The *Anopheles hyrcanus* Group in Indonesia

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ABSTRACT. Notes on the taxonomy, distribution, habits and vectorial status of the 7 known members of the *An. hyrcanus* group in Indonesia are presented, including an illustrated key and distributional maps.

INTRODUCTION

In spite of recent comprehensive studies to clarify the taxonomic status of the known species of the *An. hyrcanus* group in southeast Asia, considerable confusion still exists with regard to these similar-looking mosquitoes in Indonesia. This is particularly apparent in the Malaria Control Service where large, dark-winged anophelines exhibiting pale bands on the palps, dark lateral scale tufts on the clypeus and a dark scale tuft on abdominal sternite VII are still frequently classified merely as "*An. hyrcanus* group."

Efficient malaria control operations are based on a knowledge of the biology of the vector, but one must be able to identify the mosquito involved before studies of the life history and habits can be instituted. Malaria control activities are presently being expanded into areas of Indonesia where information regarding not only vector biology, but even vector identity, is lacking. Therefore, the ability to correctly identify the mosquito fauna of these areas is of paramount importance. For these reasons, a study of the taxonomy and distribution of this difficult and variable group in Indonesia was undertaken between 1975 and 1978.

Reid's exhaustive works on southeast Asian anophelines (1953, 1968) plus the more recent work on the subgenus *Anopheles* in Thailand (Harrison and Scanlon, 1975) have provided the background for the results reported here. In general, the morphological characters ascribed to these species in Malaysia and Thailand by the above authors are in accord with those found on Indonesian specimens. A total of 16 to 18 taxonomic features was examined on some 825 mosquitoes from the 21 provinces of Indonesia in which members of this group were encountered. A further 800-900 specimens from various provinces were checked but were not examined for all of the previously-mentioned taxonomic features. Both groups were exclusively field-captured adults.

For the purposes of a gross separation of the seven members of the *An. hyrcanus* group so far reported from Indonesia, 2 forms may be described: one

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displaying a narrow pale band on the third hind tarsal segment, which does not cross to the base of the fourth segment and the other exhibiting a wide pale band on the third tarsal segment, which crosses to the base of the fourth segment. The former, *sinensis*-form, includes *sinensis, crawfordi* and *lesteri paraliae*. The latter, *nigerrimus*-form, includes *nigerrimus, nitidus, pedi-taeniatus* and *argyropus*. This representation is the same as reported for Malaysia (Reid, 1953, 1968) and Thailand (Harrison and Scanlon, 1975) except that *pursati* does not appear to be present in Indonesia.

This is a highly variable group of closely related species, some of which show distinct geographical differences. Therefore, the diagnostic features presented in the key couplets are somewhat detailed. Complete descriptions are found in Reid (1953, 1968) and Harrison and Scanlon (1975).

Key to Females

A key to the females of the *An. hyrcanus* group in Indonesia is presented below. Illustrations of the characters cited are provided in Annex 1.

1. Hind tarsi with narrow apical pale bands, segment 4 without basal pale band (*sinensis*-form) (Fig. 1a) 2

\- Hind tarsi with moderate to very broad pale bands, segment 4 with basal pale band (*nigerrimus*-form) (Fig. 1b, c) 4

2.(1) Basal dark mark on vein 5 long, separated by less than its own length from the upper dark mark on vein 6 (Fig. 3a); mid-coxae without pale scales (Fig. 2a, b); humeral cross vein without scales (Fig. 5b); apical fringe spot narrow, extending at most from 1 to 2.2, but usually at 2.1 only (Fig. 7b) . . . . . *lesteri paraliae*

\- Basal dark mark on vein 5 short, separated by at least its own length from the upper dark mark on vein 6 (Fig. 4a); at least a few lower mid-coxal pale scales (Fig. 2d); apical fringe spot wide, extending from 1 or 2.1 to beyond 3 (Fig. 7a) 3

