

marked in the case of potassium. In the perfused isolated rabbit's heart depression is visible (see graphs IV and V); the amplitude is decreased and the heart is slowed. There is a slight decrease in the limb volume caused by constriction of the vessels; this is probably due to stimulation of the vaso-constrictor centre in the medulla.

Cumulative Action and Contra-indications—The distribution of antimony in the tissues and its elimination have not been thoroughly worked out yet, but it has been pointed out that one-third of the amount injected is excreted by the kidneys in 24 hours and probably a large amount by the bowel, so the danger of accumulation in the body does not seem very great when the organs are functioning properly. The possibility should however always be borne in mind. If heart, kidney or lung disease exists antimony should be given with the utmost caution and before starting a course of treatment these organs should be thoroughly examined or their functional state investigated. In weak, emaciated and anæmic subjects a small dose should be given in the beginning and the increase should be very gradual.

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A MALARIA SURVEY OF SAWANTWADI STATE.

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INTRODUCTION.

EARLY in 1922 the writer had the honour to be invited by H. H. the Sardesai Maharaj of Sawantwadi with the sanction of the Bombay Government to conduct an enquiry into the great prevalence of malaria in his State: the result of which investigation is here recorded.

For Western India the enquiry broke new ground and was therefore the more interesting, an interest which the prevailing physical conditions enhanced. In Sawantwadi State, however, the presence of malaria had been noted by non-medical observers long ago, for in their interesting "Memoir of the Sawant-Waree State," published in Selections from the Records of the Bombay Government, 1855, Mr. W. Courtney and Major Auld wrote: "The diseases which have been most prevalent in this country for the last fourteen years have been fevers of the remitting and intermitting types," while the medical observations for Western India, excluding any in Bombay City, have been reported in the Proceedings of the 3rd All-India Sanitary Conference in a supplement to the *Indian Journal of Medical Research*, 1914. Froilano de Mello wrote of malaria in Goa, describing the administrative difficulties, and recounted future programmes of sanitation, but scarcely touched upon the epidemiology of the subject: while Majoribanks reported the conditions on Salsette Island and came to the conclusion that a proximity to hills, where a spleen index of over 50 per cent. was usual, was the most important factor. On the coastal flats the index was often nil.*

Physical Conditions.—The State, with an area of about 1,000 square miles, lies almost wholly in the Bombay Konkan. A small tract of it however, with an average altitude of some 2,500 ft. lies "above-ghât," in the Deccan, as a narrow strip, which runs parallel to the edge of the ghât and includes the delightful hill station of Amboli.

To the South the State is bounded by Portuguese-Goanese territory; to the West by a very narrow strip of British Indian territory or waters which wash the once important harbour of Vengurla, to the North by the British Indian district of Ratnagiri; to the East by the Maharatta Kalkhapur State and the British district of Belgaum.

Nearly the whole State is gently undulating or slightly hilly; in some regions of course being more broken than in others; but the ghât with its buttresses holding up the Deccan partakes of a mountainous character. The agricultural indus-

* It is understood that Mhaskar has made a subsequent contribution to the study of malaria epidemiology in Western India in a paper on the disease in Kanara District, in a voluminous report to the Government of Bombay which has not been published.

tries of the State centre around paddy-cultivation; in some places a winter crop being taken by means of irrigation in addition to the usual crop. The cultivation in the hillier parts is restricted to the terraced neighbourhood of the nullahs, whereas the whole of the gently undulating lands is covered by the fields. Excluding the patches of cultivation, the forest holds sway; and from it good teak and other woods are obtained.

The climate above-ghât even in the hot months of April and May is very pleasant, while at Christmas it is delightfully cold. On the other hand below-ghât the humidity and enervating nature of the air is very trying.

Except in a few small bazars and in Sawantwadi town the people do not live in dense aggregations; their houses are discrete and each set in its own small holding of land, so that their condition is exactly comparable to that of a parish in England.

Preliminary Enquiry.—At the outset of the enquiry the writer found that malaria had become a serious menace at very definite dates in certain localities; for instance Narur at some time between 1860-70, Amberi 1870, Mangaon 1918, Sawantwadi town 1919, Insuli 1921. The popular opinion with regard to these outbreaks implied that the villages were previously sterile and by mischance had become infected from without, and there was a fear that places considered now sterile also might become infected.

Now although there can be no doubt that at these dates in these localities malaria started to assume alarming proportions; for the census returns, as also the abandonment of the villages and cessation of cultivation of lands proved it, yet proofs equally exist that infection was present previous to the epidemics, which, by their virulence, have left such a mark upon the popular imagination. This is an important point; these virulent epidemics do not need the explanation of a mischance infection from without, even if such an explanation be sound. They sprouted from the seed sown before, perhaps long before in the place. For instance Sawantwadi town was supposed to have become infected in 1919 from a neighbouring village Kolgaon, but Courtney and Auld, as already stated, noted its infection in 1855, and the Municipal Secretary informed the writer that 25 years ago at least and as long as he can remember in his long and official association with the town, some few cases of fever have always occurred. Add to this that in 1917-18, 84 deaths from fever were reported, and in 1918-19, 381, and the reader may be sure that even granting the fact that influenza raged in 1918-19, a large number of these deaths were due to malaria.

