

27370-6-1 1931

[Reprinted from the 'Annals of Tropical Medicine and Parasitology,'
Vol. XXV, Nos. 3 and 4, December 31, 1931]

OBSERVATIONS MADE BY DR. M. A.
BARBER ON A MELANIC, COASTAL
RACE OF *ANOPHELES COSTALIS*, GILES
(*GAMBIAE*) IN SOUTHERN NIGERIA

BY

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(Received for publication 11 September, 1931)

INTRODUCTION

The present paper is mainly an account of some highly interesting investigations made by Dr. M. A. Barber, of the West African Yellow Fever Commission of the Rockefeller Foundation, in Southern Nigeria. Melanic specimens of *A. costalis* received from Mr. McHardy, Entomologist, Tanganyika, and collected in Dar-es-Salaam by Dr. J. M. Campbell are also recorded.

At the outset it should be stated that the term 'melanic' is used only in the customary sense as implying specially dark forms of the species (see Imms, 1931). As pointed out by Imms, it is possible that the dark pigment may not be true melanin.

In 1903, Theobald described *A. costalis* var. *melas*, a 'very marked melanic variety' of this species, which was collected from Bathurst, Gambia. The type, a female, differed from typical *costalis* notably in the following characters: the apical pale palpal band divided into two by an extra dark band; costa with only one pale interruption, except at the base; wing field darker; pale rings of tarsi greatly reduced; thorax dark brown to almost black, and abdomen deep black. Since this form was described a few other isolated specimens exhibiting marked melanism, especially of the integument and female palpi, have been collected; but apparently none have been found showing such a great degree of darkening of the costa and tarsi. The following are among the localities from which such specimens have been collected:—S. Nigeria: Lagos, Forcados, Port Harcourt, Ikang; Sierra Leone: Mando. The examples from Port Harcourt and Mando are in the collection of the British Museum

provisionally determined as var. *melas*. Most of these specimens seem to have been collected at or near the coast, but no special studies of the distribution or bionomics of these dark forms had been made before Dr. Barber began his investigations in Lagos recently. It should be noted here that the mere occurrence of an extra dark palpal band is a character which appears, apparently sporadically, in a small proportion of otherwise typical *costalis* from inland localities. The majority of these specimens are evidently individual variations, but in the type of *quadriannulatus* the extra dark band is very extensive so that the extreme tip only of the last segment bears pale scales; such forms may represent a distinct variety. It should also be noted that in caught females of typical *costalis*, that have recently fed, the integument of the thorax and abdomen usually appears much darker than usual.

Barber and Olinger (1931) briefly summarise the results of observations and experiments on a dark race of *A. costalis* associated with coastal waters near Lagos and Dr. Barber has very kindly handed over to me for study, samples of the material collected and bred out during the course of these investigations.

COLLECTIONS MADE IN NATURE BY DR. BARBER

From Apapa, near Lagos, 12 October, 1930: ♂ and ♀, markedly melanic, both with very dark blackish integument; ♀ palpi with the extra dark band well developed. The dark scales of the wings, legs, palps, etc., were markedly blackish but, as this character seems to vary a good deal among typical *costalis*, it will not be referred to again. Larval pelts of these specimens with all chitinous structures, head capsule, tergal plates, bristles, palmate bristles, pecten, etc., very much darker, and fronto-clypeal markings more extensive than in normal *costalis* larvae. The pecten also showed differences from that of typical *costalis*. In the latter there is usually a very definite alternation between the long teeth and groups of about two to five shorter teeth which are more or less equal in length. In the brackish water larvae, however, there was a much less definite alternation, all or some of the shorter teeth approaching the longer ones in length. Two preserved larvae from the same collection showed most of these characters and, in addition, the

dorsal surface was darkly pigmented; the pecten teeth were rather broken. Another larva from the same locality taken with several *obscurus*, mostly from brackish water, December, 1930, resembled these two and the pecten showed a much less regular arrangement of long teeth and groups of short ones than in normal *costalis*. The pelt of a larva taken in salt water from this locality, January, 1930, agreed with those described above and the associated pupal pelt was much darker in colour than in typical *costalis*. The pelts of five out of six pupae taken in salt water, Apapa, also showed markedly dark colouration.

Lot V, reared from larvae taken in coastal swamp, of which the water was 46 per cent. sea water at the time of collection: 1♂, 2♀♀, markedly melanic. In all these the integument was blackish; in 1♀ the palpi showed the extra dark band, in the other these were normal. There was a distinct tendency to reduction of the tarsal rings.

