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Country-wide rapid epidemiological mapping of onchocerciasis (REMO) in Cameroon

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The prevalence of infection in local communities has been used as the basis for the country-wide repartition of onchocerciasis in Cameroon, following the principles for rapid epidemiological mapping of onchocerciasis (REMO) developed by the World Health Organization. The levels of endemicity were evaluated in 349 villages by rapid epidemiological assessment (REA), a method based on the examination of nodules in males aged ≥20 years. An onchocerciasis map was then drawn from the epidemiological data which had been collected previously, from clinico-parasitological surveys based on the examination of skin snips, and the results of the REA surveys. The REMO surveys allowed the main onchocerciasis foci in Cameroon to be accurately delineated, and several small endemic areas which had never been reported before to be identified. The total 'at risk' population (i.e. those for which ivermectin treatment should be considered as urgent or highly desirable) was estimated by combining the epidemiological results and the demographical data available from an administrative census. Those at risk were estimated to number 3.5 million, representing about 50% of the total rural population in Cameroon.

Ivermectin (Mectizan®) has proved to be a very effective and safe drug for large-scale treatment of onchocerciasis. In 1987, the manufacturers, Merck and Co. Inc., decided to donate the drug, free of charge and for as long as needed, to any government or non-governmental development organization (NGDO) involved in onchocerciasis control. As a result of this decision, country-wide ivermectin distribution programmes (IDP) are being developed in most of the countries where the disease is endemic, in the hope that onchocercal blindness and severe skin disease can be prevented in the near future. Most of those countries which, though at-risk, are outside of the area of the Onchocerciasis Control Programme in West Africa (OCP), are now covered by the

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African Programme for Onchocerciasis Control (APOC). In the APOC area, no large-scale vector-control operations can presently be envisaged and control of onchocerciasis depends almost entirely on ivermectin. Although Mectizan® is available at no cost, governments and NGDO planning IDP still have to pay for the drug's distribution. There is general agreement that the drug should be distributed first to those communities whose members are at risk of developing the severe and disabling ocular or dermal complications of onchocerciasis (Taylor *et al.*, 1992). In general, this risk is directly related to the intensity of infection in the community (Remme *et al.*, 1989). There are several reviews which present data on the distribution of onchocerciasis outside of the OCP area and give information on the most severely affected regions (Crosskey, 1981; Boussinesq, 1991*a*; Fain, 1991). However, the epidemiology of onchocerciasis remains unknown in many areas, one of which is Cameroon, and surveys have to be carried out urgently to fill these gaps in our knowledge. The classical parasitological method for assessing the endemicity of onchocerciasis in a region, based on the examination of skin snips, cannot be used routinely because it is unpopular, time-consuming, costly, and may spread hepatitis B virus and HIV. The World Health Organization has therefore adopted and developed an alternative method, known as rapid epidemiological assessment (REA), which is based on the prevalence of nodules in males aged ≥ 20 years and which was suggested by Taylor *et al.* (1992). Using this method to assess community endemicity levels, and selecting communities according to the principles described by Ngoumou *et al.* (1994), it has been possible to accomplish an initial rapid epidemiological mapping of onchocerciasis (REMO) over almost the whole of Cameroon. Now that the main endemic areas have been defined by REMO, further REA within those general areas which are selected for IDP will reveal exactly which communities are above the threshold level of endemicity that calls for mass treatment with ivermectin.

The aims of the present study were: (1) to produce a map of the general distribution of onchocerciasis in Cameroon, by combining the results of a considerable number of clinico-parasitological surveys (CPS), carried out for public health or research purposes before 1993, with the results of the REA surveys during 1993–1995; and (2) to estimate the total number of people exposed to severe onchocerciasis in Cameroon by combining all the epidemiological and demographic data available.

SUBJECTS AND METHODS

At the time of launching the REMO exercise in Cameroon, it was decided that no REA surveys would need to be performed in five areas because epidemiological data were already available for them from previous, large-scale CPS. These areas were the wide belt which extends across the Sudan-savanna area in the North Province (Anderson *et al.*, 1974; Le Bras *et al.*, 1976; Louboutin-Croc and Madi Kambaba, 1983; Boussinesq, 1991*b*; M. Boussinesq, unpubl. obs.), the limited focus in the Extreme-North Province (Pabot du Chatelard *et al.*, 1978; Stéveny *et al.*, 1981; Marceau *et al.*, 1986), the region of forest-savanna mosaic located in the Central Province, at the confluence of the Sanaga and Mbam Rivers (Ripert *et al.*, 1977; M. Boussinesq, unpubl. obs.), the forested Mungo and Meme Valleys in the South–West Province (Duke *et al.*, 1972; Anderson *et al.*, 1974; Moyou Somo *et al.*, 1993), and the forested Dja Valley area in the South Province (Kollo, 1993; J. Gardon, unpubl. obs.) (Figs 1 and 2). REA surveys were planned in the remaining areas, the data for which were very scarce, rough or completely absent. Despite the availability of clinico-parasitological data (Brengues *et al.*, 1975), REA surveys were performed in the Noun Valley (West Province) because more accurate information was considered necessary to plan a rational IDP in this very densely populated area.