With regard to places considered to be at present sterile, and in which it was feared that infection might supervene, such were found to be not uninfected. Banda, Ajgaon, Nerur, Kudal, Danoli, each gave a positive malaria spleen-index in the children; proof that public opinion as to the

previous sterility of places which have suffered severely cannot be relied on any more than it can in these instances. Is it likely indeed that places such as Amboli, Kudal, and Banda, all chief towns in the State lying on main roads, should have remained uninfected, while on the contrary little villages on country footpaths are severely infected, because infection has by good chance not come to the former but by mischance has come to the latter?

Ross moreover in laying down, in his Prevention of Malaria, the following demonstrable proposition "Whatever the original number of malaria cases in a locality may have been, the ultimate endemic malaria rate will tend to settle down to a fixed figure....." directly refutes arguments such as those advanced to prove that infection from without of villages in Sawantwadi State has been a matter of any importance.

It was obvious then that some other reason existed for the very variable and eccentric incidence of malaria in the State, and the problem before the writer was to determine the factors on which the variable endemicity is dependent.

Methods.—For the purpose of the enquiry the State was divided into three characteristic divisions:—

1. The slightly undulating land, comprising the valleys of the biggest rivers.
2. The mountainous ridges spurring the Deccan.
3. The broken hilly country distinct from these spurs.

Besides these tracts two others of rather anomalous nature were examined. They will be considered under the heading "Anomalous Tracts."

In each of these divisions the splenic indices were taken and the depopulation record of certain villages as compiled by Mr. Gawan Taylor, I.C.S., was regarded as confirmatory evidence of high malarial endemicity; sometimes the school attendance registers were consulted with the same object; a malaria map kept by H. H. the Sardesai Maharaj was very useful in indicating from what regions reports of severe or slight malaria had come, and finally a collateral enquiry was conducted into the prevailing mosquito fauna.

RESULTS.

1. *The slightly undulating country, or valleys of the biggest rivers.*

Endemicity.—Under this division is included the strip of land above-ghât at about 2,500 ft. above sea-level. Here the sub-assistant surgeon-in-charge informed the writer that malaria in the villages did not seem to be of much importance. The population incidence in Amboli was as follows:—

Year.	1881	1891	1901	1911	1921
	1,146	1,785	1,371	1,601	1,644

while the splenic indices taken were :—

Village.	Population.	No. of children examined.	Splenic index.
Amboli	1,644	150	8 per cent.
Gele	532	32	5 ..

Below-ghât in the region around Banda the basin of the Terekhol River opens out considerably into a wide and very gently undulating plain, which extends north-east for about six miles; here Banda town was visited, and the splenic index in 109 children was 5 per cent.

Another region in this section is the basin of the Talauda River. The malaria map mentioned above showed it to be free from malaria: but Talauda village was found to have a splenic index of 21 per cent. (101 children), while Hodauda, another small village a short way from Talauda, showed in its population returns no evidence of malaria.

In the countryside about the Lower Karli, a big river, but little malaria was betrayed by the malaria map. The splenic indices were as follows :—

Kudal ...	15 per cent.	130 children examined.
Zarap ...	5 ..	25 ..
Salgaon ...	0 ..	23 ..

In addition to the above examples the following cases, which should not strictly come for consideration into this section, may be mentioned. Satuli, a village near the foot of the ghât, was found to be very malarious, though Devsu, somewhat further away on flatter ground, was not so malarious. Sangeli a rather extensive village was much healthier in the parts nearer the river than those near the foot of the hills; Kalambist among many surrounding badly-infected places was comparatively free from malaria: it lay "more on the flat land": Ghaonal at the toe of the Narur hills was not so malarious as the villages among the hills; while the hamlets of Insuli village, which lay at the foot of Insuli ghât, were very severely infected, those on the contrary lying further down on the 'flat land' toward Banda being "quite healthy." But most striking of all was Mangaon, where the bazar, comparatively densely crowded, which lay in the centre of a wide flat area surrounded by hills was fairly healthy, though the children living in the houses along the foot of the hills were very highly infected.

All these observations establish the fact that the flat or undulating lands of the State, whether they be above-ghât or in the Konkan, are comparatively healthy.

The mosquitoes found in these tracts.—Paddy is extensively grown on these undulating lands; while the nullahs of relatively big rivers, sometimes through tributaries which pursue a tortuous course over the land, take the drainage of the

fields. The fields are but seldom summer-cropped; after the winter crop is harvested they are dried off, so that during the hot months the only water to be found on the land is in the river beds, or perhaps in the tributary nullahs, in innumerable small surface wells from which stock is watered, or in deep wells, from which man's requirements are satisfied.