Lots A and C, reared from larvae taken in fairly brackish water in coastal swamp, Lagos: 5♂♂, 4♀♀, distinctly melanic; all with integument, black or blackish brown. Palps of 1♀ with ochraceous scales tending to form a sub-apical dark band, those of other♀♀ normally three-banded.

Lots Q, R and S. Larvae and imagos from a locality near the sea, but containing *fresh water* at the time of collection.

R: 1♀, melanic, with blackish integument, 1 palp definitely 4-banded and the other with a tendency to form an extra dark band.

Q: 13♂♂, 12♀♀, tending to show melanism. Integument distinctly darker than in typical *costalis* and, in some cases, approaching the condition of specimens A and C; ♀ palpi all normally 3-banded.

S: 25 larvae. Much paler than Apapa larvae. General colouration and that of the chitinous structures very little darker than in typical *costalis*. Pecten practically normal.

Lots T and U, from a much shaded pool near the sea, fresh water.

T: 3 larvae, 2 practically normal, 1 showing some degree of pigmentation of the palmate bristles.

U: 3♂♂, 6♀♀. Integument of most specimens very little darker than in typical *costalis*, but in one or two a rather marked darkening, not so great as in A and C; ♀ palpi all normal.

M, N, O, P. Several ♂♂ and ♀♀ bred out from fresh water away from the coast in S. Nigeria. These specimens nearly all showed a normally light or moderately light brownish integument, but in one or two it was greyish in colouration ; ♀ palpi all normal.

These records show that the melanic forms of *costalis* collected by Dr. Barber in S. Nigeria, were all associated with coastal waters, and with one exception (R), those exhibiting a marked degree of melanism developed in brackish or saline water.

Dr. Barber has proved that *this form is an efficient vector of malaria parasites.*

The association between these dark forms and brackish water was further brought out by the results of experiments carried out by Dr. Barber, which are described below from notes kindly supplied to the writer.

DR. BARBER'S EXPERIMENTS ON THE DEVELOPMENT OF EGGS OF *COSTALIS* OF DIFFERENT ORIGIN IN FRESH AND BRACKISH WATER ; CARRIED OUT IN LAGOS (EXCEPT WHERE OTHERWISE STATED), 1931

EXPERIMENT I.

Material used. Eggs of *A. costalis* collected at Ibadan, 6 January. 'Ibadan is situated about 100 miles north of Lagos and probably no salt or brackish water occurs within 20 miles of the city.' Eggs laid on the night of January 7-8.

Conditions. The eggs were divided into three batches, some hundreds to each, and placed in containers in the laboratory with different types of water, as follows :—

Lots 1 and 2. *Controls.* Tap water ; crushed water plants as food.

Lot 3. Brackish water obtained from Apapa jungle where the melanic form of *costalis* was abundant. Plentiful food supplied.

Results. By January 9, eggs had hatched in all the lots. The next day the larvae in the brackish water were abnormally slender and two days later were all dead or moribund ; they were all dead by 13 January. The controls which had been developing normally were about half grown by this time, and by the 20 January had given rise to six or seven ♀♀.

EXPERIMENT II.

Material used. 'Eggs of *A. costalis* collected in native houses, Apapa, situated about half a mile from Apapa jungle. These *costalis* presumably consisted of, or contained, the (?) variety capable of breeding in brackish water. Eggs were laid on the night of January 15-16.'

Conditions. The eggs were divided into four batches and placed in containers in the laboratory with different types of water as follows :—

Lot 1. 'The same water and same container as that used for Experiment I, i.e., brackish water from Apapa jungle, the water may have fallen $\frac{1}{4}$ in. to $\frac{1}{2}$ in. in container and thus become slightly more brackish.'

Lot 2. 'Brackish water collected from Apapa jungle, January 20. Analysis made January 20, by Water Examiner for Government Analyst, Lagos—pH. 7.0; Chlorides expressed as Cl., 863 parts per million. This chloride content corresponds to about 46 per cent. sea water. Therefore of similar composition to Lagos lagoon water.'

Lot 3 *Controls.* Fresh tap water.

Lot 4 *Controls.* Lake water.

Results. Lot 1 (brackish water in which Ibadan larvae had died). In ten days the larvae were nearly full-grown and on 26 January one pupa appeared 'which later emerged as a dark *costalis*.'

Lot 2. By 27 January, twelve pupae had appeared.

Controls. Pupae appeared on January 26 and 27.

From the results of this experiment, Dr. Barber concluded :— 'Thus this type of *costalis* flourished in both fresh and brackish water.' Specimens which hatched in the course of these experiments are described below.

EXPERIMENT III.

Material used. Eggs of *costalis* from Ibadan laid on night of January 22-23.

