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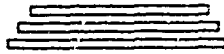
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(E.I. Martsinovskiy Institute of Medical Parasitology and Tropical Medicine, Min. Health USSR, and Institute of Malaria, Min. Health, Dem. Rep. Viet Nam)

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(submitted 20/K.:/61)



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STUDIES IN MALARIA EPIDEMIOLOGY IN NORTH VIET NAM. 2. TOPOGRAPHICAL MALARIOLOGICAL
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In comparison with the other provinces of North Viet Nam, the autonomous district of Thai Meo which occupies the northwestern, most-alpine part of the country (Fig. 1) was explored by malariologists only recently and on a very limited scale.

In Tumanov's monograph on the distribution of the anopheles mosquito in Viet Nam (1936), there are no indications for an epidemiological exploration of the huge Thai Meo territory. Pons (1943), while studying the malaria problem in North Viet Nam in the ethnographic aspect, pointed to some interesting features specific to the spread of malaria in Thai Meo but without sufficient factual data. In October, 1956, a detachment of Soviet specialists head by docent G.A. Pravikov examined about 2000 inhabitants of the city of Tuan Chou (the center of the district) and two villages in its environs; in addition, entomological collections were also made.

The absence of circumstantial data on the distribution of the Anopheles and malaria in Thai Meo and also the doubtfulness of the pronouncements by Pons concerning the features specific to the populations of this district (Thai, Meo, et al.) with respect to their sensitivity to malaria aroused us to undertake a reconnaissance investigation of the villages situated along the road from Moc Chou to Myong Lai and from Tuan Ziao to Dien Bien Phu. In this work we found 3 topographical-malariological zones on Thai Meo territory two of which, mountain-river and alpine are similar to the corresponding zones in the Thai Nguyen province. (see the report by A. Ya. Lysenko, Dang Van Ngy, Ho Van Hyu, Dang Tung Tha, *Med. Parazitol. i parazitarn. bol.*, 1961, No. 3). One is flat-mountainous and was identified by us first of all. For purposes of determining more accurately the boundaries of these zones and to make a more penetrating study of

them, in July and October of 1958, an extensive investigation of the population of Thai Meo was undertaken according to a program and along routes especially developed by us. The investigation was performed by a group of medics from the Institute of Malaria of the Ministry of Health of the DRV and the District Department of Public Health (group leader Nguyen Tien Byu).

ROUTES, TECHNIQUES AND SCOPE OF THE EXPLORATION

The settlements of the inhabitants of Thai Meo are situated chiefly in the narrow valleys along the rivers Song Da and Song Ma and in the path formed by a limestone plateau between the ridges Sipsong Cho Thai on the west and Hoang Lien Chon and Sa Fin on the east. The river valleys, characterized by a hot climate, are inhabited almost exclusively by the Thai nationality, while the poorly watered cooler plateaus are inhabited predominantly by the Meo nationality. The mountain slopes along the sides of the valley and the inter-mountain synclines (Ngia Lo, Cuang Guy, et al.) are inhabited by the other nationalities of the district: Myong, Sa, Man. The routes followed by the exploration were marked out in such a way that they passed through inhabited points situated in all of the basic topographical areas of Thai Meo (see Fig. 1).

The technique of the explorations was basically the same as was mentioned in our first report. However, special attention was given to the collection of anamnestic data among the inhabitants of Meo nationality. During a period of 3 months it was possible for us to investigate the inhabitants of 299 villages belong to 65 communities (9 of 13) from the different regions of the district (table 1).

