Studies on the biting habits of *Culicoides impunctatus* Goetghebuer, *C. obsoletus* (Meigen) and *C. punctatus* (Meigen) (Diptera : Ceratopogonidae) in Southern England

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Synopsis

An account is given of the seasonal incidence, biting activity, vertical and horizontal distribution of adults of *Culicoides impunctatus* and *C. obsoletus* in Dorset, England, and of the seasonal incidence of *C. punctatus*.

Introduction

The present paper is concerned with the biting habits of adult *Culicoides*. Most of the work was carried out on Brownsea Island, which is owned by the National Trust and open to the public. It is the largest of five islands in Poole harbour, being just under one and a half miles long and three-quarters of a mile wide, with a coastline of about three and three-quarter miles enclosing some 500 acres of land. Its vegetation includes coniferous woodlands, heath and grasslands, scrub, marshy areas and aquatic habitats. All catches were carried out amongst dense scrub vegetation, and most were made at the edge of the East Lake.

Some work was also undertaken at two sites on the mainland to the south of the island. One of these catch sites was in a small copse on Studland Heath near South Haven Point, about three-quarters of a mile S.E. of the island in an area characterised by extensive dry heathlands with scattered growths of scrub vegetation. The other site was situated in a larger copse on Arne Peninsula, some three and a half miles S.W. of Brownsea and was surrounded by mostly dry heathlands and agricultural land.

Seasonal Incidence

From February, 1964 to December, 1966, catches were made on human bait two to three times a week from 1100 to 1200 hours G.M.T. in a shaded corner near the East Lake on Brownsea Island. The times of these and subsequent catches were largely governed by the availability of boats, which ferried the author to the island. During 1965 and 1966, weekly catches from 0715 to 0815 hours were made at the Studland catch site, and from March to September, 1966, catches were also made at Arne from 1230 to 1330 hours. In all catches the author sat on the ground with outstretched legs and wore an anorack with a hood pulled over the head. This prevented midges from biting the back of the head and resulted in many of them eventually alighting on the legs or arms, from which they were readily caught in a small pooter. Those that did not settle on the limbs, but attempted to bite around the forehead, were caught in a small hand net. They were subsequently removed by a pooter. Catches were not performed on days with a wind speed in excess of about 7 m.p.h., or in rainy weather.

From 540 catches the following number of females were caught: 4481 *Culicoides impunctatus* Goetghebuer; 2473 *C. obsoletus* (Meigen); 67 *C. punctatus* (Meigen); 14 *C. pictipennis* (Staeger); 8 *C. heliophilus* Edwards; 5 *C. pulicaris* (L.); 1 *C. halophilus* Kieffer; 1. *C. achrayi* Kettle & Lawson and 1 *C. segnis* Campbell & Pelham-Clinton/ *reconditus* Campbell & Pelham-Clinton. Only the first two species were sufficiently numerous to allow their seasonal incidence to be obtained. However, a New Jersey type of light-trap (Mulhern, 1934) with a 150 W tungsten bulb operated from 1700 to

0800 hours about three times a week on Brownsea during May to October, 1966 caught, among other species, 353 *C. punctatus*. As the catch of this species from both sampling methods showed the same build up of its population, results have been combined to obtain its seasonal incidence. The numbers of *C. obsoletus* and *C. impunctatus* caught at bait during each catch period have been converted to Williams' means (M_w) (figs. 1–2), this being a variation of the geometric mean (Haddow, 1960). The numbers of *C. punctatus* caught at light on each trap night have been similarly expressed as Williams' means (fig. 3).

Adults of *C. obsoletus* first appeared at bait in April, except in 1966, when the population was large and a few appeared at Studland in the middle of March (fig. 1). In all catches maximum biting occurred in May, after which biting was considerably

