[Reprinted from MOSQUITO NEWS, Vol. 20, No. 4, December, 1960]

THE MOSQUITO FAUNA OF KOHAT-HANGU VALLEY, WEST PAKISTAN

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DESCRIPTION OF THE AREA. The Kohat-Hangu valley is situated in Kohat District of the Province of West Pakistan (33.34 N, 71.27 W). The altitude varies from 3,000 to 4,000 feet above sea level. Parallel to the 26-mile long road between Kohat and Hangu, which passes through the hill tract, is the river which gains in its volume by confluence of hill streams at frequent intervals. The river bed, which is mostly rocky and covered with gravel, is, for the most part, devoid of any vegetation excepting a few patches of grass around the rocky pools which give protection to anopheline larvae. The soil is alluvial. Most of the villages are situated on either side of the river and quite a few are on the hillocks. Excepting areas where there is water supply by hill streams most of the tract is stony waste covered with a few stunted shrubs. Natural vegetation other-

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wise is sparse, excepting the orchards watered by streams.

KOHAT CANTONMENT. The cantonment is well wooded, and apart from the gardens of the bungalows, it is largely under cultivation. Most of the country in the immediate neighbourhood of the cantonment is also cultivated, growing mainly vegetables and grain, e.g. wheat and barley. There are no rice-fields in close proximity to the cantonment. There are a large number of water channels in the area which irrigate the fields and also water the gardens. These channels during the course of flow become untidy, and thus provide pools and puddles in which breed anopheline mosquitoes.

CLIMATE AND METEOROLOGY. According to the climate classification of West Pakistan proposed by Ahmad (1951), the valley lies in the Secondary Division, Kohat-Waziristan of the minor region of Middle Himalayas and northwestern hills under the major region, the subtropical continental highlands. The winters are cold and snowy, with winter showers. The second rainy season in the area is the spring season. The climate is dry and hot in summer and cold and humid in winter. The maximum temperature reached in May and June is 107° F.–108° F. and the minimum in December and January is 47° F. Kohat, which is at one end of the valley, registers an annual rainfall of 10 inches, and Hangu which is at the other, receives a precipitation of 16–26 inches annually. Thus the mean for the valley is about 18 inches. Naqvi and Qutubuddin (1954) have given tables showing rainfall and humidity figures for the year 1948, and 1949. From these figures it appears that February and March, on the one hand, and July and August on the other, account for the highest rainfall. These are also the months of highest humidity.

BREEDING SITES OF ANOPHELINES. Sinton (1917), who made a survey in the area and reported on the malaria figures and anopheline mosquitoes of Kohat district, restricted his investigations mostly to the cantonment. Hence a detailed account of the various breeding places of anopheline and culicine mosquitoes in the valley is lacking. Naqvi and Qutubuddin (1954) confined themselves to a detailed description of breeding sites of anopheline species only, which is briefly recapitulated below with a view to presenting here a complete picture of ecological conditions in the valley.

Drain pits, formed from the irrigation channels that take off from the hill streams; borrow pits made at the time of the construction of the railway; and ricefields, which are few, are the breeding sites of *A. culicifacies* the malaria vector, and *A. fluviatilis* a probable factor in malaria transmission.

BACK WATER FROM HILL STREAMS. These are small and large collections from hill streams in the river bed in which breed *A. culicifacies* Giles, *A. maculatus* Theobald and *A. turkhudi* Liston.

SLOW RUNNING WATER AND ROCKY PITS. In the river bed there are slow running water courses and rocky pits devoid of vegetation. These are also breeding sites of *A. culicifacies* and five other species.

FOOTHILL STREAMS. The fast running hill streams breed *A. fluviatilis* James.

IRRIGATION CHANNELS. Are the branches of the hill streams.

TANKS. Water for drinking purposes is stored in masonry and mud tanks. These receptacles are not the major source of anopheline breeding but neither are they completely free from it.

Of the above, borrow pits and drain pits are described as the most frequent breeding sites of the vector, *A. culicifacies*.