Clinico-parasitological Surveys (CPS)

The numbers of communities and patients examined during the large-scale CPS carried

out before 1993 are summarized in Table 1. All, except those carried out in the Dja Valley, were based on examination of both nodules and skin snips in people of both sexes aged ≥ 5 years. During the CPS carried out by the *Institut Français de Recherche Scientifique pour le Development en Coopération* (Boussinesq, 1991*b*; M. Boussinesq, unpubl. obs.), the prevalences of microfilariae were age- and sex-standardized using the OCP method (Moreau *et al.*, 1978).

REA/REMO Surveys

The REMO survey carried out during 1993–1995 followed the principles described in detail previously (Ngoumou *et al.*, 1994). Briefly, the process was developed in three successive stages. First the country was divided into six major bioclimatic/biogeographic divisions (BGD), which were then further sub-divided, on the basis of the watersheds of the major river-drainage systems, into a total of 21 zones (BGZ), each showing more or less uniform hydrology in relation to potential breeding sites for the *Simulium* vectors. Each zone was considered to be uniform with respect to the pattern of onchocerciasis transmission and, within it, a sample of communities considered most likely to be highly endemic for onchocerciasis was chosen for survey, using the REA method of Taylor *et al.* (1992). The detailed logical process used for the zoning, and the map obtained, have already been presented (Ngoumou *et al.*, 1994). During this stage, the areas to be excluded from REA survey were also identified. These included: (1) the regions known as 'empty zones', where the human population density is < 1 inhabitant/km^2 (i.e. national parks, game reserves, areas of dense forest, and the large savanna area located south of the Adamaoua Plateau); and (2) the areas totally unsuitable for the breeding of blackflies (e.g. the densely populated but swampy area in the eastern part of the Sahelian Extreme-North Province, and the summit area of Cameroon Mountain).

The second stage of the REMO consisted of selecting the communities to be surveyed within each BGZ. The main criteria used were the distance between the communities and the rivers, and the location of the communities in first, second, or third line, according to the criteria defined in West Africa (Rolland and Balay, 1969). In addition, the selection was performed so that the maximal distance between one selected village and the next was ≤ 50 km. Using this method, a total of 322 villages was selected for REA.

The third stage consisted in carrying out the REA surveys themselves. The REA team had four members (i.e. supervisor, nurse, driver, and interpreter). The co-ordinates of the villages surveyed were recorded with an accuracy of 1 km using a global positioning system (Pyxis® IPS360, Sony). The REA was based on the examination, in each selected community, of a sample of 30 adult males, aged ≥ 20 years, for the presence of nodules (Taylor *et al.*, 1992). The sample was selected randomly from those residents whose activity was principally rural.

Additional REA Survey in the Northern Part of the North Province

In 1992, the NGDO River Blindness Foundation, in co-operation with the Cameroon Ministry of Public Health, launched a mass IDP in the North Province of Cameroon. Baseline data were available from the CPS quoted above, but the northern limit of the meso- and hyper-endemic area was not well defined. A specific REA survey was therefore carried out to determine this boundary. This was an important issue because it was decided that the hypo-endemic communities of the focus should only receive clinic-based treatment. Owing to the greater degree of accuracy required, the selection of the villages to be surveyed was not done using the REMO procedure described above. Rather, it was performed so that the maximal distance between one selected village and the next was at the most 5 km, and it included 68 villages. Otherwise, the examination was carried out following the protocol described above.

