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MORPHOLOGIC STUDY OF THE ADULTS OF THE DIFFERENT TYPES IN THE ANOPHELES SINENSIS GROUP*

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Summary 1. Different types of the Anopheles sinensis are very common in provinces along the lower reaches of the Yangtze River. Even though Kweichow is located further inland, we have discovered five different types of the A. sinensis: the broad decked egg type, the medium decked egg type, the narrow decked egg type, the extremely narrow decked egg type, and the A. kweiyangensis.

2. On the basis of the adult morphology of these five types, the mosquitoes may be divided further into two groups according to the presence of white scale tufts on the outer coxae. In the group with white scale tufts on the outer coxae, the mosquitoes are also larger in size, the wedge-shaped pale marks on the abdominal sternites are very marked, and the brown scale tuft on the 7th abdominal sternite is large. A. kweiyangensis, the broad decked egg type and the medium decked egg type of the A. sinensis belong to this group. In the group without white scale tufts on the outer coxae, the mosquitoes are smaller, the wedge-shaped pale marks on the abdomen are not marked, and the brown scale tuft on the 7th abdominal sternite is small. The narrow decked egg type and the extremely narrow decked egg type of the A. sinensis belong in this group.

3. Our comparative studies show that various types of the A. sinensis are different from those found in Malaya, Japan, and the Phillipines, and their role in the classification scheme need further study.

4. Adult females from these five types found in Kweichow Province are described briefly. A key for identification is also included.

I. Introduction

Past research has proved that the narrow decked type of the A. sinensis found in southern China is the chief vector of disease in malaria (Ho Ch'i (0149 3823), 1962; Feng Lu-pai and others, 1962) and Malayan filariasis (Feng Lan-chou (3301 5695 3166) and others, 1960). Therefore, differentiation of the various types of A. sinensis is very significant in actual practice. However, because the types and groupings of A. sinensis found in different localities differ, a somewhat more dependable method still used up to the present time is classification according to the morphology of the eggs. This is very inconvenient in actual practice. For this reason, a way for differentiating adults among the various types of the A. sinensis, particularly differentiating between the type with broad decked eggs and the type with narrow decked eggs, is urgently needed for actual practice.

Numerous authorities have suggested ways to differentiate adults of these two types of A. sinensis, between those with broad decked eggs and those with narrow decked eggs. For example, Feng Lan-chou and others (1958) proposed the following points of differentiation on the basis of specimens taken from Hangchow: "Besides its large size, the adult female from the broad decked egg type of the A. sinensis also has coarse palpi, the two terminal white bands usually narrower, the black segment between the white bands wider and more distinct; black scales on wing dull and dirty-looking, white scales yellowish; large and distinct pale marks on corresponding margins along posterior branches of the 5th longitudinal vein; propleural bristles numerous, about 6-10; background color of abdominal sternites black, in clear contrast to pale marks. In the narrow decked egg type (small size) of the A. sinensis, this situation is reversed. Apart from a smaller size, the adult female has finer palpi, the two terminal white bands wider, the black segment in between much narrower, almost obscured by a seemingly single segment made up of the two white bands; black scales on wing blacker, and white scales whiter; none or only a few pale marks along corresponding margins of posterior branches of the 5th longitudinal vein; propleural bristles few, about 4-6; background color of abdominal sternites light, pale marks not noticeable." In suggesting these points for differentiation, Feng Lan-chou and others also pointed out great variations in change among them and the difficulty to clarify morphology on the basis of any one point. However, when considered together under most situations, these two types may be differentiated. To simplify mastery procedures, Ho Ch'i and others (1962) have suggested that the absence or presence of T-shape marks on the lateral abdominal conjunctivae be used as one condition of differentiation. That is, those mosquitoes with T-shape marks belong to the broad decked egg type of A. sinensis, while those without, belong to the narrow decked egg type. In our work, we have discovered that besides possible changes in this characteristic, the lateral conjunctivae are not discernible in specimens whose abdomen are no longer distended as the result of

blood having been digested or eggs having been laid, and there is no way to make an assessment on the basis of this characteristic.

It is obvious that at the present level of achievement, we do not have a simple and dependable method to differentiate adults from various types of the A. sinensis group. Because of this, we have made a comparative morphological study of adults from various types of the A. sinensis found in Kweichow Province, with the hope of finding some more dependable and less variable characteristics to meet actual needs.