Conditions. The eggs were divided into two batches and kept in containers in the laboratory as follows :—

Lot 1. *Controls.* Fresh water, the same as used in experiment II, 3.

Lot 2. Some of the brackish water from Apapa used in

experiment II, 2 (see above); this water may have evaporated slightly, but was *diluted* with an equal volume of water from the lake. It was still brackish to the taste.

Results. By January 24, eggs had hatched in both lots. On the third day those in lot B were all dead and very small, but the controls appeared to be developing normally. The experiment was discontinued at this stage.

EXPERIMENT IV.

Material used. 'Eggs from *Anopheles* spp. (almost certainly a mixture of *costalis* and *funestus*) sent by Dr. Drysdale Anderson, from the inland locality Abeokuta. It is doubtful whether brackish water exists in the vicinity of this place or not.'

Conditions. The eggs were divided into two batches and placed, on January 19, in containers in the laboratory with water of different types as follows:—

Lot 1. Brackish water, some of that used in experiment II, 2 (analysis given above). Water not diluted.

Lot 2. *Controls.* Fresh water from the lake; larvae transported to Liberia at end of January.

Results. After three days there was no sign of growth of larvae in Lot 1, which were all dead. The control larvae developed normally, giving rise in time to adults of *costalis* and *funestus*, in spite of transportation to Liberia. It was noted that the larvae of *funestus* took longer to develop than those of *costalis*.

DESCRIPTION OF EXAMPLES REARED OUT BY DR. BARBER IN EXPERIMENT II

Lots 1 and 2, developed in brackish water: 8 ♂♂, 14 ♀♀. Integument of thorax and abdomen markedly blackish in all specimens. Three ♀♀ with a well-developed extra dark palpal band and this distinctly indicated in two others; the tarsal rings tending to be narrow in about half the specimens.

Lots 3 and 4, developed in fresh water. 5 ♂♂, 9 ♀♀. Integument of most of the specimens showing practically normal pale brownish colouration but, in three, distinctly darker and greyer than normal, though paler than in Lots 1 and 2. In one ♀ the palps showed a distinct indication of an extra dark band on one palp, and in another

there was a very slight suggestion of this on both palps (pale ochraceous scales present but palps somewhat rubbed).

The results of this experiment strongly indicate that the form or race of *costalis* which is capable of developing in brackish water, becomes much blacker in integument and tends to show the extra dark palpal band in a higher percentage of females when reared in brackish water than in fresh water.

DISCUSSION

From the above records it seems clear that Dr. Barber has demonstrated the existence of a race of *costalis* with marked melanic tendencies, which breeds in the coastal swamps near Lagos, and which differs from forms of *costalis* found inland in Southern Nigeria, in that the larvae are capable of developing in brackish water. It would also appear that the colouration characters of this race are highly unstable, the full degree of melanism being only developed when the larvae are reared in brackish water, or at least, in water from the coastal swamps. Dr. Barber notes that even in the season when the water of the coastal swamps becomes fresh, these waters differ from ordinary fresh water, the mud and underlying materials being peculiar. In this connection it is interesting to record two specimens recently received from Mr. J. S. McHardy. The specimens, a male and female, were reared from larvae collected by Dr. J. M. Campbell, in 'dark brown rain water pools in a swamp, Dar-es-Salaam (water, however, was not acid although it looked peaty enough, pH. 7.8).' As Mr. McHardy notes, these specimens both have the integument unusually dark and the female palpi show a well-marked extra dark band, but the tarsal rings are broader and more distinct than in Dr. Barber's melanic forms. It is possible that this represents a melanic race which has arisen on the East Coast of Africa independently from that found in Southern Nigeria.

The question arises whether Dr. Barber's coastal race is the same as Theobald's '*costalis* var. *melas*' or not, and reference must be made to Christophers' (1924) conclusion that 'there is no reason to suppose that this constitutes a true local variety. The fourth palpal band and bridging of the pale costal spots are among the ordinary manifestations of melanism in *Anopheles*.' From

Dr. Barber's observations, however, it is seen that the general blackening of the integument is the most constant characteristic of the melanic forms found in Lagos. This is also a feature of Theobald's type specimen, but the question whether this represents an extreme form of the same race or belongs to another which has developed independently could, apparently, be settled by examination of a series of specimens collected from the saline waters near Bathurst. Dr. Edwards, who kindly re-examined the type, noted that the front tarsi were entirely unbanded and, although Dr. Barber's dark specimens exhibited a tendency to reduction of the tarsal markings, none showed this in so great a degree as in the type of *melas*, nor was there any marked melanism of the costa. In other respects, however, the darkest Lagos forms agree pretty well with the type of *melas*. In this connection it may be mentioned that amongst a collection of material in a poor state of preservation, I have seen from Bathurst, was a female in which the costa was distinctly melanic but the palps practically normal. It would appear, therefore, that the Gambia race is possibly subject to much variation.

