PRELIMINARY OBSERVATIONS ON WEATHER CONDITIONS AND THE ACTIVITY OF BITING FLIES.

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Methods.

There are several references in the literature to the effect of weather conditions on the activity of biting flies in Britain, but none of them is quantitative. This absence of data gives interest to some observations made at Kinlochewe in Wester Ross during a course on Field Entomology in July 1955. The methods adopted here are open to criticism on several counts but, in spite of this, it is considered that the results obtained make a useful contribution to this subject. Over a period of twenty-four hours from 10.30 a.m. on 13th July until the same time on 14th July regular hourly observations were made on weather conditions and on the biting and flying activities of blood-sucking Diptera. Representatives of four genera belonging to three families were caught, the most common being *Culicoides* and *Haematopota*, with occasional *Simulium* and *Tabanus*. In these genera only the females feed on blood and the very few males captured were all *Culicoides*.

The six people participating in this work were arranged in three pairs, each of which was responsible for the observations during the same four-hour shift both day and night. Thus Miss B. A. Hopkins and Mr. R. H. Parish were responsible for the periods 10.30 a.m. to 2.30 p.m. on 13th July and 10.30 p.m. on 13th July to 2.30 a.m. on 14th July. Likewise Miss B. M. Leighton and Dr. R. Varma collected from 2.30 to 6.30 in both the afternoon and early morning and Mr. S. Liu and Dr. D. S. Kettle from 6.30 to 10.30 in the evening and morning.

At the start of each set of observations—at 30 minutes past the hour—one individual made the meteorological observations while the other sampled the air-borne population with a sweep net. Sweeping was done in a straight line between two fixed markers about seventy yards apart and situated at least fifty yards from the base tent. By siting the sweep path this distance from human beings it was hoped to obtain sweep net collections unaffected by the attractiveness of man as a source of food. This goal seems to have been reached since the sweep net and biting collections are not particularly related. The number of sweeps entered in Table I varied between 60 and 72, with a mean of 66. Immediately the "beat" had been covered the collector returned to the tent to examine the catch. On one occasion—6.30 a.m., 14th July—it was very likely that female *C. impunctatus* entered the sweep net to bite the collector while he was removing the catch.

The biting rate was determined by both workers collecting all biting flies which alighted on the legs—ankle to knee—of one individual for 30 minutes in every hour, from 15 minutes before until 15 minutes after the hour. A note was made of the numbers of each genus collected in each 15-minute period, but the catches were not kept separate. These observations were made near one end

of the sweep path in order that the two sets of data should refer to similar populations. Once again, as soon as the period of observation was over, the area was vacated for 15 minutes before the next sweep.

All observations made between 30 minutes before the hour and 29 minutes afterwards are recorded in Table I as being made at the hour. Thus the weather observations and sweep net collections given for 11 a.m. were actually made at 10.30 a.m. and the biting rate from 10.45 to 11.15 a.m.

The meteorological observations included temperature, humidity, light intensity, rain, cloud and wind. Temperature and humidity were determined with a whirling hygrometer. The intensity of illumination was measured with a Weston Master II Lightmeter reading the light reflected from a white card held at right angles to the incident light, *i.e.* in the normal plane. Cloud cover was estimated as the amount in tenths of the total sky obscured by cloud. Wind speed was estimated by its effect upon movable objects. A scale of numbers was used which was not quite the same as the Beaufort scale. The numbers given here tend to indicate lower wind speeds than the Beaufort equivalent. It should be remembered that the wind values are spot readings and windier or calmer periods may well occur between readings.

All the observations were made on an area of windswept moorland east of the Torridon Road (B858) South of Kinlochewe, Wester Ross.

Results and Discussion.

The period of observation began in brilliant hot sunny weather under a cloudless sky, but a breeze soon sprang up and during the late afternoon the sky gradually clouded over, although it remained very hot and bright (Table I, Figs. 1–3). Later during the evening it became cooler and after midnight the cloud cover became complete, the wind increased and it began to rain. This rather cold, dull and windy wet weather continued until almost the end of the observation, when there was a brief period of calm and a break appeared in the clouds. The contrast between the start and end of the period can be seen by comparing the first and last lines of Table I, which gives the 10.30 a.m. weather figures for 13th and 14th July. The 14th is 13·5° F. cooler, its saturation deficiency is 6·5 mbs. less and the illumination is only one eighth that of the previous day.