During the rains the nullahs are seething torrents, but during the dry weather small pools dammed up by silt or debris are left at the sides of the river beds. These pools were found to harbour the natural carrier *culicifacies*, as also the slight carrier *fuliginosus*, as well as *rossi* and *vagus*; the presence of *vagus* in these tracts is interesting as it has previously been taken to be a more eastern species; however there was no doubt about its occurrence for adult specimens were hatched out from larvæ with posterior clypeal hairs set close together, which is diagnostic of this species. A summer crop of paddy is taken very often from the beds of the nullahs above-ghât, and at times in the fields *jamesi* and *culicifacies* were found in large numbers.

In the tributary nullahs, which have carved a tortuous course over the land a good deal of scour takes place during the rains, and afterwards when the water decreases weeds spring up, and anopheline breeding pools are formed. In such situations *jamesi*, *vagus* and *rossi* were found, whether the bed of the nullah was rocky or earthy.

The writer's visit did not correspond with the cultivation of the winter-paddy, but it seems likely that its mosquito fauna would be identical with that which he found in the fields of the sparse summer crops. These species were:—*punctulata* (one specimen), *jamesi*, *barbirostris*, *rossi*, *vagus* and *culicifacies*.

A large number of larvæ were identified as of either *barbirostris* or *sinensis** but not a single specimen of the latter species was hatched out at any time, a most striking difference from that obtaining in more eastern paddy fields.

In the shallow wells for watering stock the mosquitoes found were *vagus*, *rossi*, *fuliginosus*, *barbirostris*, *jamesi*, none of them a potent carrier.

The mosquito survey then in this section bears out the conclusion reached in the endemicity survey that the slightly undulating regions of the State, whether above-ghât or in the Konkan, suffer but very slightly from malaria; the mosquitos here, with the exception of *culicifacies* are not serious carriers: here and there *culicifacies* occurred in fair numbers while *jamesi* and *fuliginosus*, both slight carriers, were taken in enormous quantities in some of the paddy fields. Nevertheless the conditions of village life seem to be such that a fair prevalence of a species which is a bad carrier or a great prevalence of a slight carrier does not

* This species is now correctly named *hyrcaneus*, but it is better known as *sinensis*. In the larval stage it is indistinguishable from *barbirostris*.

produce generally more than a very low endemic index.

2. *The mountainous ridges spurring the Deccan and the villages along the ghât.*

Endemicity.—The ghât forms a bastion some 2,000 ft. in height, the Deccan at its summit, the Konkan at its foot. Within the limits of the State it is spurred by two gigantic buttresses, which may be termed the Narur Massif, and the Mangaon-Masantosh Ridge; each of which was the object of investigation.

(a) *The Narur Massif.*—This region it is that has suffered so severely during the last generation and in it malaria has probably been endemic for ages; but the epidemics which have produced such alarm date from the decade 1860-70. The malaria map shows that almost without exception the villages here have suffered severely; the depopulation having been considerable (Gawan Taylor) as the following table shows:—

	1881	1891	1911	1921
Gotos*	1105	830	640	406
Nawaji	618	562	388	213
Wados	366	297	247	145
Tulsolit. Narur	533	490	349	210

(b) *The Mangaon-Masantosh Ridge.*—This ridge is a long spur with subsidiary spurs about 30 miles along its main axis. It is comparatively narrow and steep, and its elevation is gradual from its toe to the level of the Deccan. To the south it is pot-hook shaped, and the bend of the hook embraces the site of the capital town Sawantwadi.

The villages along the ridge are very severely affected, though those which have lands approximating to the larger streams in the bounding valleys are not so unhealthy: moreover those which lie higher up on the ridge, or toward the higher end of the ridge are not so badly hit. The malaria map bears out these general statements very well: the map shows very strikingly that the villages high up on the ridge, or on the ghât at the Deccan end are marked as only slightly affected.†

The following figures give examples of depopulation in villages on the ridge:—

	1881	1891	1901	1911	1921
Kaleli	951	1,000		819	494
Kurkeri	1,565		1,704	...	1,257

The splenic indices of the following villages were taken with the result shown.

Akeri	..	..	97%
Pediya	..	..	60%
Mangaon	..	..	64%
Mazgaon	..	..	51%
Kolgaon‡	..	..	97%
Sawantwadi & environs.	..	..	85%
Charathe	..	..	63%
Insuli	..	..	64%
Dobachichal t. Insuli	..	..	91%

The mosquitoes prevalent in these tracts.—The species of anopheline in the ravines which course

down the sides of these hills which one would expect to find more than any other is *maculatus*, the bad malaria carrier. And indeed it was discovered in all such situations; for example in the rocky nullahs on Narendra Hill behind Sawantwadi town.** Where however such nullahs were densely shaded by foliage *leucosphyrus* was found, while in springs or swamps of water at the hill-foot, rather below the *maculatus* range, the species *theobaldi* which is stated to be a carrier, was very prevalent. Sometimes among much aquatic vegetation *theobaldi* was associated with *fuliginosus* and *jamesi* or where the water was fouler or muddier with *vagus* and *rossi*.