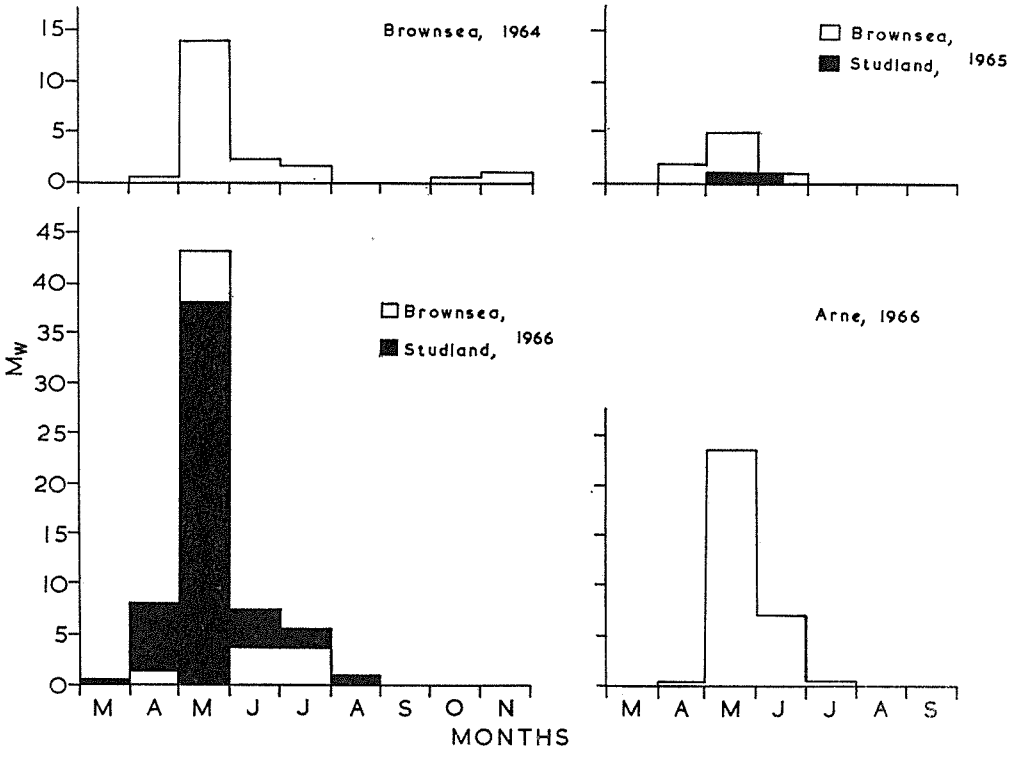

FIG. 1.—Seasonal incidence of adults of *Culicoides obsoletus* from 1964–66.

diminished. The last adults of the year were caught in July or August, except on Brownsea in 1964, when adults reappeared in small numbers in late October and early November. There were marked annual variations in the size of the population. In 1965 its size both on Brownsea and at Studland was very small compared with that of the preceding year, but in 1966 a very marked increase in the population occurred at both sites. Kettle (1956) found that a close positive correlation existed between summer rainfall (May–September) and larval density of *C. impunctatus* the following autumn. Winter precipitation (October–April) recorded at a meteorological station four and a half miles north of the island during the period 1963–66 was 20·0, 17·0 and 23·6 inches, respectively. A comparison of these values with the numbers of *C. obsoletus* caught in 1964–66 suggests that a high winter rainfall results in an increase in the adult population the following summer.

The first biting adults of *C. impunctatus* appeared at the beginning of May, and in all catches the population peak was reached in June, after which, in both 1965 and

1966, the population crashed (fig. 2). In 1964, however, peak densities did not occur until the third week of June, and the population was still large in July. The last adults were usually caught in late September or early October, but at Arne none were found after August. The monthly population trends were very similar at all three catching stations, but the densities at Studland and Arne were higher than those encountered on Brownsea. On the island the population in 1964 was considerably larger than that in the two following years, and at Studland the population in 1965 was greater than that in 1966.

The combined results from light trap and bait catches show that *C. punctatus* first occurred in April, reached a peak in June and died out in August (fig. 3).