Indices used for Assessing Endemicity Levels

As the cornerstone of the present study was the REA survey, the main index used for

TABLE 1

The numbers of communities surveyed (NCS) and subjects examined (NSE) and the epidemiological indices recorded during the clinico-parasitological surveys of onchocerciasis in Cameroon prior to 1993

Survey area	*NCS*	*NSE*	*Index**	*Reference*
Mandara Mountains, Extreme-North Province	7	1039	PN, PMF	Stéveny *et al.* (1981)
	7	1000	PN, PMF	Marceau *et al.* (1986)
Koza, Extreme-North Province	17	2657	CPI	Pabot du Chatelard *et al.* (1978)
Vina-Mbere Basin, North Province	6	1126	PN, CPI	Anderson *et al.* (1974)
	13	1801	PN, PMF	Le Bras *et al.* (1976)
	39	11 416	CPI	Louboutin-Croc and Madi Kambaba (1983)
	49	8828	PN, PMF	Boussinesq (1991*b*)
Benoue Valley, North Province	5	795	PN, CPI	Anderson *et al.* (1974)
	8	2124	CPI	Louboutin-Croc and Madi Kambaba (1983)
	7	1489	PN, PMF	Boussinesq (1991*b*)
Faro-Deo Basin, North Province	48	6980	PN, PMF	Louboutin-Croc and Madi Kambaba (1983)
	14	1643	PN, PMF	M. Boussinesq (unpubl. obs.)
Sanaga Valley (left bank), Central Province	5	1132	PN, PMF	Ripert *et al.* (1977)
	25	4678	PN, PMF	M. Boussinesq (unpubl. obs.)
Sanaga Valley (right bank), Central Province	39	7283	PN, PMF	M. Boussinesq (unpubl. obs.)
Noun Valley, West Province	12	1039	PN, PMF	Brengues *et al.* (1975)
Mungo and Meme Valleys, South–West Province	4	702	PN, PMF	Duke *et al.* (1972)
	11	1913	PN, CPI	Anderson *et al.* (1974)
	4	1213	PN, PMF	Moyou Somo *et al.* (1993)
Dja Valley, South Province	12	1567	PMF	J. Gardon, unpubl. obs.
	32	846†	PN, PMF	Kollo (1993)

*PN, Prevalence of nodules; PMF, prevalence of skin microfilariae; CPI, clinico-parasitological index (percentage of patients with nodules and/or skin microfilariae).

† All males aged 20 years.

