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PARASITIC INFECTION OF MAN ON KAR KAR ISLAND, NEW GUINEA

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Abstract. The prevalence of protozoan and helminth parasites of the intestinal tract in a Papua New Guinea island with a population of 16,800 was assessed by surveys of a series of randomly selected villages. There were significant differences in the severity of infection with these parasites between the two linguistic groups inhabiting the eastern and western halves of the island. Blood examinations for malaria and microfilariae also differed. It is thought that these differences reflect obscure microenvironmental factors in what would appear to be an epidemiologically homogeneous population.

Kar Kar (Dampier) Island is situated some 10 to 20 km off the north coast of New Guinea and 50 to 60 km northwest of the town of Madang. The island lies in approximately longitude 144.5° and latitude 4° of south. This island was the venue of a multidisciplinary study of human adaptability in the humid tropical lowlands of New Guinea organized under the auspices of the Institute of Human Biology of Papua New Guinea, The Royal Society of London, and the Australian Academy of Science in the International Biological Program. The investigation involved studies in demography, nutrition, and physical anthropology, which were associated with physiological experiments on working efficiency, heat tolerance, and respiratory function. An extensive epidemiological and medical survey was also undertaken. The present report describes the general distribution and nature of human parasitic infection.

Kar Kar is a volcanic island some 80 km in circumference (Fig. 1). The central volcanic cone rises to 1,849 meters in height and is clothed with a dense, uninhabited, lowland rain forest. The population of 16,800 is concentrated on the rich volcanic soil of the coastal slopes 4 to 8 km in width: here the population density varies from 40 to 80 per hectare. In this area there are a few remnants of the primary rain forest but much of the land is occupied by some ten extensive coconut/cocoa plantations and a complex system of native gardens and secondary forest. The climate is equable with little fluctuation in temperatures, which average around 28° C. There is an abundant rainfall of approximately 355 cm a year. There are no accurate records of rainfall but the popular impression is that the southeast of the island receives a higher rainfall than the north. Although the period of southeast trade winds from May to September tends to be less humid than the northwesterly trade wind season of November to April, rain usually falls throughout the year. Most of the land slopes gently towards the sea, although in some small areas on the east and northwest of the island low-lying land near the sea is subject to inundation and there are some small swamps to which sago (*Metroxylin sagu*) had been introduced in pre-European times.

In general, the Waskia, who speak a non-Austronesian language, dwell in the northern areas of the island whilst the Takia people occupy the southern areas. The Takia speak a Melanesian (Austronesian) language closely related to the languages spoken by the inhabitants of the small coastal islands adjoining the town of Madang.

The people live in houses raised on small piles above the ground, which are gathered into villages of variable size. Most villages are of 200 to 400 inhabitants. The villages are situated either in immediate proximity to the sea or within 8 km of it. Their altitude varies from sea level to approximately 300 meters.

This paper describes the results of investigations in a series of villages which were selected because they typified different ecological situations scattered between the two linguistic groups inhabiting the island; the Waskia villages of Langlang, Urara, Dorogodan, and Kaul village, which in fact is a composite of four villages