In the paddy fields at the foot of the hills and in the little valleys between the hills, the writer unfortunately had no opportunity of making any observations before the land was dried off; whereas some potent carrier may have been found in those situations. In one place, a few specimens of the reputed carrier *karwari* were captured in a swampy grass-grown ravine where the conditions much resembled those of paddy cultivation, which indicates that during the wet season this species may be more commonly found in the paddy. Besides this finding a few patches of irrigated paddy harboured *punctulata*, *barbirostris*, *jamesi*, *rossi*, *vagus* and *fuliginosus*, or the same fauna as in paddy on the gently undulating lands.

It is permissible here to introduce a comparison with another country, Malaya, where the mosquito fauna is Indian in type. In the paddy fields there among the hills the variety of *minimus*, named *aconitus*, a bad carrier, delights particularly in the swift running water of the irrigation channels; its occurrence therefore in these Indian paddy fields is not improbable. However in the course of the enquiry only two irrigating channels which were being used were encountered and although very carefully searched, yielded no other species than *jamesi*.

In the shallow surface wells at the edge of all paddy fields are found *fuliginosus*, *barbirostris*, *vagus*, and *rossi*; in pukka wells of which a very large number were diligently examined, only two contained anophelines (*fuliginosus*, *vagus*).

Where the hill streams have debouched on to flatter or less hilly country or have discharged their waters into rocky streams running through the main valleys which bound the Deccan spurs, the mosquito fauna changes its character. Except rarely no *maculatus* is found; but swarms of *culicifacies*, *rossi*, *vagus*, *fuliginosus*, *barbirostris*; on one occasion the variety *aconitus*. During the rains these water courses must be raging torrents, and probably nothing living therein survives; but after the rains the scour of the spate has left most attractive anopheline breeding places;

* Gotos in 1861 had a population of over 1,600.

† This remark applies also to the villages of the Narur Massif.

‡ Here Dr. Kulkarni, assistant to the enquiry, found in a boy a case of transposition of the viscera.

** This species associated with a protanopheles, at present unidentified, was also taken above-ghat in the rocky nullahs of the low hills.

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the danger of which must be considered most carefully.

To these streams with their swarms of *culicifacies* or to what other factor is the very high endemicity of these tracts due? Are the hill nullahs responsible, or the paddy fields, or the open surface wells, or a combination of them?

The streams may indeed hold *culicifacies* in large numbers, but the splenic indices shew that proximity to them is not so dangerous as in the hills where *maculatus* lives.

The paddy fields probably are not a considerable cause of trouble; any more than they are on the flatter lands of the State, for three reasons:—

(1) The malaria season lasts from October to about January in all parts of the State. At this season the paddy fields have been dried off after harvesting, so that paddy-anophelines are not so prevalent, and would cause less malaria, not more.

(2) The variety *aconitus* which would probably be the chief culprit is a variety which lives chiefly in the irrigating channels; but when the malaria season starts the irrigating channels are empty.

(3) The mosquitoes which were caught in the off-season in a few blocks of irrigated paddy were all only slight carriers, if carriers at all; and it is not likely barring *aconitus*, that in the malaria season the mosquito fauna would be different.

As for other possible factors in the terrain the evidence of endemicity is unequivocal that the hills and not the flatter land harbour the source of malaria, and as in the hills everywhere the bad carrier *maculatus* was found, presumably this is the main cause of the trouble.

3. *The broken hilly country distinct from the Deccan spurs.*

Endemicity.—To the south-west, and to the west of the State are tracts of hilly land which are separated by low-lying land from the spurs buttressing the Deccan; for instance the hilly land to the south-west is nowhere connected with the Mangaon-Masantosh Ridge by land more than 160 ft. above sea-level. To the south-west, taking the orientations in order, the country has the reputation of being malaria free, the malaria map showing only one village as slightly malarious (Sherle), while at Madura the spleen-index of the children was found to be 0 per cent. In the western block, so Mr. Gawan Taylor informed the writer, "the most astounding increases of population have taken place in recent years"; and on the malaria map no place is marked as malarial. The spleen-indices there are:—Math 8 per cent., Nerur 4 per cent., Nerurpur 12 per cent., and Sathe Awath 0 per cent.

The Anophelines of this section.—These tracts in their physical features are characterised mainly by rice-field terraces on the

hill sides as well as on the flatter expanses of country; nullahs running up into the hills and nullahs through the flatter country.