Haematopota (Table I, Fig. 4).—Two species of clegs were captured, *H. pluvialis* and *H. crassicornis*. Their daily biting cycles are statistically inseparable ($P = 0{\cdot}5$), and in the following account the results will be amalgamated. They were actively attempting to feed during the hot bright morning and afternoon of 13th July. Earlier they had been very troublesome before the observational period began, and it is of interest that none were captured on the 14th, when it was cold and dull. Clegs remained active until sunset at 9 p.m., when the sun descended behind the hills. The intensity of the cleg-biting fell off slowly from the start of the observations at 11 a.m. until 4 p.m. (31 to 21), then there was a sudden decrease in cleg attack between 5 and 6 p.m. (11 and 5), followed, rather unexpectedly, by renewed cleg activity at 7 and 8 p.m. (17 and 19), after which there was very little cleg biting. This dip in the curve of cleg activity required an explanation. It was associated with a small drop in temperature of 4·5° F. and a sudden decrease in illumination to about

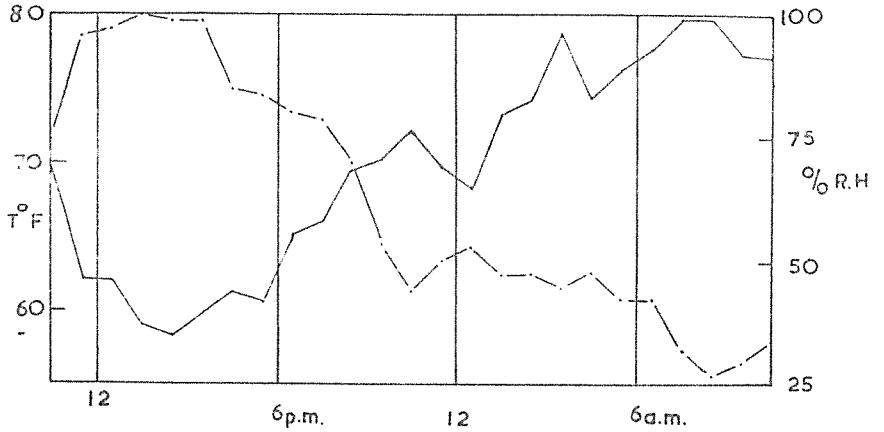

FIG. 1.—Temperature (broken line) and per cent. relative humidity (continuous line) during 24-hour period.

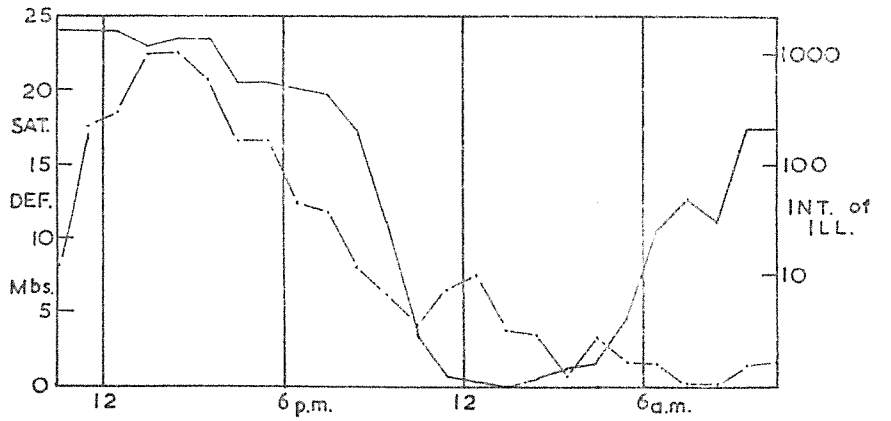

FIG. 2.—Intensity of illumination (continuous line log. scale) in foot candles and saturation deficiency (broken line) during 24-hour period.