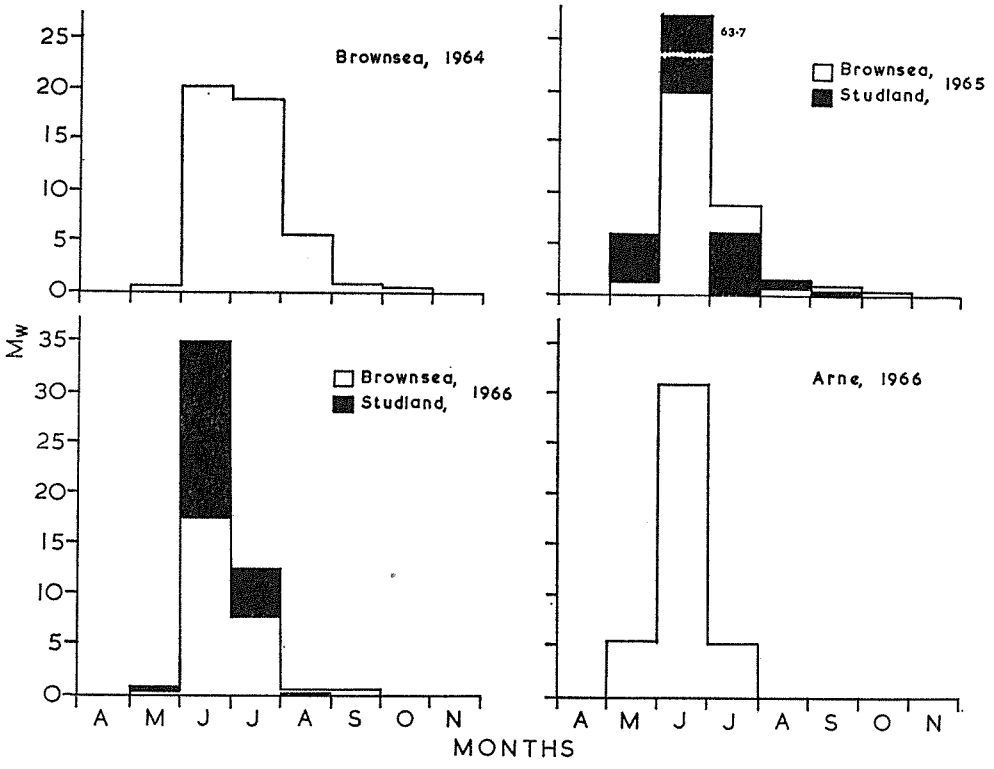

FIG. 2.—Seasonal incidence of adults of *Culicoides impunctatus* from 1964–66.

Except for the few *C. obsoletus* caught in October and November, 1964, there is no indication of any bimodal distribution in the three species. The pattern of the seasonal incidence of *C. obsoletus* and *C. impunctatus* results in a severe biting nuisance throughout May to July.

ARRIVAL AT BAIT

As had been experienced with mosquitoes of the area (Service, 1969), it was very noticeable that a larger number of midges appeared at bait at the start of the catch than during the remaining period. To investigate this, ten one-hour catches, from 1100 to 1200 hours, were carried out at the East Lake site on Brownsea during July 1965. Only *C. impunctatus* was sufficiently common to permit analysis of the results (Table I). The numbers caught in the first 15 minutes of the catches were greater (55·6 per cent.) than those caught during the remainder of the catch. The explanation is probably that at the start of each catch numerous hungry unfed midges, resting in the surrounding vegetation, are quickly attracted to bait and are caught in addition to those

TABLE I.—*Numbers of* C. impunctatus *caught in four quarter-hour periods in ten one-hour catches*

Intervals	Catch No. 1	2	3	4	5	6	7	8	9	10	Total catch and percentage
First quarter hour	62	43	29	22	65	48	52	34	44	47	446 (55·6)
Second quarter hour	23	17	10	11	29	23	27	11	15	20	186 (23·2)
Third quarter hour	8	11	8	7	11	14	11	3	8	11	92 (11·5)
Fourth quarter hour	7	6	5	8	13	13	8	5	4	9	78 (9·7)