During the course of the investigation, a study was made of the spleens of 28,908 persons (8.3% of all the inhabitants of the district) and thick-drop blood

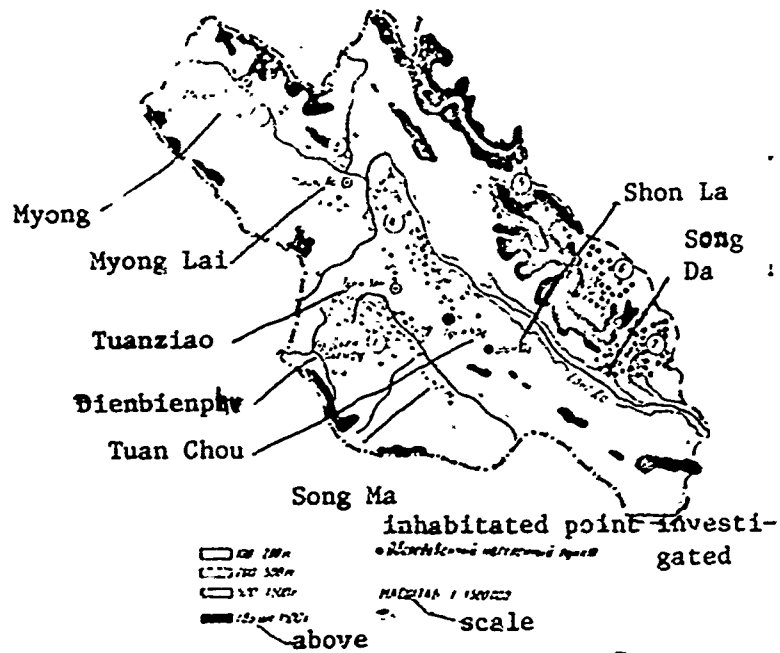


Fig. 1. Hypsometric map of the autonomous district of Thai Meo and the routes of the exploration.

Table 1. Number of inhabitants of different nationalities (ethnic groups) covered by the investigation.

Nationality	Number of Villages	Number of Inhabitants Studied
Mec.....	..	12 080
Thai.....	>	8 387
Sa.....	?	2 205
Man.....	.	1 988
Myong.....	13	1 396
Total.....	248	26 656

preparations were made from 28,647. 7102 Anopheles mosquito individuals were captured in the dwellings and identified by species. In view of the fact that it is difficult to find the site and elevation of the location of some of the villages covered by the investigation, data from only 248 villages of the 299 were processed. (table 2).

Table 2. Frequency of encounter of *A. vagus*, *A. minimus*, and *A. jeyporiensis* as affected by the elevation of the villages studied

Elevation of situation of the village, m above sea level	Total number of villages studied	of them, with the presence of					
		<i>A. vagus</i>		<i>A. minimus</i>		<i>A. jeyporiensis</i>	
		abs. number	%	abs. number	%	abs. number	%
100	7	7	100.0	5	71.4	1	14.3
200	8	7	87.5	7	87.5	5	62.5
300	29	22	76.0	28	96.5	9	31.0
400	21	17	81.0	17	81.0	3	14.3
500	16	9	56.6	10	62.5	0	0
600	10	7	70.0	6	60.0	1	10.0
700	9	4	44.4	6	66.6	1	11.1
800	12	7	58.3	3	25.0	1	8.3
900	23	9	39.1	15	65.2	1	4.3
1000	18	12	66.6	7	38.8	2	11.1
1100	25	12	48.0	4	16.0	1	4.0
1200	15	5	33.3	5	33.3	1	6.7
1300	8	1	12.5	0	0	0	0
1400	9	2	22.2	2	22.2	2	22.2

Table 2 (cont'd)

Elevation of situation of the village, m above sea level	Total number of villages studied	of them, with the presence of					
		A. vagus abs. number	%	A. minimus abs. number	%	A. jevporensis abs. number	%
1500	7	0	0	0	0	1	14.3
1600	1	0	0	0	0	0	0
1700	1	0	0	0	0	0	0
Total	219	133	60.7	119	54.3	29	13.2

RESULTS OF THE INVESTIGATION

A strict confinement by elevation among the different nationalities of the Thai Meo district is to be noted (fig. 2). Different nationalities, even those which live on one elevation, select specific micro-terrains corresponding to the features specific to their economic activity and mode of life. The basic occupation of the Thai nationality is irrigated rice farming; the villages are relatively large, the houses are big, constructed on poles ("2-story types"), the open space beneath the floor of the dwelling is used as a stable for buffaloes and in part as a pig sty. The economic and sanitary-hygienic level of the dwellings is relatively high; in particular, in most of the houses there are canopies (mosquito nets). The Myong nationality is closest to the Thai nationality in cultural level and living habits. They also build 2-story houses and use canopies. The overwhelming majority of the population of Myong nationality is concentrated in the southern regions of the district. The Thai nationality and the the Myong nationality rarely settle at elevations above 500 and never