In only one hill side nullah was a spring of water found and in its weedy pool *fuliginosus* and *jamesi* were taken. Probably at certain seasons in such situations *maculatus* would also be found, but as the splenic indices shew, this species is here not a serious thing. In some nullahs on flatter ground *theobaldi*, *rossi*, *jamesi* were captured.

From the rice fields, which were for the most part dry, only *jamesi* was taken, in an irrigating channel. Probably the paddy mosquito fauna in general is the same as that found on the undulating tracts already described.

Special mention may be made of a tank at Nerurpur artificially formed between some hills. In this tank *fuliginosus* and *jamesi* were found in large numbers, and such a prolific breeding place is likely to cause trouble by sheer weight of numbers; which may account for the fact that here the splenic index was higher than elsewhere.

Such malaria therefore as occurs in this division is to be ascribed to species which are not serious carriers or perhaps to serious carriers, e.g., *maculatus*, which are not present in considerable numbers.

4. *Anomalous Tracts.*

Reference must now be made shortly to the two somewhat anomalous tracts, lying in the south-eastern and northern corners of the State. Each is of a broken hilly nature, though unlike the conditions in the hilly tracts described above, malaria incidence in them does not assume a uniform character.

The south-eastern tract is reputed healthy, and on the malaria-map no village in it is marked as malarious, while Mr. Gawan Taylor who provides the following population returns, concluded that villages in its eastern (Banda) patha had suffered less than any in the State:—

	1881	1901	1921
Talkot	... 337	492	497
Degwe	... 665	783	742
Kalne	... 407	423	388
Khadpade	... 78	76	47
Fukeri	... 215	219	211
Kotgar	... 543	542	590
Asniye	... 349	339	369
Parpoli	... "shows a big increase of population."		

However on visiting such villages the following splenic indices were obtained:—

Dhanoli*	... 73%	Digne	... 0% (10 children)
Satuli	... 50%	Degwe	... 27%
Kesari	... 95%	Mokgaon	... 28%
Wafoli	... 21%	Tamboli	... 5% (1-20, in a boy who frequently went to a malarious town.)

* Mr. Gawan Taylor says that its population has been stationary for 30 years, a rather remarkable thing with such a high endemic index.

Of these places Dhanoli and Satuli lie definitely at the foot of the Deccan Ghat, while Kesari is situated at the top of a spur of the ghat which is very well seen from Amboli at 2,300 ft. so that they are analogous to those described above in section 2. The other villages in the tract with lower splenic indices probably correspond to those in "the broken hilly tracts distinct from the Deccan spurs"; for as far as the writer could see they were separated by low-lying land from the ghat or ghat spurs.

The Northern tract appears to be comparable to the South-Eastern. It comprises a block of hilly land some of which definitely buttresses the ghat and some consists of discrete hills. For instance the only malarious villages in the block occur on the Kalsuli ridge, a spur of the Deccan, whereas away from it malaria is not prevalent.

CONCLUSION.

In the main the observations above recounted have proved that (1) the slightly undulating land of the State is only slightly malarious; (2) the villages lying along the spurs of the Deccan Ghat are intensely malarious;* (3) those lying in broken hilly ground distinct from the ghat are only very slightly malarious.

Now between the incidence of the disease on plain and hill one might expect to find some difference, but here is a distinction as between two sets of hills, those connected and those not connected with the ghat, although to all appearance the condition of each is the same, with their little patches of paddy and rocky hill-streams coursing down the sides of well-wooded hills.

For an explanation of this paradox the writer must confess that he can only hazard a suggestion. The virulent malaria zone lies along the spurs of the Deccan; and these have above them the whole pressure of the subsoil water of this region: the consequence being that the filtrate seeps out all along the foot-hills; and admirable breeding-places for anophelines and particularly for the evil carrier *maculatus* arise. The water which springs into the well on the top of Narendra Hill behind Sawantwadi town, probably fell as rain on the Deccan.

On the other hand the broken hilly tracts to the west have lying above them no such filter-bed from which the hill-foot springs replenish themselves: for instance the broken hilly country to the south-west is connected with the rest of the State by land only 160 ft. above sea-level: consequently nowhere among these

hills can there be a head of water derived from the Deccan plateau of more than 160 ft., and so very little spring water can arise there.

These tracts depend entirely on the local rainfall, and in this way a further reason for the different phenomena in the two zones exists, in that the rainfall in the western hilly tracts is much less than it is near the ghat and the Deccan spurs, and fewer breeding places of surface water are provided. The explanation put forward then is simply hydro-dynamical.

For the rest, evidence to show that the species *maculatus* breeding in the springs of the hills is the chief cause of malaria in the State has been submitted, and this leads the writer to attempt to explain the fact that at very definite dates in certain localities malaria began to assume alarming proportions, that these epidemics have never abated, and have led to great depopulation of the affected areas.