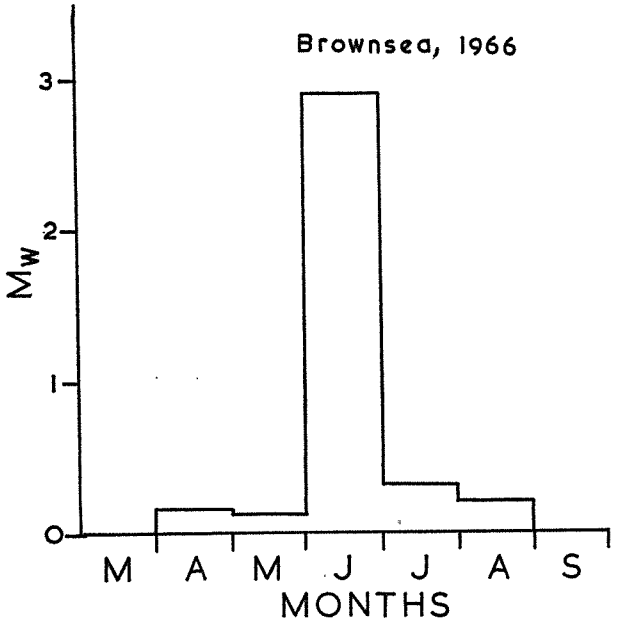

FIG. 3.—Seasonal incidence of adults of *Culicoides punctatus* in 1966.

flying into the area. After depletion of this immediate resting population, the catch comprises only those that fly into the host area. Gluchova (1958), working in Russia, described two types of attack by *Culicoides*: one, which occurred mainly around twilight, consisted of adults actively flying in search of hosts and the other occurred during the day, when midges at rest flew only very short distances to hosts in the immediate vicinity. Apart from these short flights, adults also crawled up the legs of the host to bite. This crawling type of attack was not noticed in the present studies.

HORIZONTAL DISTRIBUTION

On Brownsea and at Studland it became apparent that during the day little biting was experienced in exposed areas of moorland vegetation, but that biting occurred mainly in sheltered wooded areas. During 1966, 12 paired one-hour bait catches were carried out, between 1100 and 1315 hours, on Brownsea, at the East Lake site and in a small clearing 40 yards distant. At Studland 8 similar one-hour catches were made, between 0715 and 0930 hours, at the normal site and amongst open heathland 70 yards away. The first hour's catch was carried out at alternate sites on alternate catch days. Although surveys showed that the principal larval

TABLE II.—*Numbers and percentages of* C. impunctatus *and* C. obsoletus *caught in exposed and shaded situations*

		Exposed site		Shaded site	
Locality	No. catches	*C. impunctatus*	*C. obsoletus*	*C. impunctatus*	*C. obsoletus*
Brownsea	12	41 (9·1)	24 (4·9)	409 (90·9)	469 (95·1)
Studland	8	22 (7·6)	31 (9·9)	267 (92·7)	283 (90·1)

habitats were amongst open heathland vegetation, and although catches were performed during calm rainless periods, only a very small proportion of the total catch of *C. impunctatus* (7·6–9·1 per cent.) and *C. obsoletus* (4·9–9·9 per cent.) was caught at the exposed sites (Table II).

From May to June, 1966, 19 paired one-hour catches were performed at two sites on Brownsea and 11 similar catches at one site at Studland. Each catch site was divided into two sub-sites, separated by a known distance (8, 11 and 15 yards). Catching started at alternate sub-sites on alternate catch days. A 30-minute catch was carried out at one sub-site and followed by a similar catch at the other sub-site; the procedure was then repeated, resulting in an hour's catch at each sub-site. On Brownsea the first paired sub-sites were situated at the East Lake and eight yards apart, amongst a continuous and similar belt of vegetation. The second series consisted of two sub-sites in a small wood, separated by 15 yards. At Studland the first sub-site consisted of the normal catch site in a small copse, and the other sub-site was 11 yards distant in the same copse.

The numbers of *C. impunctatus* and *C. obsoletus* caught in the first half-hour catch at either sub-site were much larger than those obtained in the second half-hour periods (Table III), confirming that there is an initial build-up of *C. impunctatus* at bait and showing that this also occurs in *C. obsoletus*. Furthermore, although the sub-sites were separated by only a short distance, a high initial catch was always obtained at both sub-sites. This showed that sampling at the first sub-site did not appreciably affect the resting population at the other sub-site, and that the first part of the catch was drawn from a very small local area. An analysis of variance on the total numbers caught from the two sub-sites in the second series of catches on Brownsea (separated by 15 yards) showed that significantly more *C. impunctatus* ($0{\cdot}01 < P < 0{\cdot}05$) and fewer *C. obsoletus* ($0{\cdot}001 < P < 0{\cdot}01$) were caught at the first sub-site.