BREEDING SITES OF CULICINES. The principal breeding sites of the 22 culicine species reported here were as follows:

THE CHILLI BAGH AREA. Midway between the two towns Kohat and Hangu is a vast, thickly wooded area, overgrown with wild vegetation which is the chief source of culicine mosquitoes. There are trees there which hold rain water and provide breeding places for the tree-hole breeders. From this area about 75 percent of culicine mosquitoes reported below were collected.

MASONRY WELLS. Unused rotting masonry wells, although not very numerous in the valley, are a source of culicine breeding. There are undoubtedly other breeding places of culicine mosquitoes in the area, but no special efforts were made to locate them.

MOSQUITO FAUNA. Sinton (1917) did not present a detailed account of the mosquito fauna. Naqvi and Qutubuddin (1954) reported the following species of *Anopheles: culicifacies* Giles, *stephensi* Liston, *fluviatilis* James, *maculatus* Theobald, *annularis* Wulp, *superpictus* Grassi, *turkhudi* Liston, *splendidus* Koidzumi, *lindesayi* Giles, *d'thali* Patton, *pulcherrimus* Theobald, *subpictus* Grassi, *hyrcanus* (Pallas).

Of these 13 species of *Anopheles,* they could locate the breeding places of only 9. Intensive and extensive search for those of *A. superpictus, A. splendidus, A. d'thali* and *A. lindesayi* proved futile.

No adults, but only the larvae, of *A. hyrcanus* were taken in the valley. *A. subpictus* was the species found in the largest numbers, *A. pulcherrimus* in the fewest number, during the period of its survey from August to December.

CULICINE MOSQUITOES. There is no previous record of the culicine mosquitoes of the valley. As far as could be ascertained Barraud (1934) did not report any culicine species from the area. He mentioned some species occurring in the former N.W.F. Province but none from this valley. The present personal collection was casually made by the author out of interest aroused in the culicine fauna because some species which were vicious biters proved a serious nuisance during the course of collecting of *Anopheles* in certain areas, particularly the woods near Chilli Bagh. Several culicine species landed, by the hundred, on collectors in the area and bit so viciously in the day time, that collections could be made by one man from another while these mosquitoes sucked blood. Among these, as will be seen below, were mostly members of the subgenus *Stegomyia* and some of the genus *Culex*. The culicine fauna of the valley appears to be very rich and it is likely that a special survey made round the year may yield a much larger number of species.

In a collection of moderate size made from August to December, 22 species of Culicines belonging to 4 genera and 9 subgenera were identified; a detailed account of them is given below. This number is definitely far short of the total number of species that exist in the area.

1. *Culiseta indica* (Edwards). Several examples of this species were bred from larvae collected in November from foul-smelling water in an unused masonry well at Kachai village. There were many more females than males among the adults reared in this way. The occurrence of larvae in foul water is rather unusual for the genus in the Indian subregion. The other two species known from the subregion breed in ground pools and sometimes in beds of hill streams. Palpi in female adults were found to be very variable being from 1/7 to 1/5 of the proboscis in length.

2. *Aedes (Stegomyia) aegypti* (Linnaeus). Not a common species in the valley; it was collected on a few occasions biting in day time in the woody area of Chilli Bagh. It is greatly outnumbered by *w-albus* (Theobald) and its rival *albopictus* (Skuse). Since I am not at present in possession of the specimens collected in the area it is not possible to say which of the three forms recognized by Mattingly (1957) occurred in the valley. But since *Aedes aegypti* var. *queenslandensis* Theobald is common in the Mediterranean area, and Barraud (1934), not specifying particular localities, mentions it as occurring in India; and also because Mattingly thinks that *Aedes aegypti* along with a number of other mosquitoes represents a Mediterranean element in northern India and Burma, it is quite reasonable to believe that this pale form may also occur in the area. A detailed investigation in this area and for that matter in the whole of W. Pakistan will be needed in order to ascertain the occurrence of the forms of *aegypti* and limits of their penetration inland.

3. *Aedes (Stegomyia) w-albus* (Theo-

bald). A very common species in the valley; found throughout the season from August to December. It was always taken biting in day time in the Chilli Bagh area.

