Observations on the Activity of some Culicids.

Studies on the activity of insects IV.

By
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Introduction and Technique.

For some years the author of the present paper has made observations of the activity of noctuids, in order to avoid unbalanced conclusions based on particular conditions the observations were made in places with very different local climatic conditions and at different seasons.

Towards the end of August 1941 when the observations were to be continued from Tipperne*) (Fig. 1), very rainy and windy weather set in. The rain fell chiefly in the evening and night, with the result that there was no or hardly any night activity by noctuids. For a number of noctuids this meant that hunger became the master factor and changed the diurnal rhythm so that the activity occurred in the daytime when the climatic factors were above the threshold value (Bro Larsen 1943, p. 371).

Activity was determined by counting the individuals at nine stations every two hours from 6 a. m. to 10 p. m. Each station consisted of one or more clumps of *Tanacetum vulgare* L., which were almost the only flowering plants left in the place after the grass had been cut for hay making. As a check on the observations of noctuids

*) Tipperne is a peninsula protruding into Ringkøbing Fjord, West Jutland. It is fenland with no trees and along the coast there are stretches of sandy and gravelly soil. The locality is freely exposed to the influence of winds and precipitation.

a number of other insects were counted such as *Lucilia, Scatophaga* and syrphids, *Telephorus,* butterflies, and culicids.

Slightly earlier in the following year, 1942, the series of the 1941 ($^{22}/_{8}$-$^{4}/_{9}$) observations was repeated ($^{3}/_{8}$-$^{13}/_{8}$), and in September 1946 and 1947 additional studies of the diurnal rhythm of the culicids were made.

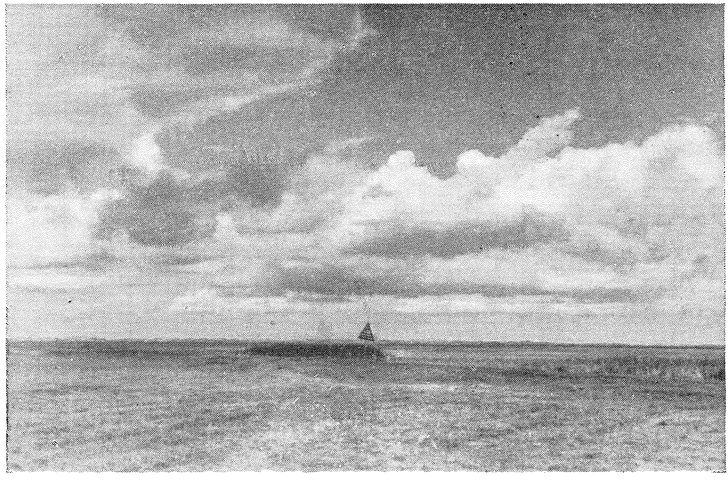

Fig. 1. The locality on Tipperne where stations I—IV are situated.

As comparative little is known of the diurnal rhythm of culicids the author is publishing her observations on the feeding rhythm of the culicids now though well aware that such short series of observations under varying climatic conditions give only a very uncertain picture of the activity and its dependence on the physical factors.

Various observations exist in literature on the influence of the microclimate on the activity and rhythm of mosquitoes. As a rule the biting of the insects is discussed (Lumsden 1947, Howlett 1910), but it also appears that the activity as a whole is affected by climate

and, particularly, by humidity. Martini observed (1936, p. 76) that species which do not usually fly by day occur in dense crowds after rain when the air is humid, and Sinton and Shute point out that during periods of warm dry weather only few anophelines are found, which is explained by the fact that under such conditions these insects live only a short time. At the same time, how-

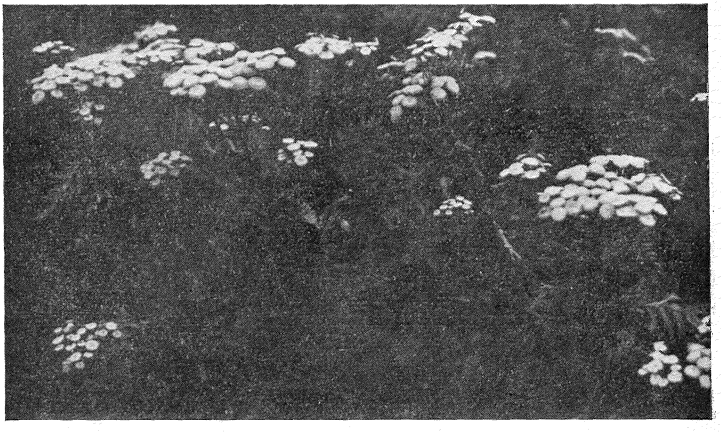

Fig. 2. Flowering *Tanacetum vulgare* with feeding Culicids.