Among the adult specimens we have examined are some females that have already laid eggs and some second generation mosquitoes reared from eggs. Repeated comparisons were made of these specimens, with particular attention to changes in morphological characteristics. On this point, detailed comparison of the mother mosquitoes and second generation mosquitoes reared from eggs the former laid provided important information. A total of 602 adult mosquitoes were examined. Among them, 226 were of the narrow decked egg type and 90 of the broad decked egg type, both taken from areas around people's houses; another 284 of the broad decked egg type of A. sinensis and two of the medium decked egg type were taken from cattle barns. A part of these specimens were obtained from Ts'ung-chiang (0654 3068) in eastern Kweichow Province and another part from P'ing-pa (1627 9741) in central Kweichow. Besides these specimens, we also examined specimens of A. kweiyangensis. While it is not too difficult to differentiate A. kweiyangensis, it is nevertheless included to eliminate confusion with the other types of A. sinensis.

II. Results

A. General description

Through assessment made after eggs have been laid, we discovered that there are four types to the A. sinensis found in Kweichow Province: that is, the broad decked egg type, the narrow decked egg type, the extremely narrow decked egg type, and the medium decked egg type. It must be pointed out that eggs of the A. kweiyangensis are very similar to those of the medium decked type.

Morphologically, adult females from the four types of the A. sinensis and A. kweiyangensis share the following characteristics: 1) Four white bands or rings to the palpus, the terminal white ring at the tip; 2) brown scale tufts on both sides of labial base; 3) all tarsi white-ringed, terminal end of legs black; 4) brown scale tuft on the 7th abdominal sternite. According to these common characteristics, these four types of the A. sinensis and A. kweiyangensis belong to the A.hyrcanus group described by Reid. As described by Reid, distribution of the A. hyrcanus group is quite extensive, covering an area that runs from Spain and southern France eastward

through the Middle East to eastern Siberia and southern Asia that includes India, China, and the Malay Archipelago, and finally to Australia. Because of this wide distribution and the complexity of group types, we take the approach held by Otsuru and others (1960) and call this group type found in Asia as the Anopheles sinensis group. For this reason, A. kweiyangensis is also included in this group type.

We do not expect to analyze in detail here the relative numbers of the four types of A. sinensis described above and A. kweiyangensis. However, experiences over the last few years show that their distribution in numbers vary according to locality. In localities of Kweichow where these several types are found in coexistence, about 40 percent of the mosquitoes found in peoples dwellings belong to the extremely narrow decked egg type, about 50 percent to the broad decked egg type, a few narrow decked egg type, and even fewer to the medium decked egg type and A. kweiyangensis. In cattle barns, more than 95 percent of the mosquitoes found belong to the broad decked egg type, very few to the medium decked egg type and A. kweiyangensis. Mosquitoes from the extremely narrow decked egg type and the narrow decked egg type of A. sinensis have not been found in cattle barns. In some places, no mosquitoes of the narrow decked egg type or the extremely narrow decked egg type of A. sinensis have been found, either in human dwellings or cattle barns.

B. Chief characteristics of adults

As reliable points of differentiation have not been found for extremely narrow decked and narrow decked egg types of A. sinensis, and most of those anopheles mosquitoes found in Kweichow Province belong to the extremely narrow decked egg type, the important characteristics for adult females from the extremely narrow decked egg type, the medium decked egg type, the broad decked egg type of A. sinensis and A. kweiyangensis only are now described in brief.

1. Broad decked egg type (large size):

1) Palpi: Hairy, about two-thirds the length of base. The 1st and 2nd white rings from the terminal end mostly narrow, the black segment between them wider. In some, the two white rings or bands merge, but such specimens are rare. The 3rd and 4th white rings are very narrow. Light colored scales cover the inner-lateral margin in the 4th ring. 2) Wings: A few light colored scales are scattered on the section from the costal vein at the wing-base to the pale mark of subcostal vein. The pale white marks at the subcostal vein and pre-apex are large. Occasionally, a few light colored scales are found along the subcostal vein. The humoral cross vein is usually scaled. White scales are noted on the anterior margin and black scales on the posterior margin of the remigium located on the inner aspect of the base of the 1st vein. Black and white scales mix at the base of the 1st longitudinal vein. The size, completeness, and

variations in pale white marks between branching veins are great. The medial pale mark and the subcostal pale mark merge, with white scales extending half into the black area between the subcostal and pre-apical pale marks. Terminal fringe markings extend from the 1st longitudinal vein to lobe between the 3rd and 4th longitudinal veins. White pale marks on corresponding margins of posterior branches of the 5th longitudinal vein vary in size, sometimes, though rarely, lacking. 3) Legs: The medial and posterior coxae show distinct white scale tufts on the outer edges, with a few white scales scattered on the upper anterior surface of the anterior coxae. Narrow white rings are noted at tips of the 1st to 4th tarsi of the posterior legs. 4) Brown scale tuft on the 7th abdominal sternite is larger.

