INDEXED

WORLD HEALTH ORGANIZATION
ORGANISATION MONDIALE DE LA SANTÉ

WHO/VBC/71.284

ENGLISH ONLY

BIBLIOTHÈQUE OMS - 7 JUIL. 1971 WHO LIBRARY

A VILLAGE SCALE FIELD TRIAL OF OMS-1211 (IODOFENPHOS) FOR THE CONTROL OF ANOPHELES GAMBIAE AND ANOPHELES FUNESTUS IN NORTH CENTRAL NIGERIA

by

R. E. Fontaine,[1] P. Rosen,[2] M. Ramasamy[3] and P. G. Renaud[4]

A village scale field trial of OMS-1211[5] was carried out in 1970 by the WHO/ACRU I, Kaduna, Nigeria to assess the residual effectiveness of this organo-phosphorus insecticide against the two principal local malaria vectors, An. gambiae and An. funestus.

The insecticide was previously evaluated with promising results in an experimental hut trial at ACRU I and also at the Tropical Pesticides Research Institute, Arusha, Tanzania and the Centre Muraz ORSTOM/OCCGE, Bobo Dioulasso, Upper Volta.

The insecticide showed such promise in these preliminary trials that a village scale trial (Stage V) was undertaken in 1969 on the basis of one round of spraying at the village of Rigachikun near Kaduna. From the evidence of the 1969 trial reported in document VBC/70.5, it was not conclusive that one round of spraying was sufficient to determine the potential of OMS-1211 in an area-wide trial employing two or more rounds. Therefore, a trial based on two rounds was planned and executed in 1970.

MATERIALS AND METHODS

Site of trial

The three villages comprising the trial area were situated 15 miles south of Kaduna in the Kujama district of Zaria province, North Central State, Nigeria.

Two villages, Riddo Hausa and a neighbouring satellite hamlet Riddo Leman hereafter designated Riddo Hausa - Leman, were selected for spraying. A third village, Riddo Hayi, located about 2.4 km from the sprayed village served as the unsprayed comparison or check village for the trial. The villages offered excellent conditions for entomological evaluation because of uniformly good hut densities of An. gambiae and year-round high densities of An. funestus. These malaria vectors emerged from common breeding sources associated with a seasonal stream and a small river, well within a mile of the villages.

The sprayed village consisted of a complex of closely spaced family compounds with habitations constructed of mud and wattle walls and thatched roofs typical of most rural dwellings in the Kaduna area. Each family compound included several smaller outbuildings used

---

[1] Project Leader, [2] Entomologist, [3] Chemist and [4] Technical Officer of the WHO Anopheles Control Research Unit I, P. O. Box 503, Kaduna, Nigeria.

[5] OMS-1211 is O-(2,5-dichloro-4-iodophenyl) O,O-dimethyl phosphorothioate also known as Iodofenphos and Ciba C-9491.

The issue of this document does not constitute formal publication. It should not be reviewed, abstracted or quoted without the agreement of the World Health Organization. Authors alone are responsible for views expressed in signed articles.

Ce document ne constitue pas une publication. Il ne doit faire l'objet d'aucun compte rendu ou résumé ni d'aucune citation sans l'autorisation de l'Organisation Mondiale de la Santé. Les opinions exprimées dans les articles signés n'engagent que leurs auteurs.

for various domestic purposes such as kitchens, animal shelters and food storage. Altogether there were 409 houses and other sprayable structures in the sprayed village. Details of the number and type structures are given in Table 1.

Insecticide formulation

The insecticide, a water dispersible powder 50 per cent. formulation, was received in Kaduna in six drums on 18 March 1970. Samples from the drums consisted of a fine white powder with free-flowing characteristics. The suspensibility in distilled water without pre-treatment was exceptionally good (98.8 per cent.) and very little sediment was present in the prepared suspensions. However, after accelerated storage for two hours at 54°, 70° and 90°C, suspensibility fell from 98.8 per cent. to 76 per cent., 56.7 per cent. and 40.3 per cent. respectively. Table 2 presents details of the formulation analysis.

Spraying operations

The full data on the spraying operations in the first and second rounds are given in Table 3.

First round. The first round of spraying was accomplished in three days between 30 April 1970 and 4 May 1970, during which time 409 structures were sprayed by a crew of three spraymen, one mixer and a foreman.