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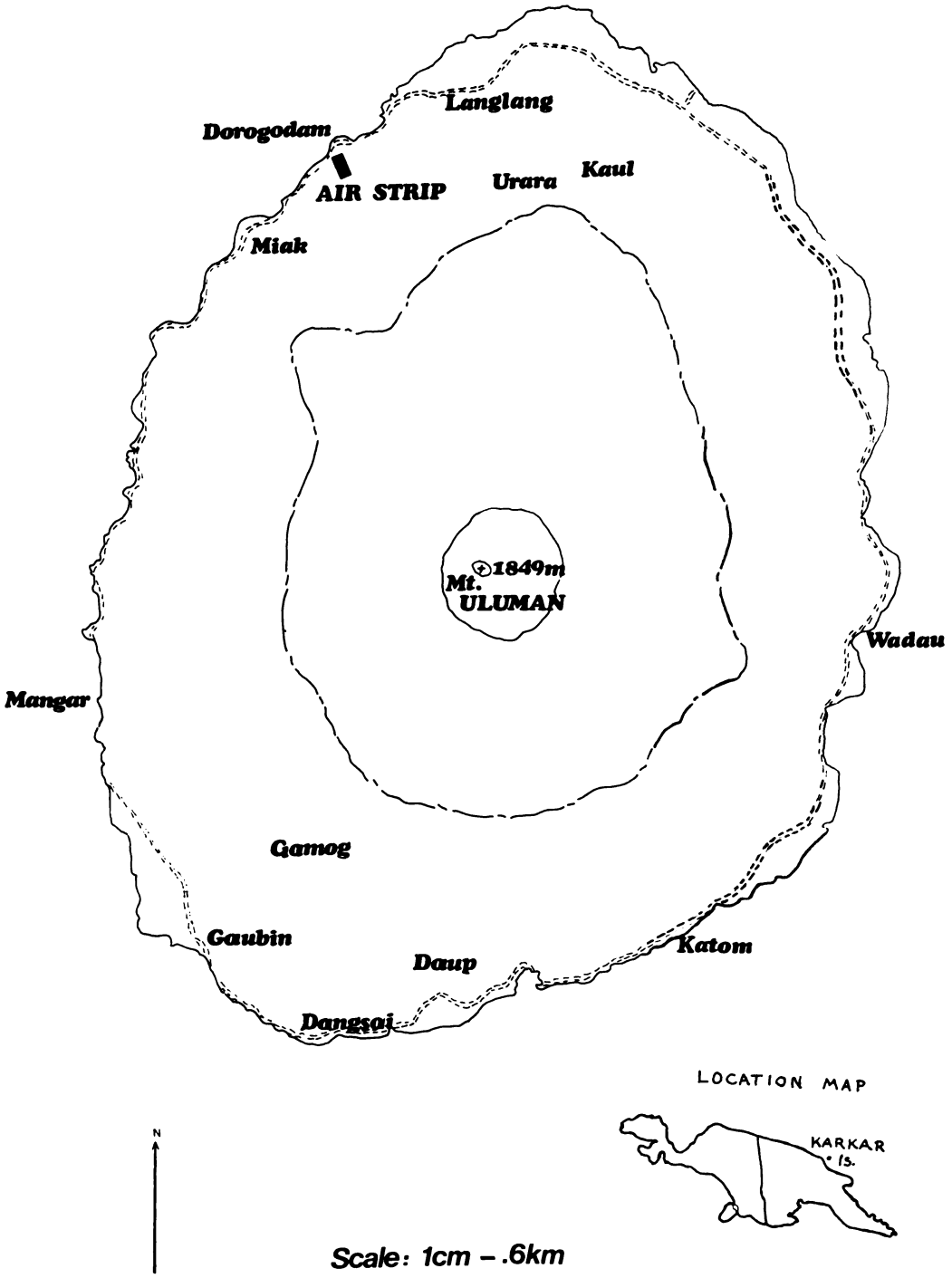

FIGURE 1. Map of Kar Kar Island.

which through increase in size have become merged in a single large complex of about 1,500 inhabitants, in the northern part of the island, and in the south the Takia villages of Gamog, Mangar No. 2, Daup, Dangsai, Katom, Wadau, and Kurum (Fig. 1). Dorogodan, Wadau, Katom, and Kurum lie close to the sea in the vicinity of coastal swampy areas. On the other hand, Urara and Gamog are elevated villages, the highest inhabited regions on the island, at about 300 meters above sea level; Daup and Kaul are at about 150 meters of altitude. Langlang, Dangsai, and Mangar are situated in the immediate vicinity of the shoreline in well-drained terrain.