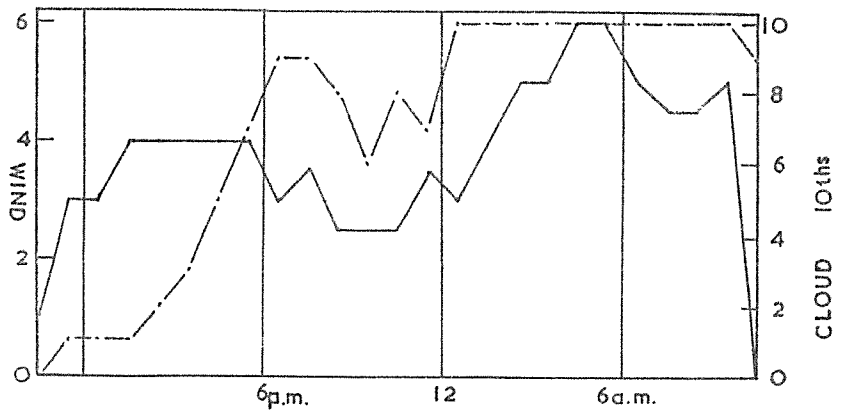

FIG. 3.—Wind speed (continuous line) and cloud cover (broken line) during 24-hour period.

TABLE I.—*Weather conditions and insect catches both in a sweep net and biting.*

Date.	Hour B.S.T.	Dry bulb °F.	Wet bulb °F.	Per cent. R.H.	Sat. def. mbs.	Int. of Ill. f.c.	Rain.	Cloud.	Wind.	No. of sweeps.	Caught in net.				Caught biting.			
											H. pluvialis, females.	*C. impunctatus.*			*C. impunctatus*, females.	*Hæmatopota.*		
												Males.	Females.	Others.		Female *pluvialis.*	Female *crassicornis.*	Others.
Jul. 13	11 am.	71·5	65·0	69	8·1	1600	Nil	Nil	1	65	1	2	1	1♂ *C. grisescens*	.	23	8	4♀ *Tabanus montanus*
	Noon	78·5	65·5	47	17·5	1600	,,	1/10	3	63	1	.	.	.	.	21	7	.
	1 pm.	79·0	65·5	46	18·4	1600	,,	1/10	3	63	2	.	2	.	.	20	8	2♀ *T. montanus*
	2 pm.	80·0	63·5	37	22·3	1200	,,	1/10	4	65	2	.	1	.	.	16	11	.
	3 pm.	79·5	62·5	35	22·5	1400	,,	2/10	4	68	3	.	.	.	.	18	6	.
	4 pm.	79·5	64·0	40	20·8	1400	,,	3/10	4	71	6	.	.	.	.	18	3	.
	5 pm.	75·0	61·8	44	16·7	550	,,	5/10	4	69	3	.	.	.	.	8	3	.
	6 pm.	74·5	61·0	42	16·7	550	,,	7/10	4	69	3	.	.	.	.	3	2	.
	7 pm.	73·5	63·5	56	12·5	500	,,	9/10	3	70	2	.	1	1♀ *H. crassicornis*	.	15	2	1♀ *Simulium tuberosum*
	8 pm.	73·0	63·5	58	11·9	450	,,	9/10	3–4	65	8	.	.	.	71	14	5	1♀ *S. tuberosum*
	9 pm.	70·0	63·5	69	8·0	200	,,	8/10	2–3	65	12	.	1	.	378	5	.	1♀ *S. reptans* group
	10 pm.	64·5	59·0	71	6·1	30	,,	6/10	2–3	65	9	1	5	2♀ *Simulium latipes*	273	1	.	.
	11 pm.	61·5	57·5	77	4·2	2·5	,,	8/10	2–3	64	.	.	.	.	.	.	.	.
	Midn.	63·5	57·5	68	6·5	0·3	,,	7/10	3–4	63	.	.	.	.	33	.	.	.