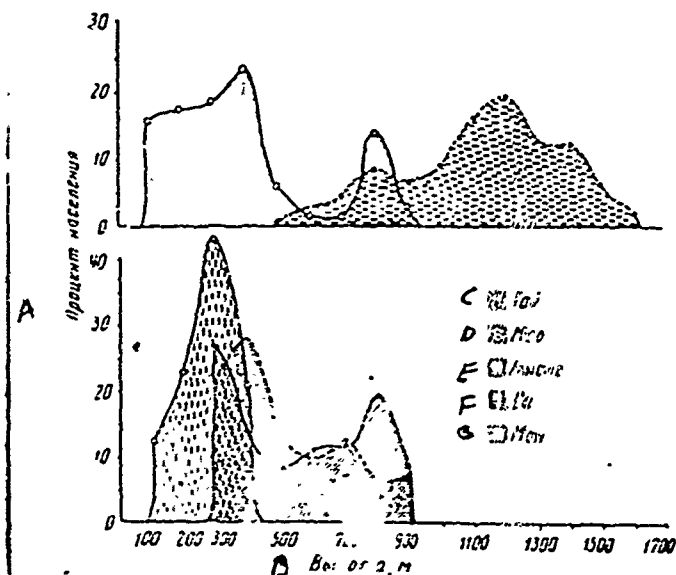


Fig. 2. Distribution of the chief nationalities of the Thai Meo autonomous district as affected by elevation of situation of their communities. A. percent of population, B. elevation, m; C. Thai, D. Meo, E. Myong, F. Sa, G. Man.

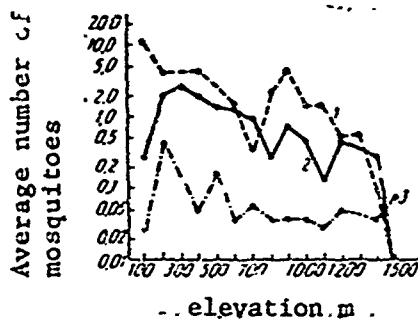


Fig. 3. Abundance of *A. vagus* (1), *A. minimus* (2), and *A. jeyforiensis* (3) as affected by elevation of the location

on the tops of ridges. On the other hand, the Meo population is never found in the valleys below 500 m; the Meo prefer to live on open, well-aerated cool territories. Meos are good hunters. Their houses are small with dirt floors. The economic and sanitary-hygienic levels of their life is nevertheless low. They do not use canopies, nor do the Sa and Man nationalities who have been

distinguished until recently by a particularly low level of sanitary culture. The Thai, Myong, and Sa nationalities live a settled life. The Man and Meo periodically move about. Domestic animals are most numerous among the Thai and Myong nationalities. There are very few among the Man and Meo. The Man, and particularly the Meo who live at greater elevations in small isolated villages, often go down into the valleys for trading and sometimes in search of seasonal work.

The entomological findings included 10 species of *Anopheles* among which *A. vagus* was predominant with 76.5%, followed by *A. minimus* with 21.4%, and *A. jeyporiensis* with 1.4%. The other species were found less often: *A. maculatus* in 0.16%, *A. hyrcanus sinensis* and *A. h. nigerrimus* in 0.15% each, *A. tessellatus* in 0.06%, *A. kochi* in 0.03%, *A. barbirostris* and *A. philippinensis* in 0.015% each. The frequency of detection of 1 species of *Anopheles* mosquito or another was unequal at different location elevations (see table 2).

As table 2 shows, *Anopheles* are found with the greatest consistency at elevations below 600-700 m; less consistently but quite often at an elevation of 700-1200 m, and only in isolated villages at an elevation of 1300-1500 m. The abundance of *Anopheles* also depends on the elevation of the village (Fig. 3).