3.(2) Wing pattern sharp, dark marks short and well-defined (Fig. 4); tip of vein 1 pale (Fig. 4c); upper mid-coxae without pale scales (Fig. 2a); humeral cross vein bare or with only 1 or 2 scales (Fig. 5b, d); apical fringe spot of medium width, from 2.1 to beyond 3 (Fig. 4d); preapical dark mark on vein 1 without pale scales (Fig. 4b) . . . . . *crawfordi*

- Wing pattern blurred, dark marks longer with scattered dark scales (Fig. 3); tip of vein 1 dark (Fig. 3c); with upper and lower mid-coxal pale scales (Fig. 2c, d); humeral cross vein with more than 2 scales (Fig. 5e); apical fringe spot long, from 1 to beyond 3 (Fig. 3d); preapical dark mark on vein 1 with some pale scales (Fig. 3b) . . . . . *sinensis*

4.(1) Wing pattern sharp, dark marks short and well-defined (Fig. 4); basal dark mark on vein 5 short, separated by at least its own length from the upper dark mark on vein 6 (Fig. 4a); usually with small humeral pale spot (Fig. 3f); basal half of costa with pale scales (Fig. 3g) . . . . . *nitidus*

- Wing pattern blurred, dark marks longer with scattered dark scales (Fig. 3); basal dark mark on vein 5 long, separated by less than its own length from the upper dark mark on vein 6 (Fig. 3a); without humeral pale spot (Fig. 4f); basal half of costa without pale scales (Fig. 4g) (except *nigerrimus*, see following text) 5

5.(4) Humeral cross vein without scales (Fig. 5b); anterior surface of remigium with a line of pale scales (Fig. 5c); preapical dark mark on vein 1 with pale scales, usually numerous (Fig. 3b) . . . . . *peditaeniatus*

- Humeral cross vein with scales (Fig. 5e); anterior surface of remigium without a line of pale scales (Fig. 5a); preapical dark mark on vein 1 without pale scales or with very few (Fig. 4b) 6

6.(5) Posterior corners of tergite VIII with a few narrow scales among the setae (Fig. 6a); with upper and lower mid-coxal pale scales (Fig. 2c, d); third pale band on hind tarsi equal or subequal to segment 5 (Fig. 1b); often with a fringe spot at vein 5.2 (Fig. 3e) . . . . . *nigerrimus*

- Posterior corners of tergite VIII without narrow scales among the setae (Fig. 6b); mid-coxae without pale scales (Fig. 2a, b); third pale band on hind tarsi considerably longer than segment 5 (Fig. 1c); no fringe spot at vein 5.2 (Fig. 4e) . . . . . *argyropus*

Experience has shown that occasional specimens of *nitidus* with an atypical wing pattern (somewhat blurred with a moderate basal dark mark on vein 5) may be confused with *nigerrimus*, since both display humeral cross vein scales, narrow scales on tergite VIII, upper and lower mid-coxal scales and scattered pale scales on the basal half of the costa. Further examination will show that the former species has dark mesonotal eye spots while those of the latter are subdued and the former species usually exhibits 1-4 propleural setae, seldom 5, while the latter shows 5-10, seldom less than 6. Also, there is usually a

greater number of the scattered pale scales in the basal half of the costa of *nitidus;* a few pale scales are found on only some 50% of the *nigerrimus,* while the presence of more numerous pale scales is practically a constant feature with *nitidus.*

A number of authors have noted that the *nigerrimus* of Java are generally darker than those from Malaysia and India and have suggested that the name *venhuisi* is available if further study justifies a subspecific differentiation (Reid, 1953, 1968 and Harrison, 1972). The only members of this species from outside Indonesia which I have examined were 16 specimens from Thailand. It was observed that they usually exhibited basal and apical dark marks on vein 6 of equal length with no dark scales among the pale scales separating them, while those from Indonesia generally display an apical dark mark as much as twice the length of the basal dark and have a few dark scales scattered between them. Also, there were usually considerably fewer dark scales among the pale ones on vein 5.1 in the Thailand specimens. On the other hand, there was no consistent difference in the number of pale scales found in the basal 1/3 of the costa and vein 1.