The marking of the thorax shows great variation; all the patterns shown by Barraud (1934) in Pl.VI Figs. 6–8 were observed. The white spot on the mid femur is also variable in position as well as in magnitude; on some it is smaller and more distal than in others. Genotypic significance, if any, of this variation is not known.

4. *Aedes (Stegomyia) albopictus* (Skuse). This species, also caught biting in Chilli Bagh, occurs in larger numbers than *aegypti* and almost equal in numbers to *w-albus*. The occurrence of this species in the valley, with a mean annual precipitation of 18 inches is of interest since over most of its range it is associated with a very heavy rainfall.

5. *Aedes (Stegomyia) unilineatus* (Theobald). Caught in moderate numbers from the same area as the above species.

6. *Aedes (Stegomyia) vittatus* (Bigot). A few specimens of this species also were taken in the same area while they were biting in day time.

7. *Aedes (Aedimorphus) pipersalatus* (Giles). Bred from larvae collected in a rotting masonry well in the month of September; not very frequently encountered in the area. A few points about the male terminalia are worth mentioning here. Coxite densely covered with strong bristles. No basal lobe present. Phallosome well-developed, lateral plate with four finger-shaped highly sclerotised teeth.

8. *Aedes (Aedimorphus) pallidostriatus* (Theobald). Many males and females bred from larvae collected in September. Male terminalia: Pubescent area of style under the curved ventral spine with a brush of long, fine hairs.

9. *Aedes (Diceromyia) micropterus* (Giles). A few females; not very common. The subgenus appears to be represented by the single species in the area. From the distribution given by Barraud, Punjab, where this species is found, is the western limit of the subgenus in the subcontinent. The other four species occur east of a line drawn from Delhi to Bombay. The occurrence of this mosquito in the area only suggests that it is a most widely distributed species from Kohat in the northwest to Madras in the southeast, and as far east as Bihar.

10. *Aedes (Aedes) indicus* (Theobald). The subgenus is represented by the single species in the area, a single female of which was taken.

11. *Armigeres (Armigeres) subalbatus* (Coquillett). A very common species in the valley; females caught outnumber the males. The abdominal markings are very constant. It may be mentioned here that the curving inwards of spines of the *bl* of coxite in the case of *kuchingensis* Edwards, as against outwards in *subalbatus* mentioned by Barraud, appears to be the result of flattening, as sometimes both conditions are observed in the two basal lobes of the same terminalia. On many occasions this species was collected on man.

12. *Culex (Lutzia) fuscanus* Wiedemann. Several males and females of this species were taken during the survey.

13. C. *(L). raptor* Edwards. This species is equally common in the area.

14. *C. (Lophoceratomyia) minutissimus* Theobald. It is not a very common species but a few examples were caught in the valley.

15. *C. (Culex) bitaeniorhynchus* Giles. Several males and females of this species were taken in the area while biting man. The two varietal forms *ambiguus* and *tenax* do not seem to occur here. The median pale band on the proboscis is very variable in size, particularly in the female. In some specimens it was twice as broad as in others. Speckling of pale scales between the pale band and the base was observed in most specimens.

16. *C. (C). vishnui* Theobald. A few specimens of this species were collected on man during the survey; identified by the dissection of male genitalia since its very close ally *C. barraudi* Edwards also occurs in the area.

17. *C. (C). barraudi* Edwards. This species, which occurs in small numbers

here, was also identified by the dissection of male terminalia. In some specimens the mesonotal scales were observed to be exceptionally pale as in *gelidus* Theobald or *whitmorei* (Giles).

18. *C. (C). tritaeniorhynchus* Giles. Occurs in small numbers in the valley. Lateral plate of phallosome was typical of the species but pubescence on the external plate was more dense.

19. *C. (C). mimeticus* Noe. A few males and females were taken.