The comparative abundance of *A. minimus* (chief vector of malaria in N. Viet Nam) in the houses of different nationalities who dwell at similar elevations is a matter of interest. The results of the studies were unified by us for this purpose into 2 groups. The first group (Fig. 4) includes villages of all 5 nationalities: routes No. 2,3,6,7 (mountain locale without flat mountain sections); the second group (Fig. 5) includes only villages of the Thai, Sa, and Meo nationalities: routes No. 1, 4, and 5, including portions of the plateau.

As Fig. 4 shows, *A. minimus* dwells in the houses of all nationalities who live at elevations of 100 to 800 m; from 900 m and above, all the villages of this group were free of *A. minimus*. The greatest population density (above 1 mosquito per day resting-place) was noted in villages at elevations of 200 to 600 m. The average number of mosquitoes per day resting place was greatest in the villages of the Myong and Man (up 4.6-5.2); it was consistently high (more than 1 mosquito per day resting place) in Thai and Sa villages; in Meo houses, there were either very few mosquitoes (at an elevation of 700-900 m) or none at all (at 1000-1500 m). In the second group of villages (Fig. 5) mosquitoes were found at all elevations from 200 to 1000 m inclusively.

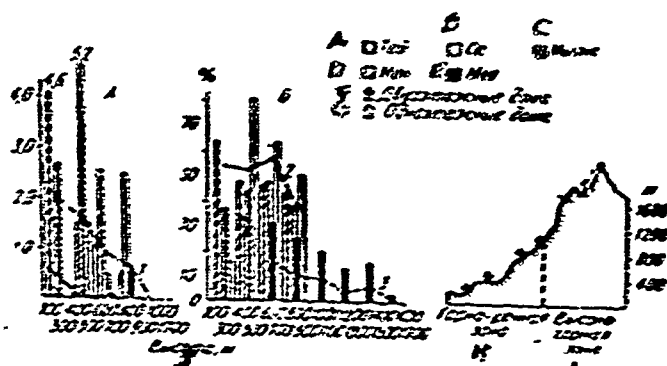


Fig. 4. Abundance of *A. minimus* (A) and malaria infestation rate of the population—total and childhood spleen indices (γ) in villages of the different nationalities Thai and Meo as affected by elevation (first group of villages). On the right: diagram of altitudinal distribution of different topographical zones 1. average abundance of *A. minimus* in houses at the given elevations; 2. child spleen index, group from 2 to 8 years, among Thai, Sa, Myong, and Man; 3. child spleen index among the Meos. A. Thai, B. Sa, C. Myong, D. Man, E. Meo, F. two-story houses, G. single-storey houses, H. mountain river zone, I. alpine zone, J. elevation, m.

The greatest average population density was noted in the villages at elevations of 300 to 700 m; here an especially large number of mosquitoes was found in the houses of the Sa. In the high-situated villages of the Meo, as distinguished

from the first group, the houses were also inhabited by *A. minimus*, although the density of the population was low--as a rule about 0.5 mosquitoes per day resting place. It is a matter worthy of attention that the elevation of 800-900 m is to some extent critical for *A. minimus*. In the first group of villages it is