2. Extremely narrow decked egg type (small size):

The chief characteristics described below are also applicable to adult females of the narrow decked egg type of A. sinensis, because reliable differences between the two have yet to be discovered. 1) Palpi: External appearance less plumose, only base distinct. The 1st and 2nd white rings from the terminal end are mostly wide, the black segment between them usually narrow, sometimes so narrow that the two white rings seem to merge. The other two white rings are narrower, and few light colored scales cover an inner edge section in the 4th white ring. 2) Wings: The section from the costal vein at the wing-base to the subcostal pale mark is black. The pale white mark at the subcostal vein and the pre-apical mark are both smaller than those found in the broad decked egg type. There are no scales on the humoral cross vein, and the remigium is similar to that in the larger type in that black and white scales are both present. The 1st longitudinal vein has four white cells. Beginning at the base, the 1st and 3rd cells are larger than the 2nd and 4th cells. The white cell at the base of the 1st longitudinal vein is covered by a few scattered black scales. Pale marks at the branching veins are usually small and incomplete, the medial pale mark usually merging with the subcostal pale mark, with white scales extending more than halfway into the black area between the subcostal and pre-apical pale marks. Terminal fringe markings extend from the 1st longitudinal vein to the area between the 3rd and 4th longitudinal veins. White pale marks on corresponding margins of posterior branches of the 5th longitudinal vein are lacking or very few if present, though specimens with the latter feature are rarely seen. 3) Legs: Very few or no white scales on the anterior surface of the anterior coxae, no white scale tufts on the outer edges of the medial coxae, though a few black or colored scales may be present sometimes, and hardly any scales have been noted on the outer edges of the posterior coxae. Narrow white rings are noted at tips of the 1st to 4th tarsi of the posterior legs. 4) Brown scale tuft on the 7th abdominal sternite is small.

3. Medium decked egg type:

1) Palpi: Distinctly plumose near base. The 1st and 2nd white rings from the tip are narrow, the 3rd white ring the widest, and

the 4th white ring the narrowest. Light scales are noted on the inner aspect of the base, and the black segment between the white rings is also covered with white scales sometimes. 2) Wings: The black section that runs from the costal vein at wing-base to the white pale mark of the subcostal vein is covered by a few light colored scales sometimes. There are no scales on the humoral cross vein. A patch of all white scales cover the remigium and the base section of the 1st longitudinal vein, pale marks of the branching veins are large, the medial white pale mark is not clearly separated from the subcostal vein pale mark, and white scales extend about halfway into the black area between the subcostal and pre-apical plae marks. White terminal fringe markings extend from the 1st longitudinal vein to the space between the 3rd and 4th longitudinal veins. White pale marks on corresponding margins of posterior branches of the 5th longitudinal vein may be noted, but variations in size and presence are great. 3) Legs: White scale tufts are very distinct on the outer edges of the medial and posterior coxae, with some white scales also noted on the anterior upper surface of the anterior legs. Narrow and light colored rings are noted at tips of the 1st to 4th tarsi of the posterior legs. 4) Size of the brown scale tuft on the 7th abdominal sternite approximates that in the broad decked egg type.

4. Anopheles kweiyangensis:

1) Palpi: External appearance plumose, practically the whole length of palpus. The four white rings are all narrow, color dull. White scales are noted on inner edge of palpal base. 2) Wings: A small humeral pale mark and a few scattered light colored scales are noted at the base of the costal vein, though the section from the subcostal vein pale mark to the pre-apical pale mark is black. The pre-apical pale mark is large, and scales on the humerus cross vein are absent. Black and white scales cover the remigium, though in most cases, black scales are more numerous at the distal end. At the base of the 1st longitudinal vein is a black spot that is separated from the black mark in front of the branching veins by a white pale mark interspersed with black scales. Between the medial white pale mark and the subcostal vein pale mark is a successive distribution of white scales that very seldom extend into the black section beyond the subcostal vein pale mark. Terminal fringe marks extend from the 1st to 3rd longitudinal veins, marginal white spots are noted in corresponding places of the posterior branches of the 5th longitudinal vein, and three black spots are noted on the 6th longitudinal vein. 3) Legs: White scale tufts are noted on the outer edges of the medial and posterior coxae, with some white scales seen on the anterior upper surface of the anterior coxae. White rings are at tips of the 1st to 4th tarsi in the hind legs. 4) Brown scale tuft on the 7th abdominal sternite is fairly large.