These events were due possibly to the introduction of the species *maculatus* which previously had not been present, or else owing to conditions for its life becoming more favourable, it may have increased enormously in numbers. What natural enemies of *maculatus* might have affected the situation is not known; but a factor connected with the reaction of this species to plant-life supplies a sufficient and it is to be hoped a true explanation.

In 1916 the writer submitted a paper to the Federal Council of the Federated Malay States by order of H. E. the High Commissioner in which it was pointed out that jungle growth is absolutely inimical to the growth of *maculatus*, and in that country this circumstance has led to a regular campaign with magnificent results to keep the swamps, streams and springs, under cover of the natural jungle. Now if jungle be so inimical to the life of *maculatus*, it is not unfair to suppose that the sudden accession of malaria in the past in certain parts of Sawantwadi State was due to the cutting down of the jungle adjoining the villages, probably for the trade in firewood.† A certain amount of colour is lent to this hypothesis by the fact that in villages higher up the ridges, where the jungle has been less disturbed, the malaria incidence is lower; and Mr. Gawan Taylor, I.C.S. when conversing on the subject made unwittingly what would seem to be two very pregnant remarks: he said "what is the matter is the great variation in the jungle."

* It must be noted that this observation in no way corresponds with Marjoribanks' finding in Salsette Island, where an isolated range of hills rising to 1,500 ft. distinct from the Deccan proved very malarious at the hill-foot.

† Another explanation for the epidemics in Sawantwadi town is needed, and this is supplied by the fact that here a great tank is formed, around which the town is built (most picturesquely); but this tank has been silting up gradually, so that latterly water-plants which previously could not grow have done so: in fact it has become a bed of water-plants, on the surface of which myriads of mosquitoes were breeding.

and speaking of the comparatively malaria-free south-eastern villages he said "generally speaking the country is well-covered with good jungle."*

These hypotheses should be at any rate the basis of preventative measures in the State. If *maculatus* be the carrier which has caused so much harm, then the most important measure is to take advantage of what is known of its biology in relation to plant life. For other circumstances standard methods will be followed.† It is fortunate that the main trouble admits of so easy and royal a road to success; the easy stage will make the whole less arduous.

The writer must conclude by thanking Mr. G. Laird-MacGregor, I.C.S., Political Agent of Sawantwadi State, for his very sympathetic administration of the enquiry, and His Highness the Sardesai Maharaj for his great help and the interest he constantly bestowed on the work, an interest which the writer begs to say augurs well for the ultimate outcome of the antimalarial campaign to be undertaken. He is also indebted to Mr. Gawan Taylor, I.C.S., for much information regarding population record. Also to Rao Bahadur M. B. Rane, State Administrator, and Rao Sahib Patankar, State Karbhari, for their efforts to make the carrying out of the enquiry as pleasant and easy as possible.

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APPENDIX.

1. In submitting this appendix of recommendations in more detail, it is presumed that it would be generally impracticable for any inhabitant of the State to remove his dwelling and his being to a more salubrious neighbourhood. The Administration then must ameliorate his condition in his present home, and the measures suggested are here grouped under the three headings:—1. Policy; 2. Organisation; 3. Methods.

1. *Policy*.—The policy to be pursued is of course dependent upon finances, but as the cost of prevention of malaria is productive expenditure, it is to be hoped that as large funds as possible will be devoted to the work. The point that such expenditure is productive need not be laboured; the results in Ismalia, the Federated Malay States and Panama shew what can be achieved.

Nevertheless to put in train intensive anti-malarial measures everywhere in the State will not be possible, so it is imperative to allocate the available funds to the best advantage.

* But the fact that for the most part this tract is distinct from the Deccan seems to provide sufficient reason for the non-malariousness.

† Details of recommendations are given in an appendix.

Perhaps in the capital town Sawantwadi an intensive campaign may be instituted, but outside it, it seems preferable to conduct some sort of campaign in all the sorely stricken places, rather than a highly-organised one in a few. Results should be forthcoming immediately and the attack can then be continued all along the line, paying special attention to the places of greatest resistance. Coincidentally a spleen index of all villages in the State should be taken for future comparison.

It is suggested that the quinine prophylaxis which has been carried on up-to-date be discontinued. Whatever be the potential value of quinine, in practice it is useless. In Salonica during the war it failed absolutely to protect the troops,‡ whilst an analysis of the seasonal case-rate of malaria in Sawantwadi town shews that the incidence curve has not been affected in the slightest by the use of the drug.

Only when (by rough and ready methods) the general high spleen-index has been reduced, can the remnants of the disease be got rid of by a more refined procedure.