The insecticide was pre-packaged in 800 grams pump charges and after mixing with village well water it was strained through a fine mesh screen before filling the sprayers. The formulation readily went into suspension, was free of gritty sediment and showed only moderate frothing. There was no sludge or other sediment in the spray tanks and the slight odour on spraying was scarcely perceptible by the following day.

There were 64 kilograms of 50 per cent. wdp. used in the operation. Allowing for a 10 per cent. wastage factor the amount effectively sprayed in grams of technical material per square metre was 1.87, somewhat less than the target dosage of 2 g/m^2.

Second round. The second round was applied on 22/23 July 1970, about 11 weeks after the first round using the same procedure and consignment of insecticide.

Although held in storage for an additional 81 days, the formulation went readily into suspension on mixing in the field and was free of gritty sediment and sludge. However, the chemical analyses (see Table 2) indicated some loss of suspensibility in the accelerated storage test. The average dosage rate was 1.83 g/m^2, nearly the same as the first round.

Safety investigations

The compound was fully investigated for safety in the 1969 Stage V trial and there were no adverse effects on spray operators or village inhabitants attributable to the insecticide. The report of the safety studies on the 1969 study was issued in WHO document VBC/ETI/69.9.

Fate of the insecticide on sprayed surfaces

In one hut selected for chemical studies in the trial village, the amount of OMS-1211 on the mud-wall surface to a depth of 1 mm in the first round declined rapidly from an estimated 2.27 g/m^2 to 0.75 g/m^2 in 30 days. The average rate of loss during this period was 50.7 $mg/m^2/day$. At least 27 per cent. of the sprayed insecticide was not present to a depth of 1 mm within 10 days of spraying due to sorption. Sorption and decomposition occurred concurrently. About 20 per cent. of the sprayed insecticide was decomposed on mud walls within 60 days of spraying. There was no evidence of the presence of OMS-1211 vapour in the air inside sprayed huts.

The build-up of active ingredient after a second round of spraying on mud walls was 1.87 g/m^2 but on thatched roofs it was only 0.72 g/m^2, possibly due to insufficient spraying. The average amounts present on the 62nd day after the second spray on mud walls and thatched roofs were 19.6 per cent. and 24.7 per cent. respectively of the total insecticide sprayed during two rounds. Further details of the fate of OMS-1211 on treated surfaces are reported in WHO document WHO/VBC/71.260.

Entomological evaluation

The entomological evaluation of the insecticide application consisted of the measurement of the following parameters at fortnightly intervals.

The resting density of An. gambiae and An. funestus was assessed by pyrethrum spray captures made shortly after dawn in the 10 houses in the sprayed and check villages. Collections were recorded by species, sex, numbers captured and classified according to abdominal condition.

The numbers of anophelines leaving the houses at night were estimated by door exit-traps. The traps were placed over the open doorways of 10 houses shortly before sundown and removed early the next morning immediately before the pyrethrum spray capture which was made in the same huts. The collections were differentiated according to sex, species and abdominal condition and the survival rate recorded after a 24-hour holding period.

The contact between man and mosquitos indoors and outdoors was assessed by human bait catches in the sprayed and unsprayed villages from dusk to dawn using two baits indoors and two outdoors. Collections were identified and determinations made of the parous rates of An. gambiae and An. funestus.

The persistence of insecticide deposits on mud walls and thatched surfaces was determined by bio-assays made fortnightly employing the WHO bio-assay technique with fed, colony An. gambiae.

Because of the dry season scarcity of An. gambiae in the trial area, first noted in early November, further assessment of the insecticide against this species was not feasible with natural populations beyond the 98th day following the second spraying. But since bio-assays showed the insecticide to be still effective against the species at the 153rd day of the second round, a special assessment was made 189 days after the second spraying employing a release and recapture technique in which 50 colony-bred An. gambiae fed females were introduced into each of 10 huts in the sprayed and check village.