METHODS

A demographic survey of Kar Kar Island was undertaken and the total population was enumerated and the place of residence of all individuals was recorded. Subsequently, the population of sample villages was asked to report for medical examinations, and at their conclusion various physical anthropometric measurements, along with specimens of blood for laboratory investigations, were obtained. A base with facilities for processing laboratory specimens and for doing clinical examinations was established in a Waskia village complex, while small field laboratories with a shelter for examinations were established in turn in the sample villages. The population of these villages was seen in family groups, 20 to 50 individuals per day, until the whole resident population had been seen, when the field station was then transferred to another sample village. Rather more clinical examinations were undertaken in the Kaul village complex, as there was a longer period of residence and individuals who had been temporarily absent reported for examination after the laboratory testing had ended. In the case of examination for filariae, the villagers were asked to report at night in a similar manner. The findings of the general medical and demographic surveys have been reported elsewhere.[1,2]

Blood specimens for examination for malaria parasites were prepared as follows: blood was obtained by finger prick using a platinum loop, approximately 5 mm^3 of blood being obtained from each subject with ten spots to a slide. This method was devised by Peters.[3] The slides were stained with a Giemsa solution buffered to pH 7.2.

For filariasis, 20 mm^3 of blood was taken by finger prick after 9 p.m., made into a thick film, and stained with the Giemsa solution buffered to pH 7.2.

In the detection of intestinal parasites, fresh fecal specimens were obtained for egg counts which were made by the McMaster technique.[4] For protozoa, fresh fecal specimens were examined, and in some cases phenol, alcohol and formalin preservative[5] was also used, all observations being based on unstained material. The concentration of all specimens was by the formol ether sedimentation method of Ridley and Hawgood.[6] Hookworm egg cultures were carried out in the Takia area by the Harada-Mori method.[7]

RESULTS

When this survey was planned it was thought that there might be differences in the nature or intensity of parasitic infection in the different ecological areas of the island, e.g., between the coastal and inland villages, and between those at a higher altitude and the others. In fact, statistical analysis of the results in which each village was compared with other villages indicated that there was no significant difference among the various Waskia villages and none among the various Takia villages. On the other hand, significant differences were detected between all the Waskia villages on the one hand and all the Takia villages on the other. This rather surprising finding has influenced us to present the results in such a way that the Waskia are pooled together, and the Takia villages are pooled together, and the two are consequently compared.

The results of the examination for splenic enlargement and for malaria parasites in these two sections of the island are described in Table 1, which illustrates a significant difference in the prevalence of malarial infection in the two halves of the island. Spleen rate was significantly higher in Takia children than in Waskia children but was significantly higher in Waskia adults than in Takia adults. The parasite rate (PR) was significantly higher in Takia children ($.01 < p < .05$) and adults ($.01 < p < .05$) than in the corresponding Waskia age groups. For the 13 villages tested, the Spearman Rank correlation between observed parasite rates and spleen rates was 0.5838 ($.01 < p < .05$) in children aged 2 to 9 years, and 0.2321 (not significantly different from

TABLE 1

Clinical and parasitological evidence of malaria infection in Waskia and Takia populations on Kar Kar Island

Age group (years)	No. examined	Overall parasite rate (%)	Percent infected with*					Clinical findings		
			Pf	Pv	Pm	Mixed	Indeterminate	No. examined	Average enlargement of spleen	Spleen rate (%)
Waskia										
2–9	353	39.4	1.0	1.5	0.3	0.2	0.2	406	1.74	45.1
15+	631	13.0	1.0	2.3	0.1	0.2	0.6	733	1.80	43.1
Takia										
2–9	245	48.6	1.0	1.9	0.4	0.3	0.2	245	2.00	63.4
15+	308	18.8	1.0	1.6	0.4	0.1	1.4	308	1.67	33.1

* Pf, *P. falciparum*; Pv, *P. vivax*; Pm, *P. malariae*.

zero) in adults. The correlation between village PR and average enlarged spleen was significant in children ($.01 < p < .05$), but not significantly different from zero in adults.