2. *Organisation*.—The control of the work is to be in the hands of a qualified medical man under the charge of His Highness the Sardesai Maharaj who is public-spiritedly determined to eradicate the canker gnawing at the vitals of his State. Under the officer-in-charge it is suggested that there should be a sub-assistant surgeon as assistant, which will allow for contingencies such as leave, sickness or other. A sanitary inspector should be appointed in each of the three *pathas* based on Sawantwadi, Kudal and Banda; and they will have charge of the village work.

This will be conducted by the requisite number of coolies who have been instructed by their superiors in their duties. If in any village one cooly only be required, a literate man with pay at a slightly higher rate than the illiterate man would be preferable: at the end of every month he would send in a return of work carried out. Of two coolies employed one should be literate; of three one may be literate, but in this case it would be preferable to place the three men in charge of a *mukadam* (or overseer). Reports of executive work should be submitted every month through the Sanitary Inspector. The inspection of the work should be continuous and thorough; if it is not, the work will not be done; or it will be done according to the illuminating ideas of the coolies, which may be at conflict with Sir Ronald Ross's. Collaterally for 'major works' the State Engineer will be consulted and give his co-operation to the requirements of any situation.

‡ Watson on p. 128 in "Prevention of Malaria" by J. Murray, 1921.

Finally the administrative department should be asked to assist, primarily through the village *foujdars* (headmen), and next through the Circle Inspectors not only in the instruction, after having been instructed themselves, of the executive coolies and *mukadams* and of their *rayats*, but also in the never-ending inspection of the work being done in their jurisdiction. Perhaps it would be feasible to grant a small antimalarial-work allowance to these men on condition of a certain measure of efficiency being shewn in these directions. Where regulations have been framed in aid of the campaign, a few prosecutions should be taken out for non-compliance. The reports of the work sent through the Sanitary Inspectors should be compiled every month and submitted as a report.

3. *Methods*.—Methods recommended are (a) local in application, (b) general.

(a) *Local methods*.—(1) To be applied to the slightly undulating tracts, vide Section (i).

The beds of the big rivers must be kept tidy. Small pools held up by silt can be filled in with silt; all débris should be taken out and burnt. The devices of local fishermen should be carefully watched to avoid their giving rise to breeding pools; and strict regulations framed that fine mesh fishing nets should not be used.

The tributary nullahs on an earthy bed should be kept clean and cleared of water-weeds, except from the banks, where the vegetation is useful for support and prevention of scour: a chain of small pools on the bed should not be allowed to remain, but a deep narrow ditch cut through them.

(II) *To the tracts about the Deccan spurs*, vide Section (ii).

It is recommended that the hill-nullahs and hill-foot springs, or in fact wherever *A. maculatus* is found breeding, be allowed to revert to their natural condition under a covering of a jungle of plant life. Even the smallest blade of grass seems to have an antagonistic effect upon the well-being of *A. maculatus* and should not be removed unless it is unavoidable. Probably there are no situations in the State where jungle would not cover up within a few months any breeding-place of *maculatus*, but whilst this is taking place some amelioration of the state of affairs would ensue if the breeding places be "trained." The ideal to be aimed at is a ribbon of jungle all along the courses of the streams.

The corollary follows that in such situations no jungle be cut down and in this respect the Forest Department should give a lead; regulations might be framed to ensure this throughout the State.

(III) *To the hilly tracts which are distinct from the Deccan spurs*, vide Section (iii).

Here the only measure of exclusively local application would depend on the discovery of *maculatus* breeding in the hill nullahs: in which case the use of jungle growth must be resorted to.

(b) *General*.

(i) *The treatment of ricefields*.—The particular danger of the irrigating channels of paddy-fields in-so-far-as in some places they are known to harbour the variety *aconitus* must be remembered. They are therefore to be kept clear and their edges cut straight and freed from weeds.

The fields themselves should be well-banked, filled with as much water as is consistent with the good growth of paddy and that not subjected to a great deal of interchange: small larvivorious fish and other creatures will then speedily appear and rapidly increase. If there be a constant interchange of water, large numbers of these larvivorious creatures are washed away, while to have the water stagnating would seem an advantage to the crop from a fertilising point of view, but apart from this it appears that the more stagnant the water the fewer are the dangerous anophelines which breed in it.

Fish need not be introduced artificially as the spawn is rapidly carried from place to place on the feet of wading birds, and develops if the conditions are favourable. All paddy-fields should be kept well-weeded, for weeds protect larvæ from their enemies. A most dangerous situation arises when the water on a field is shallow, filled with weeds, and exposed to the sun by poor growth of paddy. In fact it would probably be better for the health of the State if poor paddy lands be not cultivated.

(ii) *Of Wells*.—Wells in the State are not incriminated with causing any malaria, yet it would be advisable to stock them all with larvivorious fish. The malaria medical officer should have an aquarium in connection with his office where a sufficient supply of fish would be available. The village officers should be directed to send in a return of the number of wells in their villages and the fish distributed accordingly.