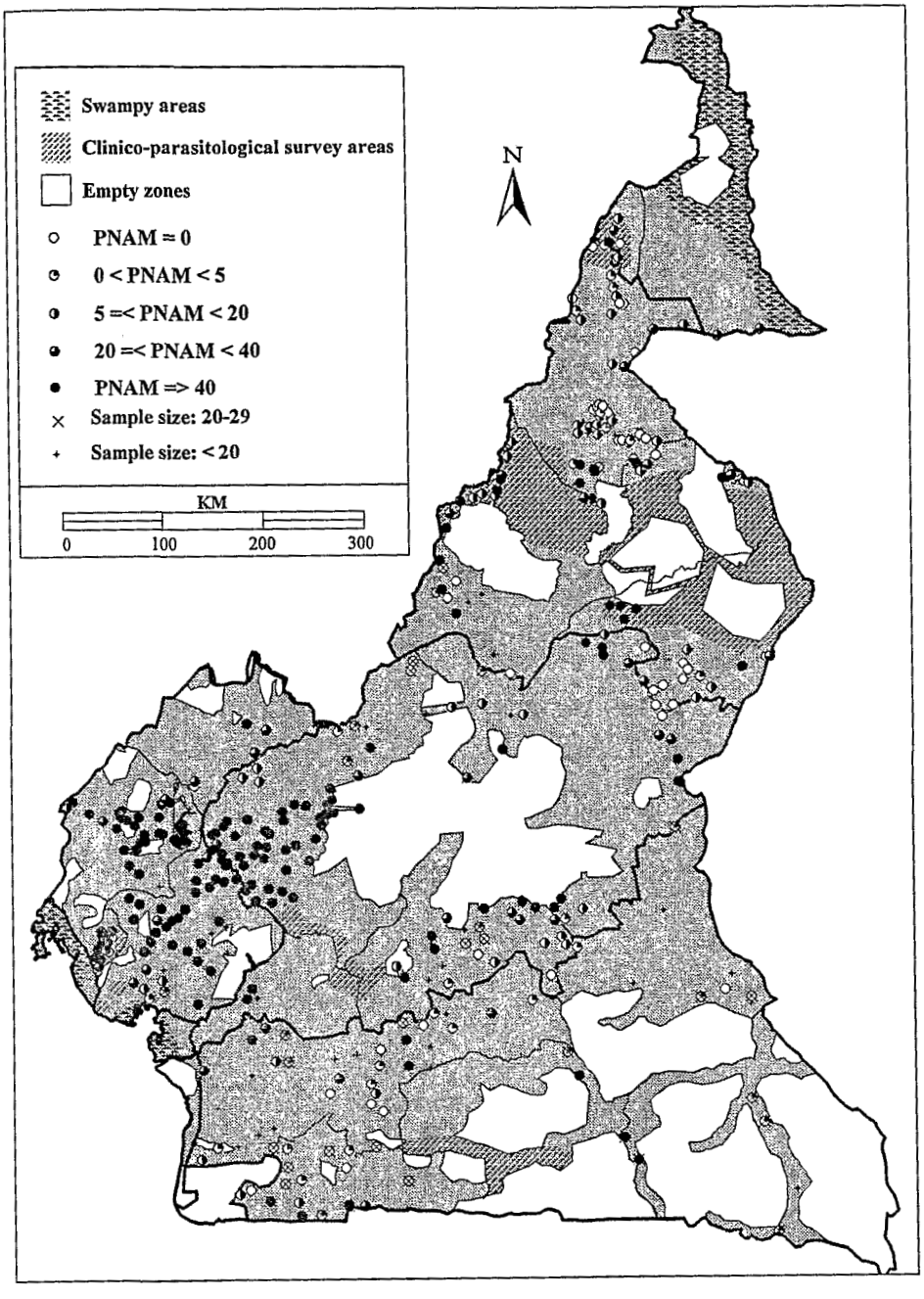

Fig. 1. Levels of onchocerciasis endemicity in the villages examined in the rapid epidemiological assessment surveys and earlier clinico-parasitological (CP) surveys. Endemicity, measured as the prevalence of nodules in males aged ≥ 20 years, is shown as ○ (0%), ○ (< 5%), ◑ (5%–19%), ◕ (20%–39%) or ● (≥ 40%). Villages where 20–29 subjects (×) or < 20 subjects (+) were examined are indicated. The boundaries of biogeographic divisions (—) and zones (—) are also shown.