Dr. Barber's observations raise the further question whether all the *costalis* which breed in brackish coastal waters in West Africa belong to a race or races which are distinct from those occurring inland. Dutton (1903) records the finding of larvae of *A. costalis* in brackish and salt water at Bathurst, and Giles (1905) found the species together with *Culex thalassius* breeding in brackish puddles about the Lagoons in Sekondi, the water in one of them containing 2,100 parts of chlorine per 100,000. In Accra, Ingram and Macfie (1917) record the finding of larvae of both these species in a pool flooded by the sea at high tide. Dutton found by experiment that eggs of *costalis* were laid in a tub containing 'sea water, taken as the tide was coming in,' and gave rise in eleven days or less, to adult mosquitos. He also found that larvae of this species from various sources remained alive in water containing up to 75 per cent. sea water, but that many of them died in higher concentrations. No mention is made of specially dark colouration in these specimens, but it is quite possible that this character was thought at that time to be merely due to individual variation. Balfour (1921) mentions no abnormality in the *costalis* he found breeding in brackish pools formed by seepage in North Khartoum.

It is well known that in other species such as *A. rossi* Giles (*subpictus*) and *A. ludlowi* Theo., fresh and salt water races are distinguished, and in some cases, these are said to differ in colouration or structure. Walch and Soesilo (1929) have recently described differences in the pectens of certain of these races in the Dutch East Indies. They show that in this region, in the salt water form of *A. rossi*, this differs from that of the fresh water form in having the shorter teeth approaching the longer teeth in length, the aspect of the pecten being described as irregular in the former. In the Philippines, however, according to Urbino (1930), the pectens of both salt and fresh water *rossi* are similar and have the teeth very unequal, while salt water *ludlowi* is distinguished from its fresh water form and from *rossi* in having the teeth all about equally long and uniform. This author also describes differences in colour markings and structure between the adults of the fresh and salt water forms of those species, and it is interesting to note that 'hypermelanism' (the occurrence of an extra dark palpal band) occurs very frequently in *fresh* water *ludlowi*. The characteristics of the brackish or salt water forms of these three species of the *Pseudomyzomyia* group are, therefore, somewhat variable but it would appear that, when the pecten differs from that of the fresh water forms, it is in the direction of lengthening of some or all of the shorter teeth. Melanism, on the other hand, is by no means a constant feature of the adults of the salt water forms, however, the reverse being the case with *ludlowi*. The colouration difference between typical *A. maculipennis* and the salt water variety, var *atroparvus* van Theil, appears to be somewhat analogous to that between *A. costalis* and the salt water forms here described. Van Theil (1929) notes that the colouration of his variety is more greyish than that of the type and that the spots and costal border of the wings are darker in the variety than in the type.

Even in *costalis*, melanism may be quite absent in specimens bred in saline water. Dr. Edwards kindly showed the writer a series of specimens of this species collected by Dr. J. T. Bradley, in 1930, on the island of Aldabra, where practically all the available water was saline. These specimens were quite normal in colouration, although they must, apparently, belong to a race that is biologically distinct from that found inland in Southern Nigeria.

Thus Dr. Barber's race possesses the peculiarity of being able

to develop in brackish water and of exhibiting a marked degree of melanism when bred in such water. This latter characteristic is interesting in view of the investigations undertaken into the effect of various chemical factors in the melanisation of certain Lepidoptera, summarised by Imms (1931). Although there are not sufficient data to discuss the actual factors concerned in the present case, the composition of the water appears to have some influence, either directly or, as suggested by Dr. M. G. Blacklock, through its effect on the food supply, in bringing about the very marked melanism of this coastal race of *costalis*.

CONCLUSIONS

It seems justifiable to draw the following conclusions from the results of Dr. Barber's investigations.

1. A race of *costalis* capable of developing in normal time in water of salinity at least equal to 46 per cent. sea water, breeds in the coastal swamps near Lagos.

2. The race is melanic, especially in the colouration of the integument of the adults, and pigmentation of the body and chitinous parts of the larvae, but the melanism attains its maximum development in specimens bred in coastal waters, especially when these are brackish.

3. Larvae hatched from eggs of *costalis* from certain inland localities in Southern Nigeria, failed to develop in brackish water, in which those of the coastal race developed successfully.

4. Larvae hatching from eggs of *funestus* originating from Abeokuta failed to develop in brackish water (slightly more than 46 per cent. sea water).

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