ever, they emphasized that the small number of insects observed may be due to activity being reduced by the low humidity of the air (Sinton and Shute 1938). Perhaps this is also the explanation of the correlation frequently seen between the number of culicids and the rainfall over prolonged periods (Bates 1945).

Experiments have shown that culicids are very sensitive to gradual changes in the humidity of the air as stated by Thomson (1938), who found that *Culex fatigans* avoided high humidity although a low degree of humidity is detrimental to the insects. "No solution to this apparent anomaly could be found", but Thomson presumes that the humidity reactions have some relation to the seeking for a resting place by the mosquitoes.

At Tipperne very low degrees of humidity are often recorded which together with the often rather strong winds must have a very drying effect. For this reason it might

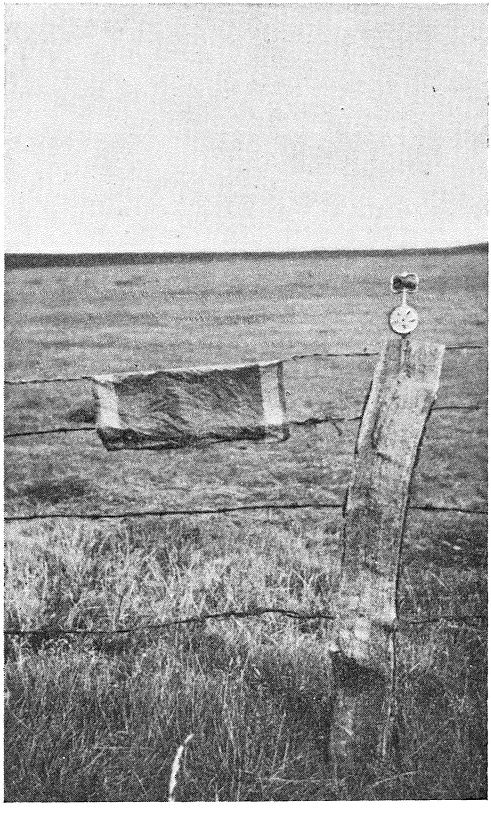

Fig. 3. Arrangement of the anemometre.

be expected that at this particular place the effect of climatic changes on the activity might be perceived.

The following species were observed: *Aëdes vexans* Mg., *Aëdes caspius* Pall., *Aëdes detritus* Hal., *Aëdes punctor* Kirby, *Culex pipiens* L. In the counts no distinction was made between the various species as the insect were not

caught, only observed — and samples were taken for determination, *Aëdes caspius* being the predominant species.

The animals were observed while feeding on the crowns of *Tanacetum* (Fig. 2) against the bright yellow colour of which the insects were easily distinguishable, and both sexes were clearly seen to thrust the proboscis into one tube after the other and suck up the nectar. When there were many insects, a distinction between males and females was only made on some of the *Tanacetum* crowns, because the insects had to be counted quickly and at a distance, for the least movement puts them to flight. This may be the reason why they have rarely been seen feeding on nectar.

Simultaneously with the counts the temperature, air humidity, and force of wind were measured. The temperature was registered partly at the standard weather house of the Meteorological Institute at the laboratory (ab. 100 metres from the stations) and partly at one of the stations. The humidity of the air was measured with an Assmann psychrometer at a height of ab. 1 meter. In 1941 the wind force was recorded on the Beaufort scale and measured at the laboratory. In 1942 the wind was recorded with an anemometer at a height of 1 meter at an exposed locality (Fig. 3 shows the arrangement).

Observations.