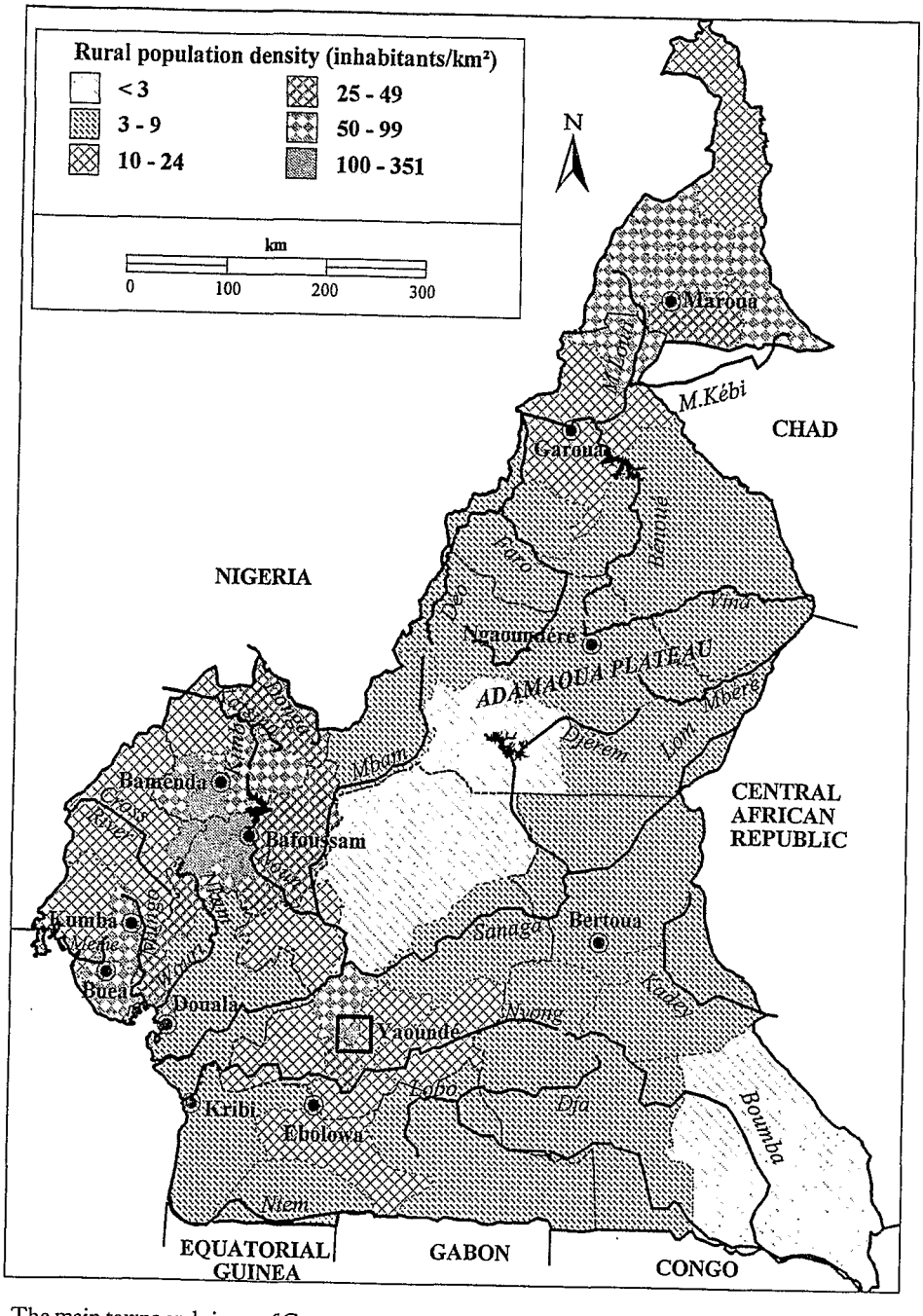

Fig. 2. The main towns and rivers of Cameroon, the rural population densities in each administrative division (*département*) and the boundaries of the provinces --- and *départements* .....

defining the endemicity levels in the villages was the prevalence of nodules in adult males aged ≥20 years (PNAM). The WHO had defined that ivermectin treatment was urgent when the PNAM was ≥40%, and highly desirable when the PNAM was 20%–39% (WHO, 1991). In the present study, villages were classified as hyper-, meso-, hypo- or non-endemic depending on the value for PNAM (≥40%, 20%–39%, 5%–19%, and <5%, respectively). In some small villages, the target size of sample (30 men) could not be reached. In such places, a sample of 20 men was regarded as giving a satisfactorily representative picture of local endemicity.

As, in most of the villages surveyed in the previous CPS, the population examined included >20 adult males, a reasonable PNAM value could be calculated from the CPS data. In the few communities where <20 adult males had been available, the parasitological results obtained from skin snips were considered to give an accurate estimate of the endemicity level when >100 residents aged ≥5 years had been examined. Hyper-, meso-, hypo- and non-endemic communities were then distinguished on the basis of the prevalence of skin microfilariae (PMF) (≥60%, 40%–59%, 20%–39% and <20%, respectively). The values corresponding to hyper- and meso-endemicity correspond to those proposed previously to define communities where ivermectin treatment should be considered as urgent and highly desirable, respectively (WHO, 1991).

Mapping

All the villages examined as part of the REMO project and the additional REA survey in the North Province were plotted on a map, using a geographical information system (Atlas GIS®, Strategic Mapping Inc.). The villages in which >20 adult males were examined were plotted in the form of pie charts showing the levels of endemicity. Amongst these villages, those in which 20–29 persons were examined were represented differently from those where the sample size was higher, so that the less reliable values could be distinguished easily. The few communities in which <20 adult males were examined were also plotted on the map, but the corresponding estimates of endemicity were not indicated.

As those villages in the areas examined during the CPS were usually relatively close to one another, they were not plotted on a map in the same way as the REA villages. However, all the data available from the REA surveys and CPS were combined in another map, in which the hyper-, meso- and hypo-endemic areas of each focus were delineated. The limits of the administrative divisions, which are the units used to estimate the number of people exposed to onchocerciasis (see below), were included on this map.

Estimation of the Population Exposed to Onchocerciasis

The population exposed to onchocerciasis was estimated by combining the epidemiological data obtained from the CPS and REA surveys with the demographic data available from the 1987, country-wide, population census. The geographical units used for estimating the exposed population were administrative divisions, for which demographic data were available, and not the bio-geographic divisions used for selecting the villages to be surveyed. For various reasons, the demographic data recorded at the lowest administrative levels (i.e. the village and the 'canton') were not available. The administrative unit used to estimate the population exposed to onchocerciasis therefore had to be at the higher level of district ('*arrondissement*'). At this level, the 1987 census distinguished urban and rural populations. As the urban population was not thought to be exposed to significant onchocerciasis transmission, the estimates of the population exposed to onchocerciasis were calculated on the basis of the rural population. The population in 1995 was estimated from the 1987 figures by assuming an increase of 2.9% per year.