VERTICAL DISTRIBUTION

It was originally intended to carry out bait catches at various heights on a steel tower erected in a small clearing in the middle of the island. However, after seven one-hour catches only 23 midges were caught from the base of the tower and none at heights of 15 and 30 feet. Consequently, during June, 1965 and May, 1966, catches were performed at the East Lake site, where there were known to be substantial biting populations. In the absence of a tower at this site, 19 one-hour catches were made between 1100 and 1415 hours, at heights of 10 and 19 feet in a tree and at its base. To avoid sampling bias, a 30-minute catch was made at each of the three levels and followed by a further 30-minute catch at each level, the order of catching at the different levels being changed in different catches to give the total of six combinations of the available sequences. A very pronounced decrease in the biting rate with increase in height was found (Table IV) and confirms the finding, obtained with sticky traps at various heights, that *C. impunctatus* and *C. obsoletus* are mainly confined to levels below ten feet from the ground. A calculation of the standard error of the difference between the percentages of the two species biting at ground level shows that the observed difference of 9·2 per cent. is not significant.

TABLE III.—*Numbers and percentages of* C. impunctatus *and* C. obsoletus *caught in half-hour periods at closely situated catch sites*

		C. impunctatus				*C. obsoletus*			
				percentage in first half-hour				percentage in first half-hour	
Sites	Sub-sites	No. catches	Total catch	Mean	Range	No. catches	Total catch	Mean	Range
Brownsea (8 yards apart)	1	8	185	83·5 ±5·9	78·6–100	8	168	69·2 ±14·9	42·0–83·3
	2	8	222	83·5 ±9·0	70·8–100	8	162	82·1 ±8·6	66·7–100
Brownsea (15 yards apart)	1	11	378	79·9 ±6·2	62·5–85·0	10	244	77·1 ±5·7	68·8–87·5
	2	11	284	79·8 ±8·5	61·5–92·1	10	443	77·3 ±8·6	60·7–88·5
Studland (11 yards apart)	1	11	341	81·6 ±7·6	61·1–87·5	7	172	83·2 ±7·1	73·9–95·7
	2	11	312	84·8 ±5·4	76·5–83·3	7	199	83·5 ±3·2	76·5–86·4

TABLE IV.—*Numbers and percentages of* Culicoides *caught at different heights*

	C. impunctatus	*C. obsoletus*	*C. halophilus*	*C. heliophilus*	*C. punctatus*
Ground level	230 (86·1)	216 (76·9)	2	0	2
10 feet	32 (12·0)	56 (19·9)	0	1	0
19 feet	5 (1·9)	9 (3·2)	0	0	0

BITING CYCLE

The only information on biting cycles of British species is from a single 24-hour catch of *C. impunctatus*, in which adults were caught for half-hour periods every hour (Kettle, 1957). Because of the general lack of information on biting times of British midges, this aspect of their behaviour was studied.

Because of the limited number of assistants it was not possible to measure biting activity over 24 hours, but four catches, from 1700 to 1000 hours, were made on Brownsea at the East Lake site in June 1965 and May 1966. Before the start of each continuous bait catch, a 30-minute catch was carried out to remove the immediate resting population, which otherwise would have resulted in a high initial catch. Continuous bait catches were carried out by the author and two assistants, each catching for a period of two hours before being relieved by one of the other catchers; during darkness a torch was used. To minimise any difference in individual attractiveness, the catchers caught at different times during each catch series. Catches were only carried out on windless and rainless nights. Within each series of catches times of sunset and sunrise only differed by one to seven minutes; the mean times of sunset and sunrise in May were 1953 and 0400 hours and in June 2018 and 0343 hours. The numbers of *C. obsoletus* caught in May and *C. impunctatus* caught in June were converted to Williams' means. They are expressed as hourly percentages of the total catch in figure 4. In both species a sudden upsurge in biting occurred at sunset and was followed by a cessation of biting from about 2300 to 0400 hours. Both species exhibited a smaller biting peak three hours after sunrise, at a much greater light intensity than that of the evening peak.