The average activity curve for both years is shown in Fig. 4, and the observations from 1947 have also been plotted. There is good agreement between them with a maximum in the morning and the evening and a minimum at noon. The later evening increase in 1942 may be due to the fact that the observations were made earlier in the year. If, however the observations from the individual days are considered, the agreement is less evident. In 1941 there were twelve days of observation,

and a total number of 279 feeding culicids were studied, in 1942 observations were made for five days (besides five not completed) and as many as 3700 culicids were counted. In 1947 — an extremely warm and dry season — only four individuals were counted during fourteen observations.

Variations in activity are shown in Fig. 5 both as absolute number of insects seen at each time of the day, totalled for all days, and as "corrected percentages".

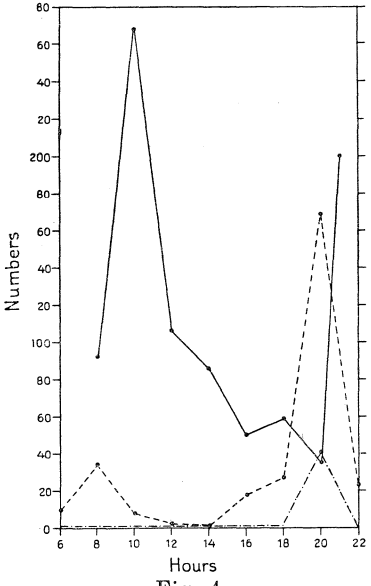

Fig. 4.

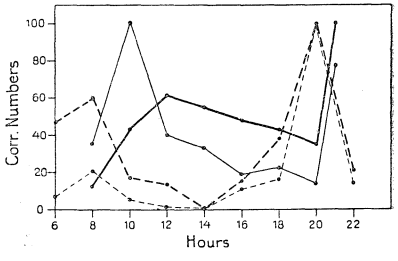

Fig. 5.

Fig. 4. Average diurnal activity. Total number of observations. ---- 1941: 279 individuals. Values multiplied by 10. —— 1942: 3700 individuals. ----- 1947: 4 individuals. Values multiplied by 10.

Fig. 5. Average diurnal activity curves. —— 1942, ---- 1941, percentual diurnal activity curves —— 1942. - - - 1941. The greatest maximum in each curve at 100 and other values determined accordingly.

Corrected percentages are obtained by calculating the figures for each separate day as percentage of the maximum figure on that day, averaging the values so obtained for each time of day and then correcting them by calculating them as percentages of the maximum average percentage.

In 1941 the morning activity peak of the percentage curve occurred at the same hours as that on the ab-

solute curve. This was true also of the evening activity peak in 1941, 1946 and 1947; but in 1942 the percentage curve shows the first peak between noon and 2 p. m. (Only this percentage curve gives a true average measure of activity changes through the day, and when as in 1942, there are odd days giving exceptionally large counts, the absolute curve gives a false picture with a displaced peak).

These circumstances may be due to the fact that in 1941 the weather was bad during the night but generally fair in the daytime while, in 1942, it was unsettled during the day with high temperatures, misty weather, a hazy sun, and many light showers so that the climatic conditions were very changeable. The activity shows evidence for light control, there is a dawn-dusk activity peak all seasons. This light controlled activity cycle is called the "diurnal rhythm". Comparing 1941 and 1942 we shall find that weather 1941 could help to create 1941 regularity, and in 1942 cause the irregularities of this year.

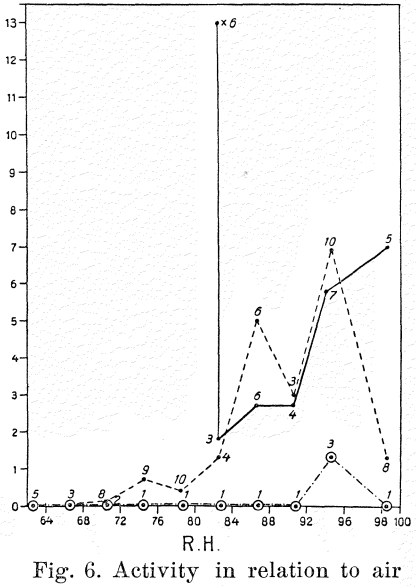

Fig. 6. Activity in relation to air humidity. — 1942. ---- 1941. ----- 1947. x: number of individuals on the day when culicids were abnormally abundant. Common ordinate is used whereby the 1942 values have been reduced so that 216 individuals = 13. The figures at the points indicate the number of counts included in the mean values.