The insignificant and inconsistent differences observed in these specimens from Thailand and Indonesia hardly warrant the establishment of subspecific ranking. Moreover, the variability in a number of morphological characters in adults of this species, not only from different parts of the country, but also among specimens within a series collected concomitantly, only serves to reinforce this position. A study of the other life stages of *nigerrimus* may reveal reliable differences in morphology upon which further division may be based, but on characters of the adult female only, this action does not seem justified.

Both Reid (1953, 1968) and Harrison and Scanlon (1975) have observed that a proportion of the specimens of *nigerrimus* lack a pale basal band on hind tarsal segment 4, thus resulting in a *sinensis*-like pattern of apical pale bands only. The former author notes that about 5% exhibit this configuration, while the latter authors calculate a figure of 19%. In Indonesia, this phenomenon is encountered with much lower frequency, as can be seen in Table 1. In Sumatera, Java, Kalimantan (Borneo) and Sulawesi (Celebes), the percentages of *nigerrimus* displaying only an apical pale band on segment 3 with no basal band or patch on segment 4 were 1.8 (169 specimens), 0 (116 specimens), 2.5 (447 specimens) and 2.7 (74 specimens), respectively. A basal pale band or patch on segment 5 as well as on segment 4 would appear to be a more common feature of Indonesian *nigerrimus* than of this species in Thailand. Harrison and Scanlon (1975) observed this pattern on only 33% of their sample, while 71.3% of Indonesian specimens showed it.

TABLE 1

Location	% *An. nigerrimus* without basal pale bands or patches on tarsi	% *An. nigerrimus* with basal pale bands or patches on tarsal segment 4 and 5	% *An. nigerrimus* with basal pale bands or patches on tarsal segment 4 only
Sumatera (169)[1]	1.8	80.5	17.8
Java (116)	0	91.4	8.6
Kalimantan (447)	2.5	64.0	33.5
Sulawesi (74)	2.7	63.5	33.8
Total (806)	Av. 2.0	71.3	26.7

[1]Numbers examined in parentheses.

There should be no taxonomic problems with the few individuals of *nigerrimus* lacking pale bands or patches on the base of hind tarsal segment 4. On these, the apical band on segment 3 is, on a proportional basis to overall segment length, clearly broader than on the 3 *sinensis*-form species.

DISTRIBUTION

The distribution of members of the *An. hyrcanus* group examined during this study is presented in Annex 2, in which the islands, with divisions by province, are listed in a general west to east orientation. Maps 1 and 2, show Indonesia divided into areas west and east of the Wallace Line. Weber's Line, proposed by Mayr (1944) as the most representative boundary between the Oriental and Australian faunas, is shown on Map 2. The distributions noted here appear to bear out Reid's (1953) zoogeographical appraisal of this group. He refers to the Malay Peninsula, Sumatera and Kalimantan (Borneo) as the endemic center for the species other than *sinensis* and notes the reduction in the number of species encountered as one moves eastward. Clearly, Sumatera and Kalimantan exhibit the most abundant *hyrcanus* group fauna in Indonesia. The paucity of species

reported here from Central Kalimantan is merely a reflection of the few collections conducted. Other than 3 *peditaeniatus* females captured in a light trap on Lombok in May 1978, limited recent collections by national and international entomologists in the Lesser Sunda Islands of Bali, Flores and Timor and at several sites in Maluku (Moluccas) Province have not revealed the presence of members of the *hyrcanus* group.

Relatively recent geologic events may be responsible for much of this distribution. During the Pleistocene epoch, the advance and retreat of the great glaciers resulted in considerable fluctuations in the level of the sea. During these most recent periods of glaciation, when large quantities of the earth's water were bound up in ice, the sea level fell between 100 and 200 meters and the Sunda shelf, upon which Sumatera, Borneo (Kalimantan), Java and Bali are located, became an extension of the mainland (Mayr, 1944). Under these circumstances, the eastward migration of continental species was facilitated. However, further eastward movement was hindered by the perpetual water barrier which existed in the deep straits between Kalimantan and Sulawesi and between Bali and Lombok.

