxygen measurement	E.C.* of water at 25° C-millimhos per cm	Chlorides in water meq/L
circumscriptus	10–36	8–34	5.8–9.7	0–18.3 (0–227)	27–32	0.41–5.3	2.8 –43
puncticollis	21–35	20–37	7.0–9.6	0–16.6 (0–214)	29–32	1.12–3.25	9.41–73.4
schultzei	7–34	7–34	7.0–9.6	1.3–20.9 (13–268)	14–29	0.23–1.11	1.5 –5.5

* Electrical Conductivity.

was 115 and in 17 of these it was dominant. It multiplies throughout the year, and was trapped in suction light traps at almost all the trapping stations. This species has a large range of breeding places but usually populates sites that are less polluted with organic matter than does the previous one. It was the dominant species in loess soil in the Negev (Southern Region). One specimen was even found in a plastic layered artificial puddle containing originally only water, but at its base, leaves from cypress trees as well as wind-drifted material accumulated. It is second in terms of distribution in breeding places after *C. circumscriptus* and is mostly found associated with it and *C. schultzei*.

C. schultzei Enderlein (? = *C. kingi* Austen). The total number of samples in which this species was found was 90, and in 24 of which it was dominant. This species was found breeding throughout the year except for December and February, and was trapped in suction light traps at all our trapping stations. *C. schultzei* is third in distribution in breeding sites after *C. circumscriptus* and *C. puncticollis*. The range of breeding sites populated by this species is more limited. It multiplies in breeding sites which generally contain little organic matter, i.e. rich in oxygen. Thus it is possible to find it more often in drainage channels than at the margins of those containing polluted water. Unusual breeding sites were also found, e.g. an individual was captured in a tree hole of an oak, *Quercus ithaburensis* (Dence) Boiss. Another individual was trapped from wet soil which had been enriched with organic matter, but had no surface water. A third individual was captured from the plastic layered artificial puddle containing only water, cypress leaves and wind-drifted accumulated material. When this species was dominant, the accompanying *Culicoides* species were: *C. circumscriptus, C. pallidipennis, C. puncticollis, C. cataneii, C. praetermissus* and *C. newsteadi*.

C. pallidipennis Carter, Ingram & Macfie. The total number of samples in which this species was found was 59, in 5 of which it was dominant. It was found breeding throughout the year except for January and February. In each site where a suction light trap was operated individuals of this species were captured. In the trappings conducted in the sheep pen of the Veterinary Institute for a period of 3 years with suction light traps this species was dominant. It is also possible to find the species in completely shaded breeding sites.

In contrast to the observations reported from South Africa (Nevill, 1968), *C. pallidipennis* does not breed in cow manure in Israel, nor in manure watered daily. However, it breeds in a rich mixture of organic matter and water-saturated soils and is the dominant species under these conditions. From the aspect of organic matter, *C. pallidipennis* populates the same biotopes as does *C. circumscriptus*, but it needs less aquatic conditions. On the other hand, it also populates edges of puddles in which the organic matter has already been decomposed. It is possible to find individuals of this species, although in small numbers, on the margins of ordinary puddles that are not rich in organic matter. It was noted that of all the *Culicoides* species whose breeding places were known to us, this species adapted to the driest breeding places. It is known that for mosquitoes the humidity of the breeding sites has an attracting effect on egg-laying females, as found by Knight & Baker (1962) for two *Aedes* species. When this species was dominant the accompanying species were: *C. circumscriptus, C. schultzei* and *C. cataneii*.

C. cataneii Clastrier (? = *C. gejgelensis* sensu Callot, Kremer & Coluzzi). The total number of samples in which this species was found was 45. It was found breeding throughout the year. In each site where suction light traps were used, individuals of this species were captured.

It is not possible to characterize reliably the breeding sites of this species because in no sample was it dominant. In experiments with artificial breeding places it was found usually only in treatments which were relatively poor in organic matter. However, in two artificial puddles rich in organic matter a number of individuals of this species were found. It was also found to breed in completely shaded sites.

C. kirovabadicus Dzhafarov. This species was found only in 4 samples. It was found to breed in artificial sites during June–October. In Israel it has not been previously captured with suction light traps.

C. obsoletus (gr.). This species was obtained from 5 samples and was found breeding in April–June. It was found to breed in wet soil rich in organic matter and also in completely shaded habitats. In all suction light trapping sites only a few individuals were caught.