It should, however, be pointed out that if, say, on account of calm

weather there has been a large maximum some time during the day, there will be no corresponding rise if favourable conditions set in again at a later hour. Similarly, a certain inertness of the activity may be observed; when favourable conditions set in, the culicids will gather on the flowers, which takes some time, with the result that the maximum cannot be counted until perhaps less favourable conditions are coming.

Fig. 6 shows the correlation between the activity of the culicids and the humidity of the air. In 1941 it appeared that the activity was at its heighest with R. H. slightly below 100 %, and a little lower at 100 %, which in practice means when it rained. But it is characteristic that with air humidity below 80 % only very few individuals were counted. In 1942 when the weather was very showery 97-100 % R. H. was favourable as these degrees of humidity were measured immediately after

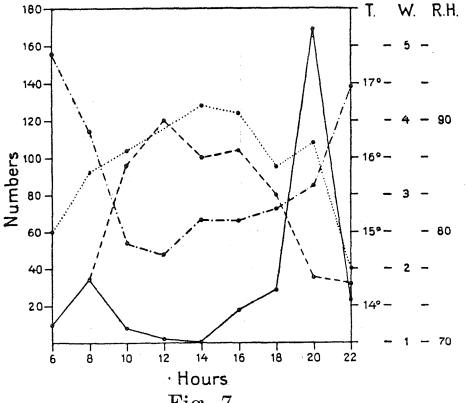

Fig. 7.

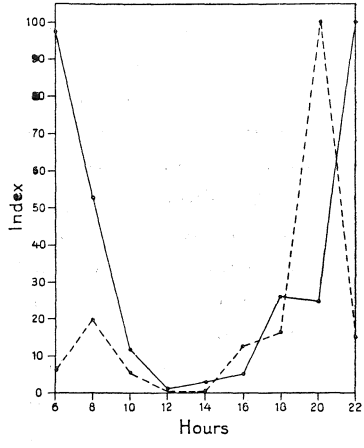

Fig. 7 a.

Fig. 7. Average diurnal variation of the three weather factors in 1941. ----- relative air humidity (R. H.). ..... force of wind (W). ---- temperature (T). —— average activity curve (N.)

Fig. 7 a. Combined factors in 1941. ----- average activity. —— = R. H.—W (cf text).

the showers. On Aug. 10th, however, when the large maximum coincided with favourable wind (see below), the air humidity was unusually low, but apart from this day values corresponding to those from 1941 were obtained. Air humidities below 80 % did not occur during this period, but in 1947 the humidity of the air was as low as 56 % and only occasionally above 90 %, the few culicids observed all being counted at above 90 % R. H.

Fig. 7 shows the average air humidity during the observation period in 1941. As might be expected, it was high in the morning, low in the middle of the day and high in the evening. The activity curve for the culicids follows it very closely except that early in the morning and late at night comparatively few insects appeared (cf. below). In 1942 (Fig. 8) the amplitude was smaller on account of the damp weather, and the showers caused a rise in the average air humidity at 12, at

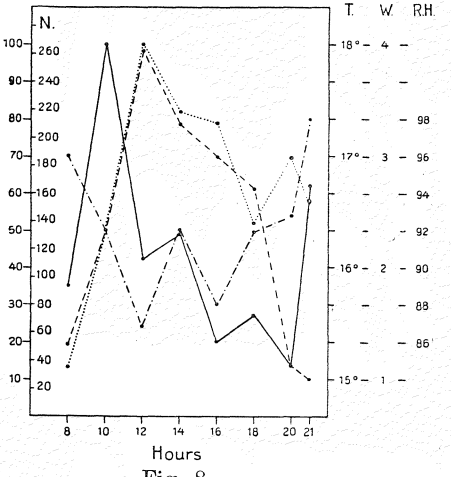

Fig. 8.

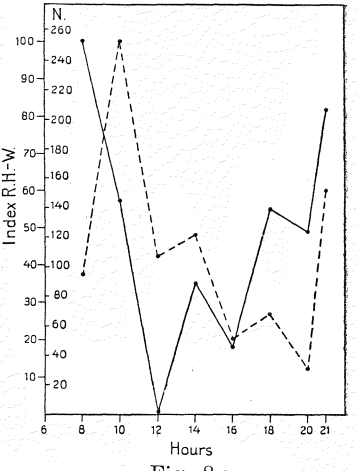

Fig. 8 a.