The comparative lack of species encountered on Java may be the result of several factors. Both Zeuner (1941) and Mayr (1944) cite the peripheral location of this island with regard to the mainland and its transitional status, with reduced humidity and habitats, between the tropical rain forest climate to the west and areas of pronounced dry season to the east. The latter author also feels that extreme volcanic activity, characteristic of Java, could have resulted in the disappearance of localized species. Certainly the effects of economic development, primarily intensive agriculture, and the destruction of the swampy habitats preferred by the group must be considered. For example, as recently as 1970, *peditaeniatus* was collected in light traps in the CDC compound in Jakarta, but with the disappearance of the swamp area habitats concomitant with housing development, the species can no longer be found there (Soeroto, 1975). On Bali, an island only some 5% the size of Java, cultivation and associated habitat destruction have been even more intense.

These data most probably do not represent the complete range of the species involved since there are literature citations referring to collections farther east in both the Greater and Lesser Sunda Islands. However, Bonne-Wepster and Swellengrebel (1953) and Reid (1953) mention the unreliability of some of these earlier species records.

The following is a list of the *An. hyrcanus* group species in Indonesia, with relevant distributional notes:

An. lesteri paraliae. The Sumatera and Kalimantan collections represent the first records of this species in Indonesia, although it has been reported from East Malaysia and Brunei (Harrison and Scanlon, 1975).

An. crawfordi. A widespread but localized species in Sumatera which has, so far, been found at only 1 site in Java. It exhibits an unusual distribution in that it is present in a number of localities in Sulawesi but has yet to be reported from Kalimantan. No immature stages were examined, but adults from the various islands are indistinguishable.

An. sinensis. This species has been found in Sumatera and West Kalimantan. The latter is the easternmost record in the archipelago for which known specimens are extant. Brug and Bonne-Wepster (1947) refer to collections as far east as Buru Island in Maluku, but these are open to question. Reid (1968) states that it is "apparently absent from Borneo and Java and the rest of the archipelago including the Philippines." A reference to Java in Harrison (1973) is termed an error by Harrison and Scanlon (1975). Knight and Stone (1977) mention no distribution east of Sumatera.

An. nitidus. Fairly widespread in Sumatera and further collections may well establish a wider range for this species in Kalimantan. Records for Java and Sulawesi attributed to Reid (1953) by Bonne-Wepster and Swellengrebel (1953) are misquotes.

An. peditaeniatus. With *nigerrimus*, the most widespread species in Indonesia. Further collecting will almost certainly fill in the gaps in the distribution shown in Annex 2.

An. nigerrimus. This common species can be abundant at times. Two females from Buru Island in Maluku examined by Reid (1953) at the Institute for Tropical Hygiene in Amsterdam represent the easternmost extension of the *hyrcanus* group in Indonesia.

An. argyropus. An extremely localized and limited species, only 10 specimens having been examined during the course of this study. Reid (1953) viewed 3 females from Jakarta and 4 from Cirebon in West Java, but in spite of many collections in recent times, particularly near the former locality, only 1 specimen has been encountered. This was near Bekasi, some 20 km east of Jakarta. Brug and Bonne-Wepster (1947) record captures of *argyropus* (under the name *pseudopicta*) from Alor and Timor Islands in East Nusatenggara and Ternate Island in Maluku, although Reid (1953) mentions that it may have been *peditaeniatus* with unusually broad tarsal bands. In view of the rather ubiquitous nature of the latter species, Reid's appraisal would appear correct. On the other hand, Steffan (1966), in his checklist of mosquitoes from the Papuan Sub-region in which he includes Maluku and Timor, makes no mention of the *hyrcanus* group.