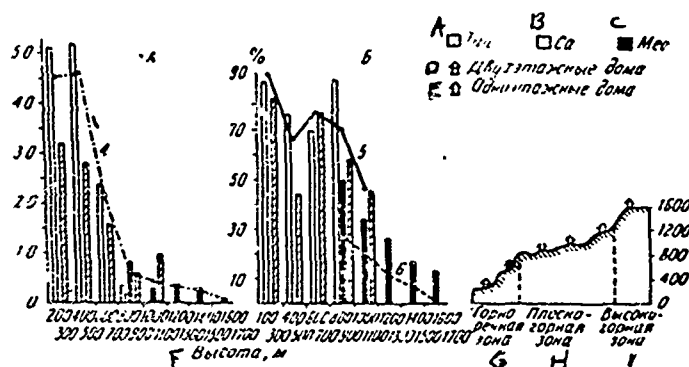


Fig. 5. Abundance of *A. minimus* (A) and malaria infestation of the population; total and childhood spleen indices (ζ) in the villages of different nationalities Thai and Meo as affected by elevation (second group of villages). On the right is a diagram of the distribution by elevation of the different topographical zones. A. Thai, B. Sa, C. Meo, D. two-storey houses, E. one-storey houses, F. elevation, m, G. mountain-river zone, H. flat-mountain zone, I. alpine zone. 4. average abundance of *A. minimus* in the houses at a given elevation; 5. child spleen index (group from 2 to 8 years) among the Thai and Sa; 6. child spleen index among the Meo.

the upper limit of the range; in the second it is the beginning of the stable but very low population density of the mosquito. Apparently, at this elevation, the breeding grounds of *A. minimus* either disappear (in the first group of villages) or are noticeably curtailed (at the transition to plateau in the second group of villages).

An examination of the population allowed the detection of 11453 inhabitants with an enlarged spleen and 1082 with parasites in the bloodstream. In 60.9% of the cases, *P. falciparum* was found; in 37.7% *P. vivax*, and in only 1.4% *P. ma-*

lariae. The malaria infestation rate, judging by the results of the investigation, was high among all 5 nationalities, and only the Meo revealed a low parasite index (table 3).

Table 3. Indices of malaria infestation

Nationality	Study of Spleen		Study of Blood	
	Number of Subjects	Spleen Index	Number of Subjects	Spleen Index
Sa.	2 339	76.3	2 303	9.7
Man	1 988	50.2	19 866	7.8
Thai.	8 976	43.7	8 874	10.7
Myong	1 651	37.9	1 629	9.1
Meo	12 872	31.4	12 817	2.3
Total . .	27 826	40.6	27 619	6.4

As a result of the analysis of the age-specific malaria infestation rate, an abrupt qualitative difference in it was found among the Meo in comparison with the other nationalities (Fig. 6). The curve of the age-specific infestation rate of the Sa, Man, Thai, and Myong nationalities has the shape of the classical curve of the infestation rate in hyperendemic foci: a rapid increase of the index in the low age groups and a gradual decrease in these indices in the older groups; the indices of the adults are noticeably lower than the indices of the 2-8 year-old group of children. For the Meo nationality, a slow increment in the spleen index whose maximum is reached only among adults is typical. The curve of the age-specific parasite index among the Meo is more constant. The magnitude of the indices fluctuates between 1.6 and 4.7%. If in the adult group,

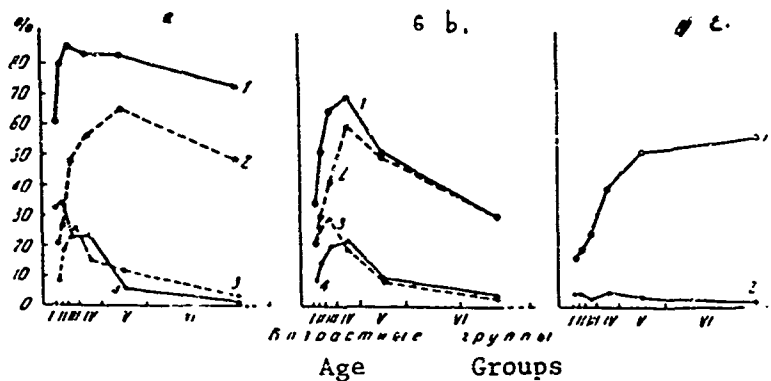


Fig. 6. Comparative age-specific malaria infestation rates of the different nationalities. I. under 1 year; II. 1-2 years, III. 3-4 years; IV. 5-8 years; V. 9-16 years; VI. 17-64 years. a. 1. spleen index of the Sa, 2. spleen index of the Man; 3. parasite index of the Man; 4. parasite index of the Sa, b. 1. spleen index of the Thai, 2. spleen index of the Myong, 3. parasite index of the Thai, 4. parasite index of the Myong, c. 1. spleen index of the Meo, 2. parasite index of the Meo.

such a low parasite index can be explained by the increasing immunity among the repeatedly infested inhabitants, then in the younger age group it testifies to low opportunities for children to become infested with malaria. This contradiction can be explained in only one way: the adults are often and repeatedly infested outside of the local foci with a low endemic degree. We find confirmation for this statement when we compare the infestation rates of populations of different nationalities who dwell for some time at different elevations with different densities of *A. minimus* in their dwellings (see fig. 4 and 5).