TABLE I—*contd.*

Jul. 14	1 am.	65·3	58·5	64	7·5	0·1	,,	10/10	3	72	.	1	4	1♀ *C. fasci-pennis*	5	.	.	.
	2 am.	62·6	59·0	80	3·9	0·0	light	10/10	4	72	.	.	1	1♀ *C. obso-letus*	.	.	.	.
	3 am.	62·6	59·5	83	3·4	0·1	,,	10/10	5	60	.	.	1	1♂ *C. fasci-pennis*	2	.	.	.
	4 am.	61·7	61·0	96	0·7	0·4	,,	10/10	5	68	.	3	.	.	.	.	.	.
	5 am.	62·7	59·5	83	3·3	0·7	,,	10/10	6	69	.	.	1	.	.	.	.	.
	6 am.	60·8	59·0	89	1·9	3·2	Heavy	10/10	6	60	.	.	.	.	19	.	.	.
	7 am.	60·8	59·5	93	1·4	25	Light	10/10	5	63	.	.	22*	.	.	.	.	.
	8 am.	57·2	57·0	99	0·0	45	,,	10/10	4–5	66	.	1	9	.	.	.	.	.
	9 am.	55·4	55·2	99	0·0	30	,,	10/10	4–5	64	.	.	.	.	1	.	.	.
	10 am.	56·3	55·0	92	1·3	200	Nil	10/10	5	66	.	.	.	.	30	.	.	.
	11 am.	58·0	56·5	91	1·6	200	,,	9/10	0									

* Probably includes midges attracted into the net by the presence of the collector.

one-third its previous intensity (1400 to 550 foot candles). This new value was held more or less constant for the next three to four hours. At the start of this period the clegs were relatively inactive but had resumed full activity by the end of this period. Had there been adaptation to the new light intensity?

Two points emerge from the sweep net collections of clegs. Firstly, they gave low catches at a time when clegs were actively biting and high catches when the biting activity was almost over. The highest net catch was made at

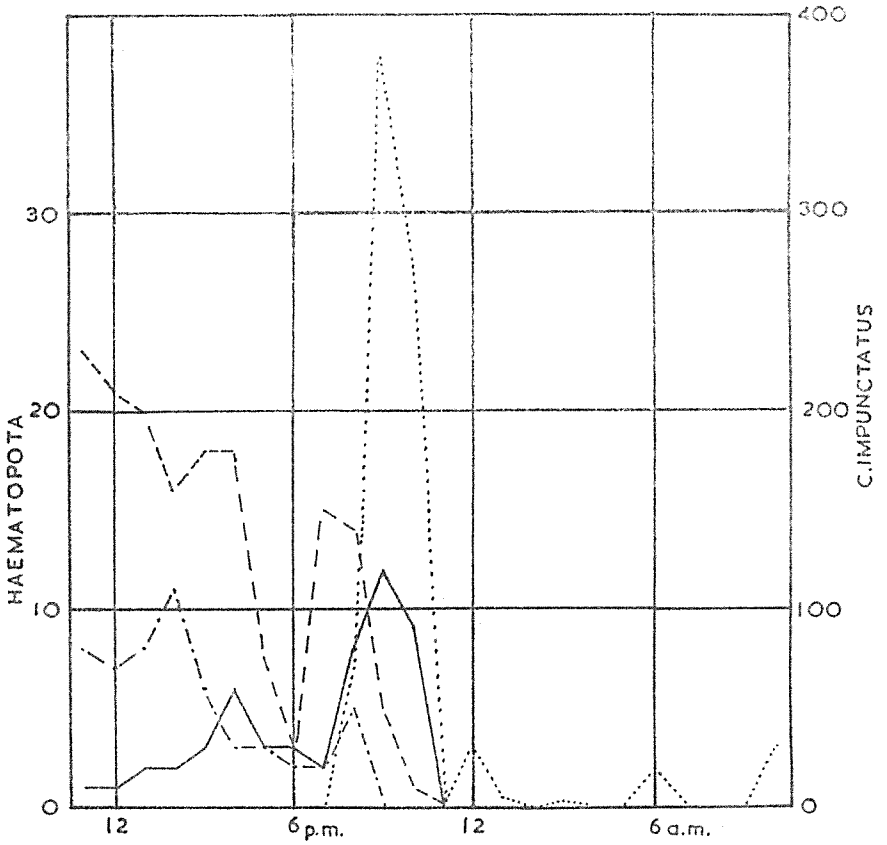

FIG. 4.—Sweep net (continuous line) and biting collections (broken line) of *Haematopota pluvialis* with biting collections of *H. crassicornis* (dash-dot line) and *Culicoides impunctatus* (dotted line) during 24-hour period.