RESULTS OF ENTOMOLOGICAL EVALUATION

Spray capture

The data on the resting densities of An. gambiae and An. funestus as determined by the spray captures in the treated village before and after spraying and for the first and second rounds is presented in Table 3. In interpreting the data it should be clarified that the pre-spray captures in the sprayed and comparison villages were made in the late dry season in April just before the wet season build-up of An. gambiae which in the area of this trial normally occurs in the first month of heavy rainfall in May. The explosive natural increase in An. gambiae during this period is very clear from the data on the check village which shows a rise in density from 2.6 females per hut on 22 April to 40.0 per hut on 12 May 1970.

As noted in Table 3, 10 days following the spraying of the first round an average density of only 0.1 An. gambiae per hut was recorded compared with 40.0 in the check village, thus clearly demonstrating the effectiveness of the insecticide.

During the 81-day period of the first round evaluation, the six fortnightly spray captures in the treated village averaged only 0.46 An. gambiae per hut compared with an average of 21.0 in the check village.

The very low densities shown in Table 3 on 7 July in the spray and exit-trap captures was attributed to inhibition of mosquito activity due to a local storm the previous night which brought heavy rain and a drop in temperature to 19°C.

The insecticidal effectiveness was further demonstrated by spray captures of An. funestus. The pre-spray average of 9.6 per hut fell to 0.1 per hut in the treated village on the 10th day after spraying compared with a density of 33.6 per hut in the check village. The spray captures covering the full period of the first round assessment in the sprayed village averaged 0.33 females compared with 21.9 in the check village.

In the second round the natural densities of An. gambiae were considerably higher than the first round in the period corresponding with the first 85 days after spraying. This is seen in the data for the check village in Table 3. The high density coincided with the peak period of annual rainfall in August and September and made possible an excpetionally good assessment of the effectiveness of the insecticide. Despite the high densities, the captures in the sprayed village remained low, ranging from an average of 0.2 to 4.7 per hut compared with 18.3 to 66.7 in the check village. After the advent of the dry season in October, An. gambiae virtually disappeared from the area, making further assessment against this species impracticable beyond 98 days after spraying the second round.

The insecticidal effect against An. funestus was even more pronounced than with An. gambiae. For example, on only one occasion throughout the 153-day period of the routine assessment did the average density in the sprayed village exceed 1.0 per hut, whereas in the check village it ranged from 14.9 to 100.1 per hut. Taking the second round period as a whole the average capture in the sprayed village was only 0.32 per hut compared with 40.4 in the check village. In contrast to An. gambiae, An. funestus continued to maintain high densities during the dry season which permitted continuing assessment of the insecticide despite the absence of An. gambiae.

Exit-trap collections

The pre-treatment exit-trap captures of An. gambiae shown in Table 4 were relatively light, reflecting the low dry season natural densities noted before under spray captures. The density averaged only 3.6 per trap eight days before spraying declining to 0.2 unfeds per trap 10 days after spraying. On the same day the density in the check village averaged 7.3 females of which 6.8 were fed and gravid.

The six fortnightly exit-trap captures made in the sprayed village during the first round assessment averaged only 0.56 females and 14 out of the 16 fed and gravids collected died during the 24-hour holding period. In the check village the average per trap was 9.8 and the mortality was less than one per cent.

The exit-trap data for An. funestus also showed a very low level of capture density during the first round evaluation in the sprayed village ranging from 0.1 to 1.6 mosquitos per trap. The six fortnightly captures made in the sprayed village averaged 0.66 females compared with 12.9 in the check village. Only 15 fed/gravids were taken during the entire assessment and of these seven died during the 24-hour holding period. In the check village the average for the period was 12.9 and the mortality of the fed/gravids was only 5.6 per cent. These data clearly establish the pronounced insecticidal effectiveness of OMS-1211 against this species.

In the second round the exit-trap capture in the sprayed village was unexpectedly high during the period 20 August to 29 September corresponding with the 29th to the 69th days after spraying inclusive. In two of the captures on 17 September and 29 September, the collections averaged about 15 An. gambiae females per trap and the 24-hour mortality of fed and gravid individuals was only 66.2 per cent. and 43 per cent. respectively. In view of the relatively early period after application, these results were unsatisfactory when compared to an equivalent period in the first round. The principal difference in the second round was a three-fold increase in rainfall and higher relative humidity which corresponded with a more than two-fold increase in exit-trap densities. Moreover, during the wet period there was visual evidence of surface moisture on mud walls which may have had a detrimental effect on the insecticide, or possibly may have temporarily influenced An. gambiae to reorient its resting to drier surfaces.