Habits and Vectorial Improtance

In general, the members of the *hyrcanus* group are swamp, swampy rice field and seepage breeders, with *sinensis* most commonly found in rice fields. Lowland fresh water habitats are the rule, although *crawfordi* can be found in forested foothills and *lesteri paraliae*, a coastal species, sometimes utilizes brackish water breeding sites. The group exhibits a preference for relatively deep, cool water, except for *sinensis* and *peditaeniatus*. Shading requirements vary. While *nigerrimus* and *lesteri paraliae* are the most tolerant, being found in sun to moderate shade, the remainder are more limited. *Sinensis* and *peditaeniatus* are sun-loving, while *nitidus*, *crawfordi* and *argyropus* incline toward moderate, even deep, shade. Emergent and/or floating vegetation is a constant feature of these habitats.

Under normal circumstances, these species are predominantly exophilic and zoophilic, with a distinct preference for water buffalo and cattle. These characteristics are particularly evident with the species other than *nigerrimus*, which will sometimes enter houses to bite man. However, host availability definitely influences feeding behavior. For example, in 1975, *peditaeniatus* were particularly aggressive during a human bait collection at a village on the Asahan River in North Sumatera Province where cattle had been removed and pigs were the only remaining livestock.

Early literature citations clearly implicate this group in malaria transmission. Van Hell (1950) presents a review of natural infection indices of stomach and thoracic fluid examinations between 1931 and 1947 from *An. (An.) hyrcanus* var. X (now *nigerrimus*), *An. (An.) hyrcanus* var. *nigerrimus* (now *peditaeniatus*) and *An. (An.) hyrcanus sinensis* in various regions of Indonesia. He calculates a combined natural infection index for var. X of 3.6% (3,914 dissections), for "*nigerrimus*" of 3.4% (1,012) and for *sinensis* of 2.4% (505). The highest individual indices, 9.5% (587) and 9.9% (466), occurred in 1939 with var. X during malaria outbreaks in Sulawesi and East Java. These figures represent both stomach and thoracic fluid examinations, the latter providing 1.4% and 0.9% of the above indices, respectively. A record of 1 positive stomach in 39 dissections of "*sinensis*" from Panamukan, West Java in 1934, is open to question since this species has not been reported form Java subsequent to Reid (1953).

Currently, the assignment of vectorial importance to a particular species of the *hyrcanus* group in Indonesia is risky because almost all of the investigations incriminating vectors were conducted prior to Reid's (1953) resolution of the taxonomic position of these mosquitoes. This situation has been commented upon by a number of authors (Bonne-Wepster and Swellengrebel, 1953, Harrison and Scanlon, 1975 and Reid, 1968).

Accordingly, further investigations are needed to clarify the status of the various species of the group, especially in the Greater Sunda Islands other than Java where they constitute a threat by virtue of wider distribution and higher density.