No attempt was made to delineate the hyper-, meso- or hypo-endemic areas within a given *arrondissement*. As the population within an *arrondissement* was often not homogeneously distributed, the proportions of the

TABLE 2

Distribution of the villages surveyed by rapid epidemiological assessment of onchocerciasis, according to the numbers of subjects/village (s/v) and the level of endemicity

	No. of villages in main survey			*No. of villages in survey in North Province*		
Endemicity	*≥ 30 s/v*	*20–29 s/v*	*≥ 20 s/v*	*≥ 30 s/v*	*20–29 s/v*	*≥ 20 s/v*
Non-endemic	50	13	63	17	0	17
Hypo-endemic	35	15	50	24	1	25
Meso-endemic	29	4	33	9	0	9
Hyper-endemic	126	15	141	9	2	11
All	240	47	287	59	3	62

population exposed to hyper-, meso- and hypo-endemicity could not be estimated from the proportions of communities found to be hyper-, meso- or hypo-endemic in the CPS or REA surveys. The level of endemicity was thus considered homogeneous within an *arrondissement*, and this level was defined by the highest level recorded amongst all the villages surveyed in the *arrondissement*. Following these principles, the 'population exposed to onchocerciasis' or the 'population at risk' was defined as the total rural population living in the *arrondissements* where at least one meso- or hyper-endemic village was detected by the CPS or REA surveys. Although geographical and information constraints led to this definition, it is probably a very useful definition, in terms of any subsequent organization of ivermectin distribution, because the *arrondissements* usually correspond geographically to health districts ('*districts sanitaires*'), at which level the health activities, including ivermectin distribution, are organized.

RESULTS

Results of the REA Surveys

A total of 10 712 males aged ≥ 20 years, living in 322 communities, was examined as part of the main REA/REMO survey. The number of men examined exceeded 30 in each of 240 of these villages, ranged between 20 and 29 in another 47, and was < 20 in the 35 remaining communities. A total of 1831 males aged ≥ 20 years, living in 68 communities, was examined as part of the additional REA survey carried out in the North Province; the number of men examined exceeded 30 in 59 of the 68 communities and ranged between 20 and 29 in three others.

Combining the results from both REA surveys, Fig. 1 shows the endemicity levels of the 349 communities in which at least 20 males were examined, and Table 2 shows the distribution of the surveyed villages according to their level of endemicity.

Distribution of Onchocerciasis in Cameroon

Figure 3 combines the results of both REA surveys with those of the CPS, and demonstrates that five main hyperendemic foci exist in Cameroon. Four of them have been described by CPS: the two contiguous savanna foci extending across northern Cameroon in the Vina-Mbere and Benoue Basins; the Dja and Lobo forest focus in southern Cameroon; and the focus located along the Sanaga River and the lower part of the Mbam River, before its confluence with the Sanaga. The REA surveys provided additional accurate details on the limits of these previously known foci, such as the southern and northern limits of the two contiguous foci extending across the North Province. However, the main findings concerned the western limits of the Sanaga-Mbam focus, where the REA/REMO surveys demonstrated that the hyperendemic areas extended westwards along the Noun River, which is the main tributary of the Mbam River, and that most of the West Province was

hyperendemic for onchocerciasis. In addition, the REA surveys gave original data on the hyperendemic areas located in the South–West Province in the Cross River Basin, and demonstrated that there is a continuity between this focus and the Sanaga-Mbam-Noun focus. These results are particularly important because the West and South–West Provinces are densely populated.

Other interesting data concerned the areas in which information was scarce, particularly the South and East Provinces, where the REA survey showed that, apart from the previously known Dja and Lobo focus and a limited focus along the Ntem River, onchocerciasis was usually non-endemic or only hypo-endemic. Similarly, the levels of endemicity were found to be fairly low in the western part of Adamaoua Province, which had never been surveyed previously.

Estimation of the Population Exposed to Onchocerciasis

Cameroon is divided into 10 provinces and 58 administrative '*départements*'. In 1987 (i.e. the year for which demographic data are available), the 58 *départements* were divided into 215 *arrondissements*. In all, 108 *arrondissements* have been surveyed, either by REA or by clinico-parasitological methods, and hyperendemic communities have been recorded in 80 of them. Some of the communities in another 11 *arrondissements* were meso-endemic, although no village in these areas was found to be hyperendemic. Thus 91 *arrondissements* were classed as meso- or hyperendemic and therefore 'at risk'. In 1995, the whole rural population 'at risk' was estimated to be 3 330 000 people (2 795 000 and 535 000 people in hyper- and meso-endemic *arrondissements*, respectively).

DISCUSSION

The present results demonstrate the feasibility of country-wide epidemiological mapping of onchocerciasis using the rapid assessment method, which was proposed by Taylor *et al.* (1992) and further developed by WHO. In Cameroon, the REA surveys were carried out by a team of four people who covered some 33 000 km during 175 days. The survey cost about U.S.$40 000, or U.S.$3.73/person examined. This amount, which includes the *per diems* of the team, the fuel and the maintenance of one vehicle, might be considered as reasonable, especially as *per diems* are relatively high in Cameroon.