20. *C. (C). theileri* Theobald. It was bred from larvae collected in association with *Culiseta indica.* Certain morphological details are worth mentioning. Scaling of pleurae as described by Barraud viz., a large patch on upper portion of mesepimeron. Proboscis brown but no median distinct pale area beneath. CV4–5, distinctly nearer base of wing than CV–4. Tergite II answers to Edwards (1941) description, viz., without a transverse band, but with a median longitudinal area of white scales which extends the whole length touching the border. In some, tergite III also somewhat like II, with no complete basal band, but a longitudinal line extending forwards.

21. *C. (C). univittatus* Theobald. This is not a very common species in the area, but a small number of specimens were collected. The spine of the ventral lobe of the phallosome is very similar to those figured by Mattingly (1954) from *Zaria* and *Djanet* in Africa.

22. *C. (C). pipiens fatigans* Wiedemann. A common species in the valley. It was collected biting man. The terminalia of several specimens examined closely resemble those of *C. p. fatigans* in the shape of the external process of phallosome. The palpi in two specimens from Kohat are somewhat like those of *australicus* Dobrotworsky and Drummond. The proboscis in one specimen is quite long. The ratio of the length of the upper fork cell to its petiole in the female wing varied from 3 to 4.5, the mean being 3.6. Number of hairs on the shaft of the male palp in specimens with a long proboscis is about 10. In another specimen with upturned palpi and normal proboscis, it is 16.

RELATIONSHIP TO DISEASE AND OTHER RELEVANT FACTS. Dissection of guts and glands showed *A. culicifacies* to be the vector of malaria in the valley. The sporozoite rate was 0.26 percent in August; 1.43 percent in September and 0.27 percent in October and 0 percent in November. Since *A. culicifacies* is one of the chief vectors of rural and suburban malaria in the Indo-Pakistan sub-continent, a great deal of work has been published on it, including an exhaustive review by Afridi and Puri (1940) and another by Rajindar Pal (1945). Subsequently the mosquito has been the subject of extensive and intensive investigations in South India by Russell and his co-workers. Most of this work has been referred to and summarized by Thomson (1951).

Since the present investigation lasted only from August to December the seasonal incidence of *A. culicifacies* could not be thoroughly studied. Nevertheless, it was observed that the species maintained a uniform density throughout the period of survey. Richmond and Mendis (1930) reported from Peshawar, about 40 miles from Kohat, that adult *culicifacies* were not encountered till the end of July, after which the species increased in number till November, the maximum prevalence being from mid-August to mid-November. This appears to be in conformity with our findings as mentioned above. As regards its preferential feeding habits it may be mentioned that a small number of precipitin tests were 65 percent positive for human blood, although most of these specimens were taken from mosquitoes resting in cattle-sheds.

Of the culicine species found in the valley the following have been found biting man: *C. pipiens fatigans, C. bitaeniorhynchus, C. vishnui, Aedes albopictus, Aedes vittatus, Aedes w-albus, Armigeres subalbatus.*

Among these, *C. p. fatigans* is the classical vector of bancroftian filariasis. The possibility of this disease establishing itself in the area, and for that matter, in

the whole of West Pakistan, can not be altogether ruled out, because it is likely that a certain proportion of refugees from Bihar and southern India may harbour the *microfilariae* of *W. bancrofti* in their blood and may serve as carriers of the disease. Further, in another member of the same complex viz., *C. p. molestus* Forskal the natural occurrence and experimental transmission of the West Nile virus has been demonstrated in Israel (See Tahori *et al.*, 1955). *C. univittatus* which is found in the valley in human habitations, is a well-known human biter and a vector of West Nile virus in Egypt, (see Taylor *et al.*, 1956). A virus belonging to the West Nile and Japanese B complex was isolated in southern India from *C. vishnui* and from *C. bitaeniorhynchus* in the Western Ghats. Also, Sindbis virus was recovered from *C. vishnui* and from a mixed pool of *Culex* spp. in Bombay state. It is suggested that this species may play an important role in the transmission of neurotropic viruses in India. Thus, it is evident that a number of dangerous species occur in the valley.