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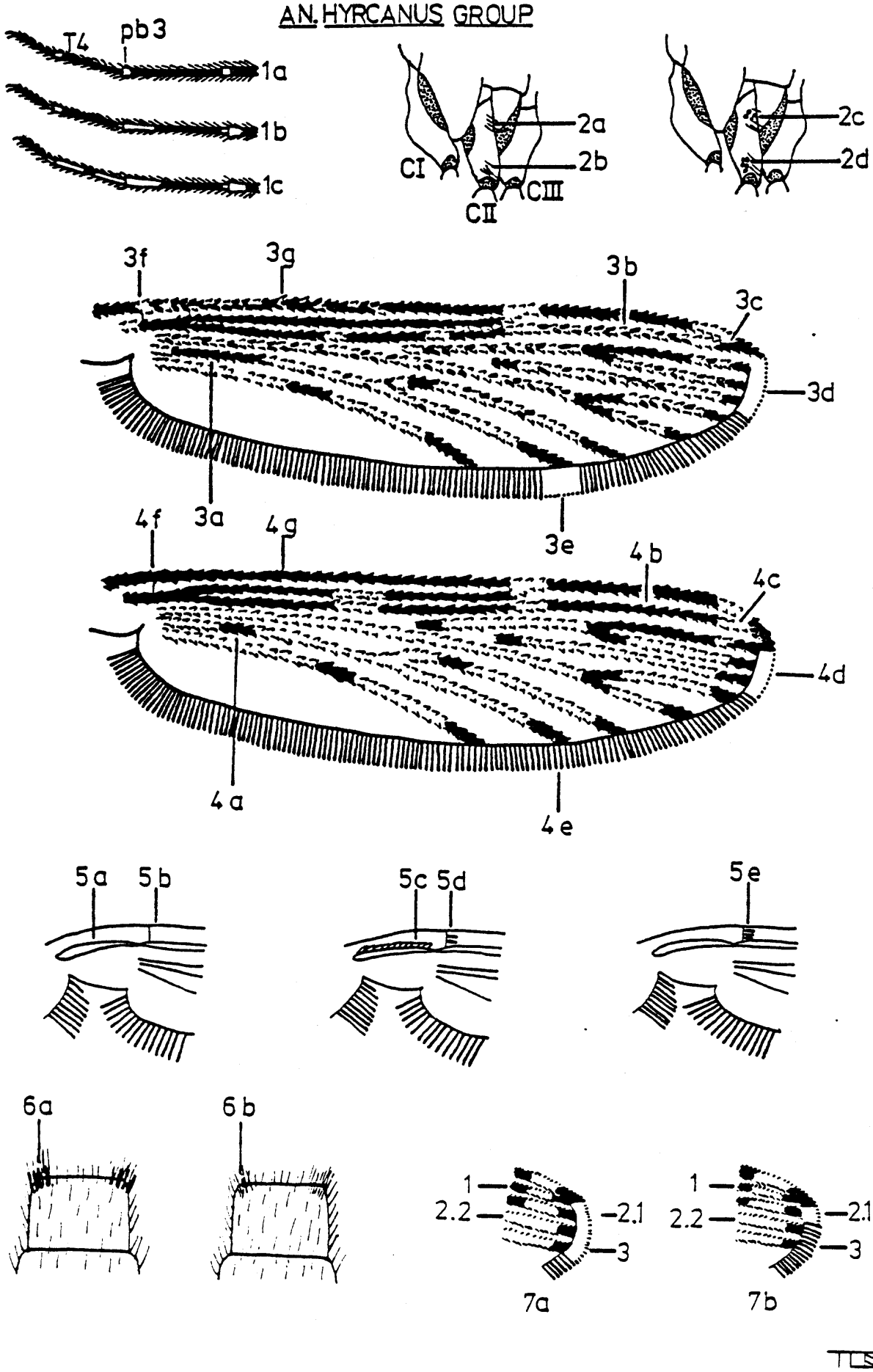
ANNEX 1