The PR fell with increasing age in both populations, reflecting the development of acquired premunition to malaria. This fall in PR was accompanied by a significant fall in spleen rate in the Takia subjects, but not among the Waskia. There appeared to be a greater persistence of *Plasmodium vivax* in the adult Waskia population, and this may explain the persistence of the splenomegaly.

The results of the survey for the presence of microfilaria of *Wuchereria bancrofti* are shown in Table 2, where the data are broken down by age and linguistic group. It is clear that there is a greater prevalence of microfilaremia among the adult Takia population than on the Waskia side of the island. Exposure to infection apparently occurs earlier in this part of the island.

Clinical manifestations of filariasis were uncommon, but were also more frequently seen among the Takia population. Thus a hydrocele rate of 0.7% was observed in the 21- to 40-year age group, and of 7.4% in the 40-year and over age group among the Takia villages, while hydrocele was not observed in the Waskia villages. Elephantiasis rates involving both sexes were 0.7% in the 20- to 40-year age group and 3.7% in the 40 and over age group on the Takia side of the island, while on the Waskia side the rate was 2.0% in the 20- to 40-year age group and 3.2% in those aged over 40 years.

The incidence of intestinal parasites is presented in Tables 3 and 4. Among the Takia examination for hookworm showed that 62.2% had egg counts less than 2,000/g feces and only 11 out of 278 (3.9%) egg counts showed an excess of 10,000/g. There was no significant difference in the egg excretion levels in different age groups. Hookworm infection was more marked in the Takia

TABLE 2

Incidence and density of microfilaremia (W. bancrofti) *in Waskia and Takia populations on Kar Kar Island*

Age group (years)	Waskia			Takia		
	No. examined	Mf rate (%)	Avg. mf/20 mm³ per infected person	No. examined	Mf rate (%)	Avg. mf/20 mm³ per infected person
0– 5	10	0.0	–	84	1.1	14
6–10	36	5.5	7	113	3.5	25
11–15	31	6.4	7	72	4.1	41
16–20	48	4.1	41	50	14.0	18
21–40	49	16.3	28	127	33.0	32
40+	31	12.9	36	107	43.9	33
All ages	205	8.7	22	553	18.8	29

TABLE 3
Incidence of intestinal parasites in Waskia and Takia populations on Kar Kar Island

Data	Waskia			Takia		
	0–14 years	15+ years	All ages	0–14 years	15+ years	All ages
Number examined	124	103	227	261	217	478
HELMINTHS (%)						
Hookworm	54.0	54.3	54.1	72.4	84.3	77.8
Ascaris lumbricoides	58.0	29.1	44.9	29.9	9.6	20.7
Trichuris trichiura	43.5	40.8	42.3	21.5	11.1	16.7
PROTOZOA (%)						
Entamoeba histolytica	4.0	4.8	4.4	0.4	2.7	1.4
Entamoeba coli	9.7	14.5	11.8	6.5	10.1	8.1
Endolimax nana	4.8	5.8	5.2	1.9	3.2	2.5
Giardia lamblia	0.8	0.9	0.8	2.7	0.9	1.8
Iodamoeba buetschlii	0.0	0.0	0.0	0.8	0.5	0.6
Percent negative for protozoa	80.6	73.7	77.5	88.9	84.7	87.0

population ($p < 0.01$) than in the Waskia villages. In the latter there were only 23 individuals with egg counts in excess of 5,000/g. There was again very little alteration with age in the severity of infection. Sixty-nine cultures of hookworm eggs prepared on the Takia side of the island revealed only *Necator americanus*.

In the Takia villages, *Ascaris* infection was not of great severity. Only 4 (1.4%) individuals had egg counts in excess of 20,000/g and only 20 (7.2%) had egg counts over 5,000/g of feces. The prevalence of *Ascaris* infection was appreciably higher among the Waskia ($p < 0.01$). Twenty-nine (34.1%) had *Ascaris* egg counts in excess of 5,000/g. *Trichuris* was also more common among the Waskia. There was significantly greater frequency of intestinal protozoan infection among the Waskia.