ZOOGEOGRAPHY. According to Wallace the eastern frontiers of Afghanistan and Baluchistan are the boundary of the Oriental Region. Kohat-Hangu valley is almost on this line. Hence, on the one hand it is at the meeting place of the Palaearctic and Oriental Regions, and on the other it is under the influence of the Ethiopian Region through Arabia and of this area, western Saudi Arabia, the Yemen and the eastern and western Aden protectorates are treated by Mattingly and Knight (1956) as Ethiopian, and the remaining divisions of the peninsula as Palaearctic. Now let us see as to what proportion of the total of 35 species occurring in the valley belongs to each of the three zoogeographical regions.

Considering first the anophelines: *A. culicifacies, A. fluviatilis, A. stephensi, A. subpictus, A. annularis, A. maculatus, A. splendidus* and *A. pulcherrimus* all are Oriental species. The Palaearctic element is represented by *A. hyrcanus, A. superpictus, A. d'thali,* and *A. lindesayi. A. turkhudi* according to Mattingly and Knight (1956) is a borderline case between Palaearctic and the Oriental Regions. However, I do not agree with them that it is restricted to western India since I collected it from Aurangabad (India) which is farther south (unpublished record).

Of the 22 species of culicines occurring in the valley *Aedes aegypti* and *Culex pipiens fatigans* are cosmo-tropical, the former occurring in the Ethiopian, Oriental and the Neotropical Regions although its natural range is considered by Mattingly and Knight (1956) to be the Ethiopian and Palaearctic Regions, and the latter is found in the tropics and sub-tropics of the New and the Old Worlds with its natural range possibly in the Oriental Region. Although the origin of *Aedes aegypti* is not known for certain, Mattingly (1953) considers it to be 'a possibly non-ethiopian species.' Of the remaining four *Stegomyia, Aedes w-albus* is an Oriental species. *Aedes albopictus,* besides occurring in the Oriental Region also occurs in South Georgia Archipelago, N.E. China to Manchurian border and Japan, Formosa, Dutch New Guinea and Hawaiian Islands. *Aedes unilineatus* is considered by Mattingly (1952) as a species of interest since it is one of the few Ethiopian *Stegomyia* which also occurs in the Oriental Region. *Aedes vittatus,* probably an invader from the Palaearctic Region, has separate Oriental, Ethiopian and Palaearctic populations and does not primarily belong to any one of these regions. Hence it is regarded as a borderline case by Mattingly and Knight (1956). The three species of *Culex,* viz., *C. tritaeniorhynchus, C. theileri* and *C. univittatus,* each have Oriental, Palaearctic and Ethiopian distribution; the first, which is an Oriental species, occurs as far southwest as Celebes, from the Mediterranean to China, Japan, West Africa and Egypt. *C. theileri* which occurs in the Oriental Regions and in the Mediterranean subregion of the Palaearctic, from Mesopotamia and Persia to Atlantic Islands, and in

the Ethiopian Region in East and South Africa, is regarded by Mattingly and Knight either as a Palaearctic intruder which has spread southwards or as a south African species spreading northwards along the East African Highlands. *C. univittatus* is more widely distributed outside the Oriental Region than within it. It is not regarded as Oriental. Amongst the remaining species, *Culiseta indica* is more or less endemic to the northwestern part of the Indian sub-region. All four species of the genus *Aedes* and *Armigeres subalbatus* and *Culex (Lutzia) fuscanus, C. raptor, C. minutissimus* and *C. barraudi* are purely Oriental species. *C. bitaeniorhynchus* has a wide range of distribution viz., Japan, Australia and the Ethiopian Region. *C. vishnui,* which is common in the Indian subregion, occurs from Mesopotamia to China and Japan. *C. mimeticus,* besides the Oriental Region, also occurs from the Mediterranean subregion to China and Formosa. Thus it would appear that the fauna in the valley is more influenced by the non-Oriental element, whether it be purely Palaearctic or a mixture of such species that are equally prevalent in both regions or are borderline cases.

ACKNOWLEDGMENTS

I am very much indebted to Dr. D. L. Collins for reading through the original MS and making very useful suggestions.

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