DISCUSSION

The seasonal incidence of *C. impunctatus* was observed in Lancashire by Hill, (1947), and in Scotland by Parker (1949), Kettle (1950), Currie (Kettle, 1950) and Reuben (1963). Hill (*t.c.*) recorded adults in May with peak densities in June, and Nielsen (1963) observed a similar seasonal occurrence in Denmark. But Parker (1949) collected the first adults a month later and observed a population peak in July. Kettle (1950) caught the first adults in May, but both he, Currie (Kettle, 1950) and Reuben (1963), obtained a bimodal distribution in June and July. Kettle (1950, 1951) thought that possibly two biological races were involved. All workers recorded the last adults in August. Although the seasonal incidence of *C. impunctatus* obtained in these catches in Northern Britain corresponds very closely with that found by biting studies in Dorset, no evidence of any bimodal distribution was evident in the south.

Very little information exists on the seasonal occurrence of *C. obsoletus*, but Hill (1947) found adults from May to October, with peak densities in June and September, and considered the species to be bivoltine. Parker (1949) also found a few adults as late as October. In Dorset, except for a few *C. obsoletus*, which reappeared at bait in October and November, 1964, there was no evidence of any bimodal distribution.

Although in Dorset few midges were caught biting in exposed sites, such as those among heathland vegetation, Kettle (1951) found that sticky traps caught substantial numbers of *C. impunctatus* in similar areas in Scotland. There are, however, basic differences in the sampling methods. Bait catches in exposed areas were only carried

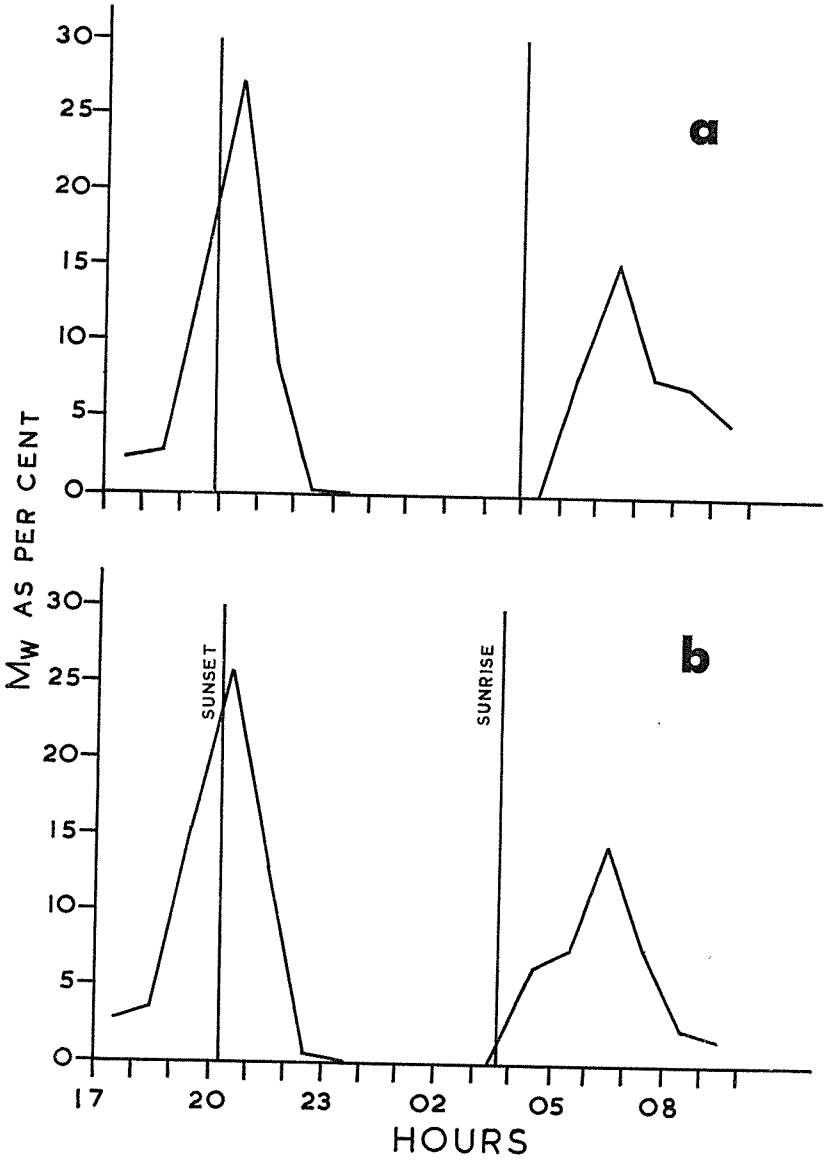

FIG. 4.—Biting cycles of adults of (a) *Culicoides obsoletus* and (b) *Culicoides impunctatus*.