Fig. 8. Average diurnal variation of the three weather factors in 1942. ----- relative air humidity (R. H.). ..... force of wind (W). ---- temperature (T). —— average activity curve (N).

Fig. 8 a. Combined factors in 1942. ---- average activity. —— = R. H. — W. (cf. text).

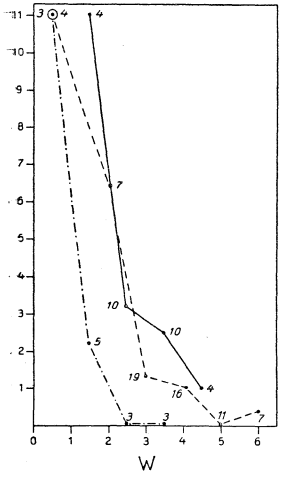

Fig. 9. Activity and force of wind. — 1942. ---- 1941. ----- 1947. In 1942 and 1947 the abscissa is secm., in 1941 the Beaufort scale. For 1941 the ordinate is actual figures, for 1942 314 individuals = 11, and for 1947 1 = 10. The figures at the points indicate the number of values in the average.

this time there was also an increase of the activity. Largely, the activity follows the humidity curve but also here little activity is seen in the morning considering the high and no doubt favourable humidity. The observations ceased too early in the evening for activity to show the late fall it showed in 1941.

In a locality as exposed as Tipperne (Fig. 1) the force of the wind must play an important part. Fig. 9 shows the average number of culicids counted at the different forces of wind in 1941 and 1942. In 1941 it changed from practically calm to force 6. In 1942 the fluctuations were on the whole slighter, but a direct comparison with 1941 cannot be made as the wind was measured in m/sec. quite near the ground. Even so, the correspondance between number of individuals and force of wind is very evident. The 1947 individuals have also been plotted and show in principle the same relations. Here the wind was measured in m/sec. at 1 meter.

The average force of the wind varies much like the humidity. It was usually calm in the morning and in the evening and windy in the middle of the day. Fig. 7 and 8 show the course of the wind curves. In 1942 conditions were more unsettled than in 1941, and they may have left their mark on the average activity. Moreover, as with air humidity, the most favourable wind condi-

tions prevailed before activity rose in the morning and after it had declined in the evening.

As regards temperature the differences between the two years were very great. In 1941 conditions changed steadily through the course of each day so that low temperatures accompanied light winds and high temperatures strong winds with the result that the greatest activity was generally found at low temperatures (cf. Bro Larsen 1943, p. 367). In 1942 the weather was so unsettled that this regular correlation between temperature and wind vanished and great activity was chiefly observed at high temperatures.

In Fig. 7 a and 8a an attempt has been made to combine the humidity of the air and the force of the wind to a common weather curve and to compare the result with the diurnal rhythm of the culicids. The temperature has not been included as with such short series of observations it is doubtful whether to make it positive or negative. The combination is quite simple: The extreme range of humidity and of force of wind is put at 100 and the intervening values are calculated. Then R. H. is counted as positive and wind force as negative (cf. Fig. 7 and 8), thus conforming to the relations shown in Fig. 6 and 9. Humidity and wind values are then summarized and the extreme range of the combination curve is put at 100 and the intervening values are calculated. This procedure can be justified, of course, only if the correlation between the activity and the individual factors is nearly rectilinear within the range.

Hence it appears that the activity curve closely follows the combined weather curves but, as already indicated, the curves diverge in the early morning and late evening.

Not immaterially the activity curve obtained for the other insects counted does not agree with the diurnal curve of the culicids because temperature and light act

as the master factors for the other insects. Accordingly, Fig. 10 and 11 show that the activity of the other insects counted reached its maximum in the middle of the day, and in case of the noctuids there was a second peak late in the evening (*Agrotis xantographa* and *Hydroecia nictitans*).

The few notes found in litterature on culicids on flowers (e. g. Knab 1907, Wesenberg-Lund 1921) often mention that only the males take nectar, but Theobald (1901) has seen both males and females on Compositae and this is also true of several of the species mentioned by Knab (1907, p. 216 & 217).