In the villages of the first group (see fig. 4) the curve of the malaria infestation rate (spleen index of the child group) is kept at a high level: more than 50% below the elevation of 700 m inclusively where the average *A. minimum* density is quite high (1 mosquito per day resting place and more). At an elevation of 800 to 900 m where the *A. minimus* density falls to 0.6 mosquitoes

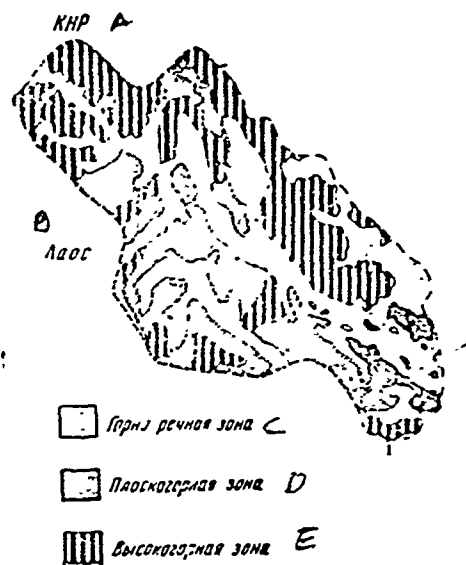


Fig. 7. Diagrammatic map of the topographical-malariological zones of Thai Meo. A. China, B. Laos, C. Mountain-river zone, D. flat-mountain zone, E. alpine zone.

per day resting place, and also above this, where the mosquitoes of this species were not found, the infestation rate of the Thai, Sa, and Man populations is noticeably decreased (spleen index 34%), and the Meo nationality is apparently not infested. (index below 10%). Thus, the villages of the first group belong to a single endemic mountain-river zone whose elevation limit has a maximum at an elevation of 800-900 m.

Above this is the nonendemic alpine zone (see fig. 4-5).

In the villages of the second group (see Fig. 5), the population infestation curve is maintained at a very high level (70% and above) up to an altitude of 800-900 m. The Meo who live at this elevation are infested sufficiently intensively but considerably more weakly than other nationalities (spleen index

26% as opposed to 70%). From this it follows that there is no justification for considering the Meo a nationality with any particular susceptibility to malaria as Pons suggests. In the all cases when the Meo living at the same elevations as other nationalities (see Fig. 4) elev. 600-900 m; see Fig. 5, 800-100), their infestation rate was relatively lower, but the clinical picture of the disease and the character of the parasitemia in the Meo children are similar to those seen in children of the other nationalities.

Although the malaria infestation rate among the Meo nationality is noted to an elevation of 1600-1700 m, the local morbidity (detection of parasites in the children who had never descended to the villages below) was observed to be no higher than at an altitude of 1200-1300 m. Some of the adults who live at elevations of up to 1200-1300 and all of those who live above this were infested with malaria in the villages situated below during their periodic visits to them.

Thus, one might speak of two endemic zones in the second group of villages: the mountain-river zone extending to the elevation of 800-900 m, and the flat-mountain zone occupying the territory at the elevation of 1000-1300 m (see Fig. 5). The comparative indices of area and location of the 3 topographical-malariological zones of the autonomous district of Thai Meo are shown on Fig. 7. In the plan for the elimination of malaria in Thai Meo, different measures had to be used for the specific mountain-river and flat-mountain malariogenic zones. The data from this investigation permit the boundaries of the zones to be more accurately delineated and the extent of the necessary measures which previously had been orientatively planned.