AN. HYRCANUS GROUP

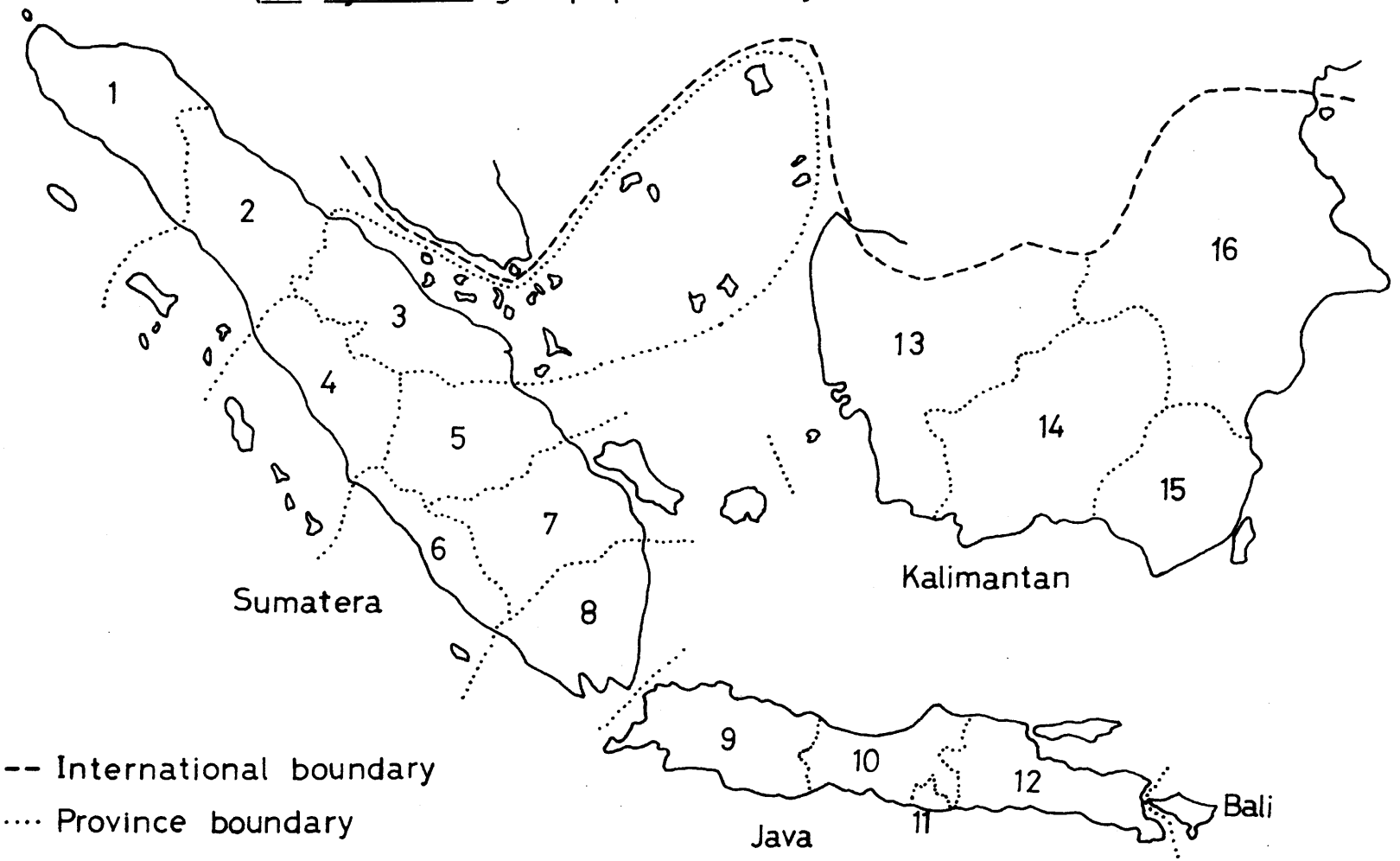


Annex 2

Distribution, by province, of the *An. hyrcanus* group in Indonesia examined during this study

ISLAND / Province	*An. hyrcanus* species						
	peditaeniatus	*nigerrimus*	*crawfordi*	*nitidus*	*sinensis*	*lesteri paraliae*	*argyropus*
SUMATERA							
1. Aceh	+	+		+	+	+	+
2. North	+	+	+	+	+		+
3. Riau		+		+	+	+	
4. West	+	+	+	+			
5. Jambi	+	+	+	+			
6. Bengkulu	+	+	+	+	+		+
7. South	+	+	+	+			+
8. Lampung	+	+	+	+			
JAVA							
9. West (Incl. Jakarta)	+	+	+				+
10. Central	+	+					
11. Yogyakarta		+					
12. East	+	+					
KALIMANTAN							
13. West	+	+		+	+	+	
14. Central		+					
15. South	+	+		+		+	
16. East	+	+		+			
SULAWESI							
17. North	+						
18. Central	+		+				
19. South	+	+	+				
20. Southeast	+	+	+				
LOMBOK							
21. West Nusa Tenggara	+						

Map 1. Indonesia West of the Wallace Line
(An. hyrcanus group present only in numbered provinces)