The only alteration which was made to the REA/REMO protocols of Taylor *et al.* (1992) and Ngoumou *et al.* (1994) was in the minimum sample size considered acceptable for an accurate estimate of the level of endemicity. Taylor *et al.* (1992) and Ngoumou *et al.* (1994) thought at least 30 adult males ought to be examined to give a representative picture of the community surveyed. Although attempts were made to examine this number in each of the present study communities, samples were sometimes smaller. Rather than ignore all of the data for the smaller samples, endemicity was estimated for communities where only 20–29 adult males could be examined. Figure 1 shows that the results obtained in these villages, usually small ones, are generally similar to the levels of endemicity recorded in the neighbouring communities where >30 persons could be examined. It therefore appears that a sample of 20–29 adult males is acceptable and can give useful data as part of a REMO.

At present, Cameroon and Nigeria are the only two countries where a REMO has been completed, (i.e. where most of the high-risk communities have been located; Anon., 1996). However, several areas have not yet been surveyed in Cameroon because, although not corresponding to 'empty zones', they were sparsely populated (less than two inhabitants/km^2) and/or because the endemicity of onchocerciasis in them is assumed to be low. These areas were the swampy coastal area near the boundary with Nigeria (BGZ Vb), the coastal strip between the mouth of the Sanaga and the boundary with Equatorial Guinea (BGZ Va), the Upper-Sanaga (Djerem) and Lom Valleys (BGZ IIIc), and the Kadei Valley (BGZ IVb). The fairly densely populated North–West Province (BGZ VIb), in which