DISCUSSION OF RESULTS

The first large malariological exploration of the autonomous district of Thai Meo (northwestern part of the DRV) revealed some supplementary facts concerning the epidemiology of malaria in North Viet Nam. The presence of *A. minimus* was established at such elevations as 1200-1500 m which are significant for this species and which are nearly twice the elevation at which it is found in the regions to the east of the Hoang Lien Chon and Sa Fin mountain ridges.

The presence of *A. minimus* at such great elevations can be explained by the fact that for the topography of the Thai Meo district, large flat mountain masses with streams and brooks suitable for breeding--not too swiftly flowing--are characteristic. The great elevation at which *A. minimus* was found has caused the presence of malaria foci which are situated very high (1200-1300 m). The Meo nationality lives here exclusively. These foci which make up in toto the flat mountain zone were distinguished by a low level of malaria transmission and can be characterized as hypoendemic.

The hypoendemic nature of the foci in the flat mountain zone is caused in our opinion, by two basic factors: the low density of *A. minimus* and the cooler continental climate. The relatively high infestation rate of adults in the foci of this zone is explained by the unilateral periodic migration of these tribesmen into the valleys in conjunction with trade and for seasonal labor.

During the course of the investigation, no factors were found which were considered to be evidence of race-specific features in malaria susceptibility among the Thai Meo inhabitants. Quite the contrary, a complete parallelism between the degree of population infestation among the different nationalities and the density of *A. minimus* in their houses, and thereby with the physico-geo-

graphical conditions of life of the different nationalities, was established. The infestation rate of the Meo population who dwell at lower limits of their inhabited area (600-800 m) is considerably less than the infestation rate of the Thai and Man nationalities who live at the same elevations as a result of the confinement of their inhabitation to poorly-watered open sections of the terrain. The Sa nationality which lives on the same elevation is more intensively malaria infested than the other nationalities, chiefly because of the close location of the settlements to mountain brooks and the low sanitary culture. The malaria infestation rate of the Thai nationality is only slightly dependent on elevation since the Thai live at all elevations in open clearings directly next to rivers and brooks, cultivate irrigated rice, and use covers (canopies). Their susceptibility to malaria is just as high as that of the other nationalities: the intensity of increasing immunity by age group is fundamentally no different from its intensity among the Man, Sa, and Myong nationalities.

There is no basis to consider, as Pons affirmed, that the susceptibility of the Thai nationality is highly different from the susceptibility of the other nationalities and that the Thai, so to speak, the race best adapted to live in malarial localities.

CONCLUSIONS

1. A. minimum on the territory of the autonomous district of Thai Meo to the west of the ridges Hoang Lien Shon and Sa Fin is distributed as high as 1300-1500 m above sea level, almost twice as high as the altitudes known for its distribution to the east of the same ridges. The cause of this difference is explained chiefly by the presence on the territory of Thai Meo of large flat mountain masses on which, despite, the great elevation of their situation, there

are favorable breeding conditions for *A. minimus*.

2. Foci of local malaria in Thai Meo were found at an elevation of 100 to 1200-1300 m. Two groups of foci are identified on the basis of the intensity of population malarial infestation: hyperendemic foci situated at an elevation of up to 800-900 m, and hypoendemic foci, situated at an elevation of 900-1000 m to 1200-1300 m.

3. Hyperendemic foci of malaria of Thai Meo are confined to river valleys and their side slopes inhabited by Thai, Myong, Sa, and Man nationalities. The totality of foci of this type make up the mountain-river topographical-malariological zone.

4. The hypoendemic foci of malaria are distributed chiefly on the flat-mountain terrain of the district inhabited almost exclusively by the Meo nationality. The totality of foci of this type make up the flat-mountain zone first identified in Thai Meo and encountered, apparently, nowhere else in North Viet Nam.

5. The differences found in the population malaria infestation rates of the different nationalities of Thai Meo depend not on the racial classification, but rather on the confinement of their settlements to different topographical-malariological zones either due to custom or economic reasons, and the sanitary-hygienic level.

6. The topographical malariological investigation of Thai Meo permits a well-founded and economical plan for the elimination of malaria in the district and its prevention, after this improvement in sanitary conditions has been completed, to be projected.

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