C. praetermissus Carter, Ingram & Macfie. This species was found in 2 samples from the artificial breeding sites in September–October. At Bet-Herut (Coastal plain) in 1972, it was the dominant species in suction light traps kept for 4 months in a turkey run. With the traps in the sheep pen at the Veterinary Institute (Coastal area), only a few individuals were obtained.

C. coluzzii Callot, Kremer & Bailly-Choumara. This species was found in 3 samples in July and September at Kishon and Ta'anakh streams and in a drainage channel. In suction light traps placed in sheep pens in northern and southern Israel, a few individuals of this species were captured. The samples in which this species was found were taken near canes of the plant *Phragmites communis* Trin. In these places the water was shallow and the mud rich in organic matter evolving from this plant.

C. newsteadi Austen. This is a widely distributed species in Israel. In the Yezre'el Valley and northern Negev (Gilat), *C. newsteadi* was dominant in suction light traps placed in sheep pens. It was also dominant in suction light traps operated for 6 months in a turkey run at Givat Hayyim. In the artificial breeding sites only 1 individual was found, this occurring in October.

C. longipennis Khalaf. An individual was found in September on the banks of the Ta'anakh stream. In suction light traps placed in sheep pens in north and south Israel, a few individuals were captured.

C. lailae Khalaf. An individual was found in June on wet soil rich in organic matter where the temperature of the mud was between 18–34° C. A number of individuals were captured by a suction light trap in the sheep pens of the Veterinary Institute.

C. haranti Rioux, Descous and Peck. Two individuals were found. One was captured with an emergence trap placed from July to September in Newe Ya'ar (Yezre'el Valley) and the second in November at Pardess Hanna (Coastal area). Both were trapped in holes in the Tabor oak trees. The breeding site of this type was named by Bates (1949) as "container habitats." A number of individuals were also captured by the suction light trap in a sheep pen at Newe Ya'ar.

C. semimaculatus Clastrier. Two individuals were found in an emergence trap placed from July to September in a hole of a Tabor oak tree at Newe Ya'ar. By suction light trapping only one individual of this species was caught at Newe Ya'ar.

C. begueti Clastrier. Three individuals were found in an emergence trap placed from July to September in a hole of a Tabor oak at Newe Ya'ar. Similarly one individual was captured in November at Pardess Hanna. A few individuals were captured in a suction light trap placed in a sheep pen at Newe Ya'ar.

The following abiotic parameters in breeding sites were measured: water and mud temperatures, pH, dissolved oxygen, electrical conductivity and chloride content of the water. Of these, dissolved oxygen showed the highest seasonal correlation with the *Culicoides* population, and this even in regard to *C. circumscriptus,* the species found in the artificial breeding sites study to be the most tolerant to lack of oxygen.

C. circumscriptus and *C. puncticollis* which are the most abundant in breeding places in Israel populate biotopes contaminated with organic matter, while *C. schultzei* populates breeding places either uncontaminated or only slightly contaminated with organic matter; all these preferring sites with free surface water. *C. pallidipennis* prefers moist biotopes rich in organic material without surface water.

Due to our studies we are now able without sampling to identify with a high degree of confidence the breeding places of these 4 species.

A succession of *Culicoides* species occurs in breeding places. When a biotope contaminated with organic matter loses its organic matter, *C. circumscriptus,* which was the dominant species till then, is replaced by *C. schultzei* which becomes the dominant species.

It was found that *Culicoides* is able to populate very small biotopes, both natural and artificial, the size and shape being unimportant, as long as the proper conditions prevailed. The speed in which new biotopes are populated is impressive, and adults appear after 19–31 days according to the season and conditions in the site itself.

In the artificial biotopes, algae, especially the filamentous type, were found to be important as oviposition sites. In those cases where the algal film and the attached *Culicoides* eggs had been eaten or destroyed by tadpoles of the species *Rana ridibunda* there was a drastic decrease in the number of emerging *Culicoides.*

In Israel sewage and drainage channels and temporary biotopes such as puddles resulting from irrigation and sewage leakages and winter puddles are quickly colonized and these are very important. It can be supposed that the permanent breeding places maintain the population of *Culicoides* and serve as a source for temporary biotopes. These temporary sites which exist in large numbers throughout the year cause both the increase and the dispersion of *Culicoides* species. These facts are important from the epidemiological aspects of diseases transmitted by *Culicoides* and also as pertaining to the control of this insect.

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