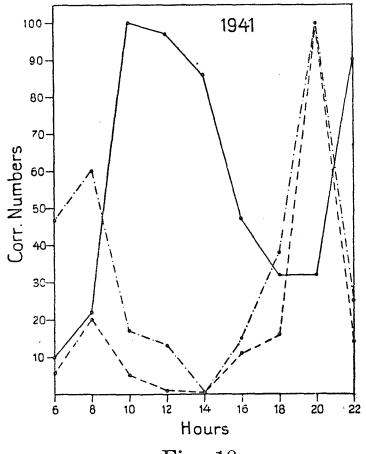

Fig. 10.

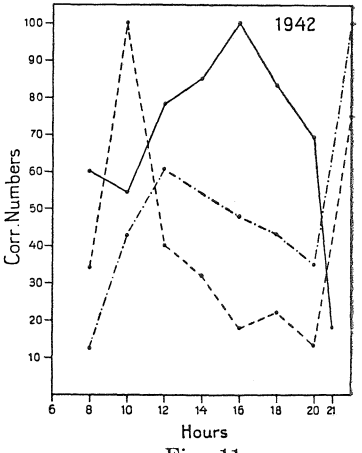

Fig. 11.

Fig. 10. Average diurnal activity of culicids and other insects: —— flies, *Charaeas graminis, Hydroecia nictitans*, and *Agrotis xanthographa*. For each species (for flies each group) the average diurnal rhythm has been plotted with the maximum = 100 and the other values determined accordingly. Then the average curve for all species has been plotted, the maximum again given as 100, and the other values have been adjusted. ---- actual curve for culicids 1941. --- - percentage curve 1941. 16.9 = 100.

Fig. 11. The actual (----) and the procentual (---.-) activity of *Culex* and (——) the course of the average curve for flies, *Telephorus, Hadena bicoloria,* and *Charaeas graminis* (for method cf. Fig. 10).

In 1941 54 per cent males (175 individuals) and in 1942 75 per cent males (2880 individuals) were counted on *Tanacetum*. On Aug. 10th, 1942, about three times as many culicids were counted as on any other day (1319 males and 77 females), but if that particular day is excluded, the percentage of males was 56. Male culicids do not suck blood and the vegetarian food must be a normal part of their nourishment. As males and females are found feeding together on the flowers, vegetarian feeding also seems to be a natural occurrence in the life of the females. The fact that the abdomina of female culicids are distended with a clear fluid in the morning and evening has been confirmed at Pilehuset by H. Greve and E. Tetens Nielsen[1]). However, in 1921 female culicids were observed by Wesenberg-Lund, who found that flower-feeding Aëdinae were only seen on days with a low temperature. He consequently concluded that the flower-feeding is connected with bad weather. It might therefore be presumed that a lower temperature limit exists below which the females do not suck blood but take vegetatian food, and this theory could be supported by the observation that the insects were biting only once when counted at Tipperne. This was on Aug. 9th at 2 p. m. — the hottest day of the period. It should also be remembered that on the whole the periods of observation were selected as climatically unfavourable periods (cf. p. 263). But still it is more probable that flower-feeding is normal for female culicids, and that the unfavourable weather conditions merely intensified their visits to flowers.

The investigations were carried out at the laboratory of Tipperne, and I am most grateful to Professor R. Spärck for allowing me to work on subjects outside the task I had undertaken. I am also indebted to Dr. S. L. Tuxen of the Zoological Museum, who identified

[1]) Personal comunication, unpublished.

the culicids, and to F. Søgaard Andersen M. Sc. for assisting me in the work.

Summary.

A series of counts of feeding culicids on *Tanacetum* made in 1941 and 1942 with additional investigations in 1946 and 1947 show that:

1. In 1941 there was a regular diurnal rhythm with the maximum activity in the morning and the evening at the lowest force of wind and the highest air humidity (p. 268 and Fig. 4 & 5).

2. In 1942 the activity was more irregular, but the lowest force of wind and the highest air humidity of the day was recorded near or at the time of peak activity (p. 271).

3. On basis of these observations it is imposible to prove the existence of the diurnal rhythm separate from the influence of the physical factors of air humidity and wind as the activity proved to be greatly affected by changes in these factors, while the temperature seemed to be of less importance.

4. Males and females visited the flowers in almost equal numbers. The females were only observed to bite once during the counts (p. 275).

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