According to the chief characteristics of the adult mosquitoes described above, the following key for identification is prepared:

1. Wing with terminal pale mark, pre-apical pale mark, subcostal vein pale mark, humeral pale mark, and 3 black spots on the 6th longitudinal vein ..... A. kweiyangensis
   Wing with terminal pale mark, pre-apical pale mark, subcostal vein pale mark, no humeral pale mark, and with 2 black spots on the 6th longitudinal vein 2
2. Medial and posterior coxae with no white scale tufts on outer edges ..... Extremely narrow decked egg type of A. sinensis and narrow decked egg type of A. sinensis
   Medial and posterior coxae with white scale tufts on outer edges 3
3. Palpus most wide at 3rd white ring from tip, remigium and base of 1st longitudinal vein covered completely by white scales .... Medium decked egg type of A. sinensis
   Palpus with 4 white rings about equal width, the 3rd and 4th white rings of equal width at least, and remigium and base of 1st longitudinal vein covered by black and white scales .... Broad decked egg type of A. sinensis

III. Discussion and Conclusion

Since 1936 when Baisas and Hu proposed inclusion of several anopheline species similar to A. sinensis (sinensis, lesteri, pseudosinensis, nigerrimus, williamsoni) and A. lesteri into one group, more detailed studies of this group have been made by Reid (1953, 1963) in Malaya and Otsuru and Ohmori (1960) in Japan. In China, especially in areas south of the Yangtze River, numerous studies have also been reported in recent years on A. sinensis types. Not only do different types of A. sinensis prevail widely in provinces along the lower reaches of the Yangtze River, they also exist in Kweichow Province (Feng Lu-pai, 1962). Because adult variations among members of the various types of A. sinensis are great, differentiation is also difficult. For this reason, we have compared the five types found in Kweichow (including A. kweiyangensis) represented more specifically by the adult females, in an effort to find some more reliable differentiation characteristics.

According to some characteristics listed by this article, female mosquitoes from various types of A. sinensis including A. kweiyangensis, may very distinctly be divided into two large groups:

1. The broad decked egg type of A. sinensis, A. kweiyangensis, and the medium decked egg type of A. sinensis. The individual body size of mosquitoes from this group is larger, there are very distinct white scale tufts on the outer edges of the medial and posterior coxae, the wedge-shaped pale marks on the abdominal sternites are very marked, and the brown scale tuft on the 7th abdominal sternite is large and noticeable.

2. The narrow decked and extremely narrow decked egg types of A. sinensis. Individual body size of mosquitoes from this group is smaller, no white scale tufts are noted at outer coxae, the wedge-shaped pale marks on the abdominal sternites are not noticeable, and the brown scale tuft on the 7th abdominal sternite is small. However, features distinguishing the extremely narrow decked egg type from the narrow decked egg type are still to be uncovered.

Besides these characteristics, these two groups can also be differiated according to the morphology of their eggs. For example, in the first group, the decks of the broad decked egg type eggs are widest, while the decks of eggs from A. kweiyangensis and the medium decked egg type are almost the same in width. The second group that includes the narrow decked and extremely narrow decked egg types have eggs with decks much narrower than those in the other group, and marginal deck structure that is also quite different.

Whether these different types of A. sinensis constitute a species problem and whether there is a correlation between these and species reported in the foreign literature, we feel such determinations are difficult before detailed morphologic studies are made of various phases in the life histories of these mosquitoes. This author has compared the broad decked egg type, the medium decked egg type, the extremely narrow decked egg type, and the narrow decked egg type of the A. sinensis separately with A. lesteri found in Japan (Otsuru, 1960), A. lesteri found in the Phillipines (Baisas, 1936), A. lesteri found in Malaya (Reid, 1953), and A. sinensis (none in the Phillipines) and Yatsushiroensis of Japan etc., that are described by these foreign investigators, in detail, and finds that there are differences in many characteristics such as the palpi and scale distribution along wing veins. While it is hard to say if these differences are due to geographic factors, the existence of different species or subspecies is very possible. For example, Reid has reported from Malaya that A. lesteri found there has been named A. lesteri paraliae by Sandosham (1959). And A. pseudosinensis that was recognized as such by Reid hasalso been grouped by Baisas as A. lesteri pseudosinensis. Whether the narrow decked egg type of A. sinensis (including the extremely narrow decked egg type) as found in China may be related to any of the foreign A. lesteri, characteristics such as narrow pale mark at wing tip of A. lesteri paraliae of Malaya, its main feeding on oxen blood, and breeding along salty coastal areas show it to be different. Besides some morphological differences, A. lesteri from the Phillipines and Japan breed mainly along beach areas and the relationship with man is not great. These characteristics make them different from the narrow decked egg type of A. sinensis.

For this reason, we feel that different types of the A. sinensis group in China must be studied in greater depth and detail before their position in the classification scheme can be determined.

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