(iii) *Of tanks and pools*. Such collections of water are not dangerous when kept free from weeds and of a sufficient depth of water. They must therefore either be carefully conserved or drained away. Netting of all fish of over a certain size should be encouraged so as to save larvivorious fish from destruction.

Shallow shelving uneven edges are protective to larvæ, and they must be cut clean and deep. A small pool may be filled up, or after being tidied up, sprayed with a mixture of crude oil and kerosine, (4 parts to 1) from a knapsack sprayer.*

* Good knapsack sprayers are obtainable from Messrs. Leslie & Co., Chowringhee, Calcutta.

(iv) *Of drains and ditches.*—Should any swampy ground be drained by open ditches it is very necessary that the antimalarial officer should see that no bad malaria carrier breed in them. This is especially important in the *maculatus* zone. If bad carriers are found the ditches should be swept out with stiff brushes once a week, and oiled (*vide* para iii. supra). A deep, narrow ditch is not likely to lead to trouble whereas a shallow, broad one is.

(v) *Pisciculture.*—Fish should play a prominent part in the measures to be undertaken. Some situations in which they would be useful have already been indicated: tanks for breeding different species should be constructed at the laboratory of the Officer-in-charge. The water in them should be shallow and flowing and the natural insect food supply encouraged by an artificial bank of water weeds and grasses; but this food should be supplemented by a little finely chopped meat which should be kept constantly changed. As mentioned elsewhere the natural protection of these little fish can be ensured to a great extent by netting all fish larger than themselves.

(vi) *Of rocky nullahs.* Rocky nullahs in the hills are dealt with above in the local treatment of the tracts about the Deccan spurs, but when they debouch on to flatter ground and *maculatus* disappears, they must be subjected to different measures. It is best to "train" them. All potholes on the rocky surfaces must be filled with concrete, all other irregularities in the stream bed straightened, debris removed, the banks tidied and supported by a growth of vegetation small and big, and in general any mechanical principles applied to ensure the stream flowing evenly and as deeply as possible.

WHAT ARE THE DEPARTURES FROM HEALTH AND THE DISEASES WHICH ARISE FROM THE NEGLIGENCE, IGNORANCE AND SELF-INDULGENCE OF MAN?

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HERE we begin an enquiry which has at present no finality, for though it is generally recognised and admitted that the voluntary conduct of a man is directly responsible for laying the foundations of certain types of ill-health yet we have comparatively little exact knowledge of the matter and can speak only vaguely.

The leave and pension rules of Government penalise to some extent those Government servants whose disabilities are acquired through avoidable errors of living which were not imposed on them by the exigencies of the public service. So there is State recognition of the fact that a man's ill-health in certain circumstances may have been

caused by his own conduct over which he had at the time full control.

This seems to be the only instance in our modern world of the condemnation of ill-health. Ill-health from whatever cause expects and generally receives sympathy. A man may be pursuing a course of life which all his friends know, even if he himself chooses to ignore it, must end in a breakdown sooner or later. They may say "What a fool so and so is to go on as he is doing!", they may endeavour to dissuade him from his courses, but ostracize him or otherwise show disapprobation, never! When the inevitable breakdown comes, sympathy for the man is shown and perhaps sympathy of a practical nature for those dependent on him. Public condemnation is limited to saying "how foolish!" and such conduct is not regarded as a crime, a social sin which merits punishment as much as any other sin against the community. The resulting ill-health and all its consequences are regarded as sufficient punishment.

Ill-health from any cause, voluntary or involuntary, brings punishment with it to the sufferer in the shape of poverty and loss of the amenities of life. It is a biological, if not a man-made social law that no downward departure from the normal lacks its attendant punishment.

We cannot here discuss whether risks taken are worth while or not, whether ten years of intensified effort followed by a breakdown are worth more to the individual or to the community than thirty years of less intense effort followed by no breakdown. It is certainly true that a great force acting for a short time may accomplish something which a lesser force, even though it act for a long time, might never accomplish, and it is for the future to decide whether voluntary breakdowns are to be condemned as sins against the community and whether the community should accept the voluntary sacrifice of individuals for the apparent general good. One thing at least seems clear, a voluntary breakdown for a purely individualistic and selfish motive cannot on any ground escape condemnation.

These particular points do not, however, affect the main issue. It is comparatively seldom that the good of the community as a whole is dependent on the efforts of an individual. We are here concerned with the widespread ignorance and indulgence of mankind which results in much ill-health, misery and distress, and lessens the total sum of the happiness and the wealth of the community.

Let us go over the question systematically and see, if we can, what individual man can do to avoid disease and remain healthy.

Comparatively few children, perhaps 30 per 1,000 births, are born so defective that they cannot survive for long. Thus the totally unfit are speedily eliminated and the remaining 970 ought, accidents and disease apart, to live out the natural term of life. Our knowledge of ante-natal influences and ante-natal pathology is not yet sufficient