out during the day and only caught hungry unfed midges, whereas sticky traps sampled continuously for 24-hour periods and caught, in addition to males, females that were not necessarily engaged in host seeking. There would have been possibly little difference between the biting rate in exposed and sheltered sites if the catches were carried out at sunset. At this time the catch would consist mainly of adults actively flying into the host area, and not of adults resting in the immediate vicinity. In fact Gluchova (1958) found that at twilight midges flew from their resting sites in woods to bite in more exposed situations. The patchy horizontal distribution of *C. impunctatus* within a more or less uniform vegetative area was very marked in trials with sticky traps made by Kettle (1950), and was also evident in this species and *C. obsoletus* at the catching sub-sites on Brownsea, which were separated by only 15 yards. These localised differences in the densities of midges are probably mainly

associated with the distribution of larval habitats and suitable resting sites for unfed adults. Such a patchy distribution, in even small areas, makes it difficult to obtain accurate absolute, or comparative, estimates of population size when only a few sampling sites are worked. In Dorset, there was a well defined vertical distribution of adults. In sheltered areas very few *C. impunctatus* and *C. obsoletus* were caught biting at ten feet, or above. Kettle (1951) caught more *C. impunctatus* on sticky trap sites at ten than at two feet above the ground, but unfortunately there is no information on the distribution of unfed, blood-fed and gravid individuals caught on these traps.

In Denmark, Nielsen (1963) found that little biting by *C. impunctatus* occurred during the day or night, most occurring at sunset and sunrise. Parker (1949) caught maximum numbers of *C. impunctatus* and *C. pallidicornis* Kieffer from vegetation around sunset; a smaller peak of activity was recorded at sunrise but during other times few midges were caught. Similarly Hill (1947) found a very marked increase in the numbers of *C. impunctatus* and *C. obsoletus* that alighted on a black cloth at sunset, a smaller increase in numbers of *C. impunctatus* also occurring at sunrise. In contrast to this, Reuben (1963) caught large numbers of *C. impunctatus* in suction traps over 24 hours and found no marked increase in flight activity at sunset or sunrise. Maximum biting by *C. impunctatus* and *C. obsoletus* occurred at sunset on Brownsea Island, and the biting cycle of *C. impunctatus* was very similar to that obtained by Kettle (1957). These biting cycles do not necessarily reflect general activity cycles: in North America, Bidlingmayer (1961) often caught large numbers of *C. furens* Poey in motor powered aspirators at times when very few were biting. During the day a relatively low and regular level of biting is probably maintained in *C. obsoletus* and *C. impunctatus*. This does not, however, mean that little biting is experienced during the day, because in shaded situations a large local resting population will be responsible for an immediate high biting rate at any time of the day.

Summary

Human bait catches performed over three years in southern England showed that adults of *Culicoides obsoletus* (Meigen) were present from March or April to July or August, maximum biting occurring in May. Adults of *C. impunctatus* Goetghebuer were caught from May to August, with peak densities in June. Neither species exhibited a bimodal distribution. Results from light traps and bait catches in 1966 showed that *C. punctatus* (Meigen) was present from April to August with a population peak in June. During the first 15 minutes of any one-hour catch the numbers of *C. obsoletus* and *C. impunctatus* caught were greater than in the remainder of the catch. During the day biting populations had a very local and patchy distribution, even within uniform habitats. Very little biting occurred in exposed areas. Bait catches at ground level and at 10 and 19 feet showed that about 80 per cent. of the midges were caught at ground level. In continuous bait catches from 1700 to 1000 hours, maximum biting occurred at sunset.

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