9 p.m. and over half (29 out of 52) of the total sweep net catch was made in the three catches of 8, 9 and 10 p.m. This may indicate either that clegs are not active during the heat of the day unless a suitable host is available or, perhaps more likely, that under warm conditions they are able to avoid the net. Whatever the explanation, it is clear that clegs may be actively flying in the evening when the biting rate is low.

The second point is that, although there were only approximately three times as many *H. pluvialis* as *H. crassicornis* biting (162 : 55), the sweep net collections

were almost pure *H. pluvialis* (52 : 1). This difference is highly significant ($P < 0{\cdot}001$) and probably represents a difference in specific behaviour.

A comparison was made between the numbers of clegs caught biting in the initial and succeeding 15 minute period to find if there were any delay in their finding the host. Although a few more (+ 16 per cent.) clegs were caught during the second period, the difference was statistically insignificant (Table II).

Culicoides (Table 1, Fig. 4). Only one species of *Culicoides* was obtained in any number—*C. impunctatus*. No midges were taken biting until 8 p.m., when the light began to fade rapidly (450–200 f.c.). At this time the temperature was still high (73·0° F.) and the relative humidity moderately low, about 60 per cent. The peak biting activity was attained in the next period, when 378 midges were caught. During this spell the sun descended behind the hill. This produced an immediate outburst in midge activity, as indicated by the capture of 30 adults between 8·45 and 9·00 and 348, or more than eleven times as many, between 9·00 and 9·15. During the subsequent period, in which a similar number of midges were captured (273 cf. 378), the increase between the first and second 15 minute periods was × 1·7 cf. × 11·6.

Little midge activity was encountered during the night when the wind remained high (fig. 3). In the morning, after three consecutive 30 minute periods of exposure for biting (7, 8, 9 a.m.) in which only one midge had been captured, the fourth period (10 a.m.) yielded nothing for 25 minutes, then there was a sudden burst of midge activity and 30 females were captured in a few minutes. This persistent biting continued after the allotted period (10.15 a.m.). It was then noticed that a dead calm prevailed. It is interesting to compare this period with the same time the previous day when preparations were being undertaken. Then it was hot and bright and the clegs were troublesome; now it was dull, calm and humid and the midges were unbearable.

Unlike *Haematopota*, more *C. impunctatus* were captured in the second than in the first 15 minute period of biting (Table II). Even when the sunset figures are omitted the difference is still highly significant. It seems reasonable that there should be a time lag between the arrival of a suitable host in an area, its perception by the insect and the arrival of the insect on the host. The response of a large insect like a cleg is likely to be quicker than that of a tiny midge.

TABLE II.—*Catches of flies attempting to bite in two consecutive* 15 *minute periods; (a) including (b) excluding sunset* 9 *p.m. figures.*

	H. pluvialis *H. crassicornis.* ♀.	*C. impunctatus* ♀. (*a*)	*C. impunctatus* ♀. (*b*)
1st 15 mins. . .	107	196	166
2nd 15 ,, . .	124	696	348
Total . .	231	892	514
P . . .	insig.	<0·001	<0·001

Sweep net catches of *Culicoides* were not particularly interesting, occasional specimens, both male and female, being captured intermittently throughout the 24 hours. Once again there was a lack of correlation between biting and flight activity.

Tabanus.—Six female *T. montanus* were captured attempting to bite around noon under bright sunny conditions.

Simulium.—Two female *S. tuberosum* were taken biting at 7 and 8 p.m. respectively, and a female belonging to the *S. reptans* group at 9 p.m. In the next hour two female *S. latipes* were caught in the net.

Summary.

This paper presents the results of a 24 hour study of weather conditions and the biting and flying activities of *Haematopota pluvialis*, *H. crassicornis* and *Culicoides impunctatus* on open moorland at Kinlochewe in Wester Ross. The importance of high light intensity and warmth in relation to the activity of *Haematopota* sp. and of low light intensity and calm conditions to the activity of *C. impunctatus* is indicated. The results are discussed in some detail.

Acknowledgments.

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