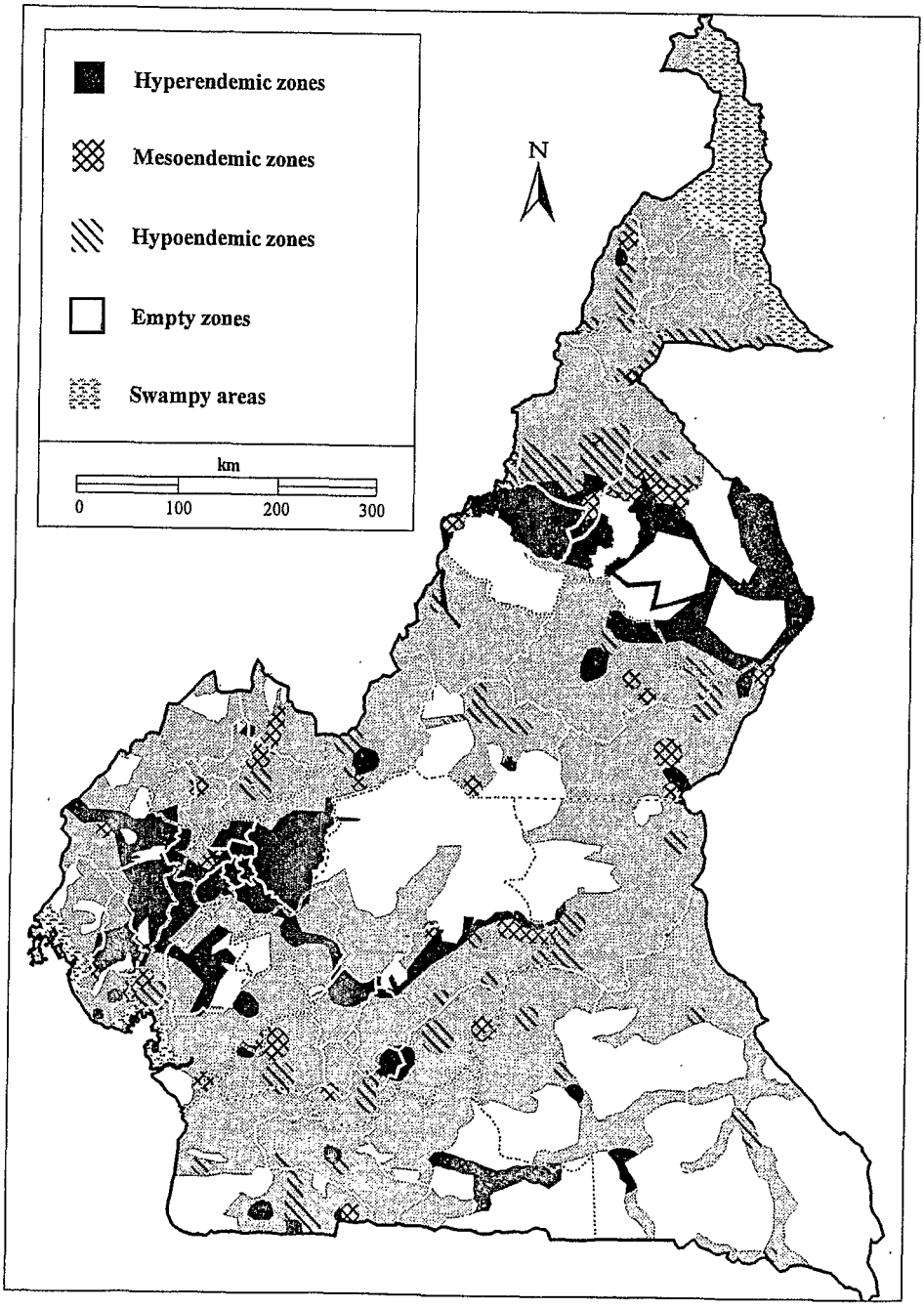

Fig. 3. Distribution of areas endemic for onchocerciasis in Cameroon. The boundaries of the provinces (.. .. ..) and *départements* (white lines) are also shown.

the villages along the tributaries of the Kimbe, Katsina Ala and Donga Rivers are probably highly endemic (Duke, 1967), could also not be surveyed for logistical reasons. Additional REA surveys should thus be performed in these few areas in order to complete the map of onchocerciasis in Cameroon.

Those areas of Cameroon that have not yet been surveyed by any CPS or REA/REMO survey include: (1) the areas (just mentioned) that still need to be surveyed (53 *arrondissements*); (2) the areas excluded at the first stage of the REMO process (five *arrondissements* in areas where the population density is less than one inhabitant/km^2 and 27 *arrondissements* in areas totally unsuitable for the breeding of blackflies); (3) the 15 urban *arrondissements*; and (4) the seven *arrondissements* where the samples in each village were all of <20 adult males. Overall, 107 *arrondissements*, containing 3 173 000 people, have never been surveyed.

In Cameroon, the REA surveys have served to define the limits of previously reported foci and have provided detailed information on several hyperendemic areas for which the data were fairly scarce. The largest of the latter areas spreads through the West and South–West Provinces, where the population density is very high (exceeding 50 people/km^2 in most areas). Such high population densities may have epidemiological consequences. In the West African savanna, Prost *et al.* (1979) found that the prevalence of onchocercal blindness in a given community was partly related to population density. It seems that high population densities do not influence the prevalence of infection but lead to a 'dilution' of the intensity of transmission, and thus to a low mean microfilarial density in the communities. The results of a recent parasitological survey (J. Kamgno, unpubl. obs.) indicate that such a phenomenon may occur in the West Province of Cameroon; although 30 of the 41 villages surveyed were hyperendemic according to the PNAM, only five had a community microfilarial load (Remme *et al.*, 1986) above 20 microfilariae/skin-snip. The clinical consequences of onchocerciasis in this area, which may thus be relatively mild despite high levels of endemicity, should be investigated further.

Besides the identification and delimitation of the most severe onchocerciasis foci, the results of REMO may be very helpful in evaluating the populations at risk, for which IDP are urgent or highly desirable, and in planning the number of Mectizan® tablets to distribute every year in a given country. This is all the more useful in the framework of the launching of APOC, which aims to develop self-sustaining, country-wide, community-directed treatments with ivermectin in 16 endemic African countries outside the OCP (Remme, 1995).

Ideally, the most elementary health divisions should be used to estimate the populations exposed to hyper-, meso- or hypoendemicity very accurately. In Cameroon, these elementary divisions are the health areas ('*aires de santé*'), each of which covers several villages. Unfortunately, as no demographic data exist for the health areas in Cameroon, these divisions could not be used to estimate the total population at risk. The calculation had to be based on the higher level of health district, each of which generally corresponds geographically to an administrative *arrondissement*. Using this method, the population at risk, as defined above, was estimated to be about 3 330 000. Adding estimates of the 'at-risk' populations in the few areas where surveys are still needed to complete the map, especially the North–West Province, the total population at risk becomes roughly 3.5 million, or about 50% of the total rural Cameroonian population. These values confirm that onchocerciasis is an important public-health problem in Cameroon. Moreover, although they represent the number of people exposed to infection and not the population actually infected, these values suggest that the estimate of the number of infected people in Cameroon (1.3 million), made before the launching of the REMO (WHO, 1995), was too low.

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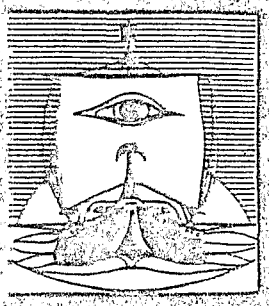

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