DISCUSSION

These investigations have revealed a varied pattern in the prevalence of parasitic infection in a geographically limited population. They are therefore of substantial interest in defining the great range of microenvironmental factors which influence health. It is probable that rainfall and humidity are greater on the southeastern extremity of the island where the Takia predominantly live. Here, also, the land form provides a more gentle inclination towards sea level and a greater area of land liable to inundation, with the presence of moderately extensive sago swamps. On the other

TABLE 4
*Range of helminth egg counts in Waskia (Wa) and Takia (Ta) populations on Kar Kar Island**

No. eggs/g feces†	Percent positive for											
	Hookworm				*Ascaris*‡				*Trichuris*			
	0–14 years		15+ years		0–14 years		15+ years		0–14 years		15+ years	
	Wa	Ta	Wa	Ta	Wa	Ta	Wa	Ta	Wa	Ta	Wa	Ta
0– 2,000	60.4	68.7	20.3	65.2	0	0	0	0	66.6	6.3	22.3	5.7
2,001– 5,000	12.5	17.8	9.7	17.3	29.1	9.5	8.7	5.7	0	0	0	0
5,001–10,000	6.2	3.8	1.9	9.1	27.1	8.2	4.8	2.4	0	0	0	0
10,001–20,000	2.1	3.8	1.9	4.1	0	0	0	0	0	0	0	0
Over 20,000	0	0	0	0	18.7	2.5	1.9	0	0	0	0	0

* Waskia villages—Dorogodam, Kaul 1 and 4, Urara, and Langlang; Takia villages—Dangsai, Gamog, Katom, Mangar 2, Daup, and Wadau.
† No. of egg counts: Waskia, 0–14 years, 48; 15+ years, 103; Takia, 0–14 years, 157; 15+ years, 121.
‡ No subject with *Ascaris* infection had egg counts below 2,000, or in the 10,001 to 20,000 category.

hand, the Takia people have situated in the center of their population the Lutheran Mission Hospital of Gaubin, and are therefore in greater proximity to medical aid. The Waskia population live in a slightly less moist environment but are more remote from the hospital at Gaubin. An efficient road system provides all villages with ready access to the hospital and there are aid post facilities scattered around the circumference of the island. There is little or no economic difference between the two halves of the island.

Although malaria is an important and universal problem on Kar Kar, the levels of intestinal parasitic infection here are low compared with the results of surveys which have been undertaken in other locations in coastal and highland mainland New Guinea.[8] This difference may perhaps be attributed in part to the relatively advanced state of economic development on Kar Kar, where hygienic practices are better than those encountered in other comparable situations in Papua New Guinea.

REFERENCES

1. Hornabrook, R. W., Crane, G. G., and Stanhope, J. M., 1974. Kar Kar and Lufa: Epidemiological and health background to the human adaptability studies of the IBP. *Phil. Trans. R. Soc. Lond. B, 268:* 293–308.
2. Hornabrook, R. W., 1974. A demography of the population of Kar Kar Island. *Phil. Trans. R. Soc. Lond. B, 268:* 229–239.
3. Peters, W., 1957. Report on a malaria survey in the Sepik District. *Med. J. Aust., 1:* 861–868.
4. Gordon, H. McL., and Whitlock, H. V., 1939. A new technique for counting nematode eggs in sheep faeces. *J. Council Sci. Industr. Res. Aust., 12:* 50.
5. Burrows, R. B., 1967. A new fixative and technics for the diagnosis of intestinal parasites. *Am. J. Clin. Pathol., 48:* 342–346.
6. Ridley, D. S., and Hawgood, B. C., 1956. The value of formol-ether concentration of faecal cysts and ova. *J. Clin. Pathol., 9:* 74–76.
7. Harada, Y., and Mori, O., 1955. A new method for culturing hookworm. *Yonago Acta Med., 1:* 177–179.
8. Ewers, W. H., and Jeffrey, W. T., 1971. *Parasites of Man in Niugini.* The Jacaranda Press, Queensland and London.