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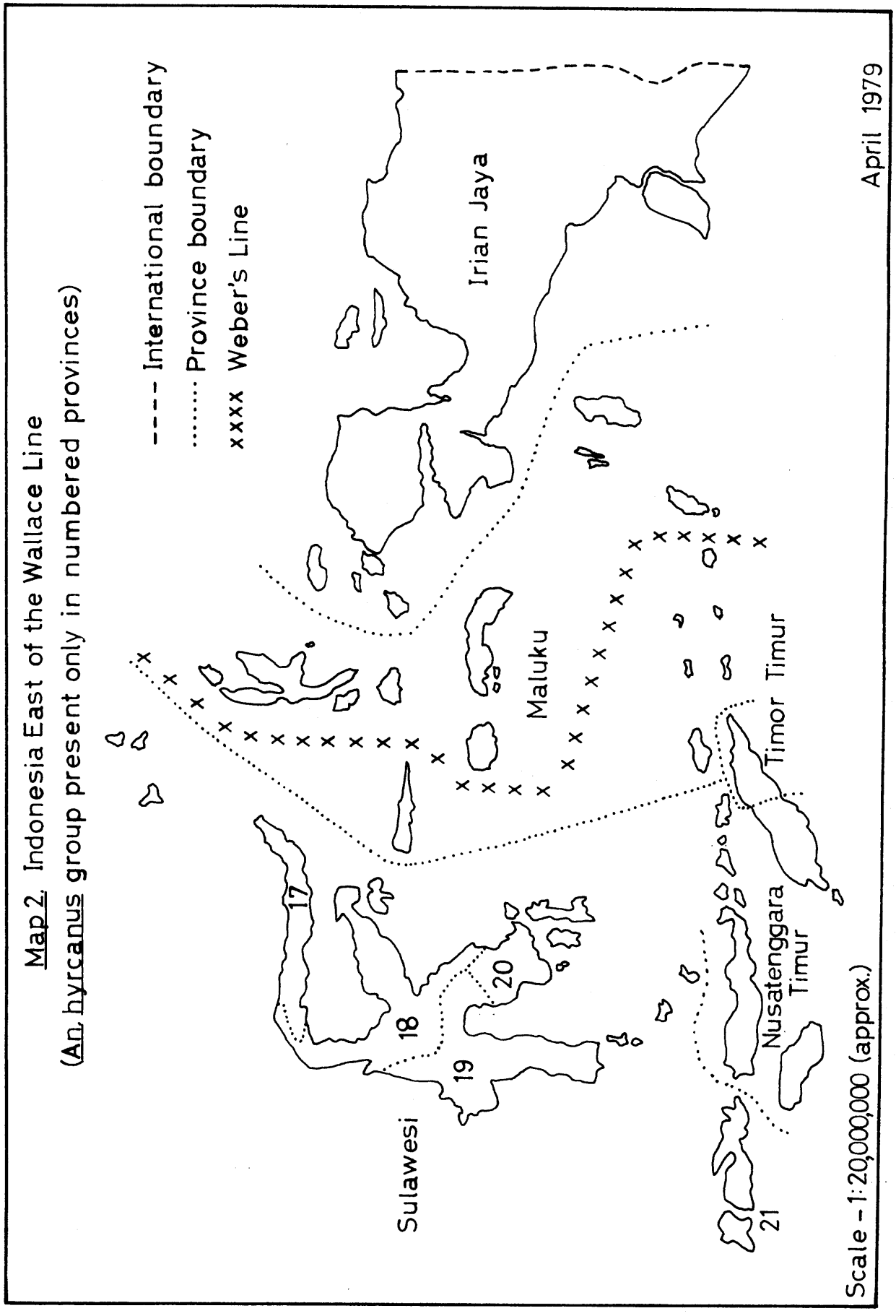
April 1979


Map 2. Indonesia East of the Wallace Line
(An. hyrcanus group present only in numbered provinces)
---- International boundary
..... Province boundary
xxxx Weber's Line
Irian Jaya
Maluku
Timor Timur
Nusatenggara Timur
Sulawesi
17
18
19
20
21
April 1979
Scale - 1:20,000,000 (approx.)