The vulnerability of An. funestus to this insecticide noted in the first round was confirmed by the second round exit-trap data. Throughout the 153-day period of the second round assessment the average capture in the sprayed village exceeded 1.0 per trap in only three out of 11 collections. Of greater importance was the fact that only one of the females held 24 hours survived; one female out of 13 survived on the 57th day after spraying.

Human bait captures

The catches for An. gambiae and An. funestus indoors and outdoors are given in Table 5 for the first and second rounds of spraying.

The influence of the insecticide on indoor biting rates was clearly apparent on the ninth day after spraying the first round when the average/bait in the sprayed villages was only one per bait compared with 34 in the check village. Outdoors the disparity between the rates in the sprayed and check villages was less, averaging 3.0 to 12.2 respectively.

The reduction of An. gambiae indoor biting in the sprayed village was maintained throughout the period of the first round assessment, averaging only 3.0 per bait compared with 30.2 in the check village. Although the margin of difference in the rate of the outdoor segment of the population was less (3.2 in the sprayed village versus 12.2 in the check) it was sufficient to indicate a pronounced insecticidal effect.

The pre-spray biting rate of An. funestus on 27 April in the late dry season, when densities of the species were normally low elsewhere in the Kaduna area, averaged 58 females per bait/night indoors in the sprayed village and 36.6 in the check village. Outdoors the rate averaged 10 and 40.5 per bait respectively.

In the first post-spray observation made on 11 May 1970 no An. funestus were collected indoors in the treated village and outdoors the average per bait was only 1.5 compared with rates of 23.5 and 22.0 respectively in the check village.

The overall average biting rate for the first round indoors in the sprayed village was 0.85 compared with 15.5 in the check village while the outdoor rates averaged 0.5 and 20.1 for the sprayed and unsprayed villages respectively.

In the second round the overall biting density of An. gambiae in the sprayed and unsprayed villages was considerably higher than the first round reflecting the naturally occurring higher densities of the species during the peak rainfall months in August and September. The pronounced reduction in the rates in November merely reflects the natural decline of the species that normally occurs with the onset of the dry season in that month.

The difference between the biting rates in the sprayed and unsprayed villages was not as striking in the second round as in the first. Indoors the ratio was 1:3 respectively compared with 1:10 in the first round. Outdoors the ratio between the sprayed and check villages was only 1:2 compared with 1:4 in the first round. However, when An. gambiae reached peak densities in September, the numbers biting in the comparison village ranged between 49 and 61 per bait/night and in the sprayed village, between 8.5 and 37.5 per bait/night.

In the second round the reduced biting rate of An. funestus observed in the first round was also maintained throughout the 126-day assessment period, despite a large increase in the natural densities of the species in the area.

The average per bait of nine observations made indoors during the period in the sprayed village was 1.8 compared with 27.1 in the check village. Outdoors the rates were 2.2 and 15.5 respectively.

In spite of a substantial reduction in the man-mosquito contact in sprayed houses as indicated above, considerable numbers of An. gambiae continued to bite in them throughout the assessment period and An. funestus biting reappeared in them within about three weeks after spraying. This fact, considered in connexion with the exit-trap data (see Table 4) showing the 24-hour survival of some An. gambiae females would indicate the probable continuation of malaria transmission in the presence of this insecticide on walls and ceilings.

Parous rates of females captured

Table 6 presents data on the parous rate of An. gambiae and An. funestus. In both the first and second round of spraying the proportion parous indoors and outdoors in the sprayed village was less on the average than in the check village. This reflects a decrease in the proportion of older females in the population apparently due to the insecticide.

The parous rates of An. funestus shown in Table 6 were similar to that of An. gambiae. However, the number of specimens available for dissection in the sprayed village was extremely low in the first round, being only six indoors and one outdoors compared with 70 and 41 respectively in the check village. The numbers available for dissection in the first round in the sprayed village were too low to judge the effects of the insecticide on the parous state, but do indicate the effectiveness of the insecticide in reducing the numbers biting.

Bio-assay of sprayed surfaces

The data of bio-assay tests made on mud-wall and thatched roof surfaces using colony bred, fed An. gambiae females are given in Table 7.

During the 81-day period of evaluation of the first round the mortality on mud walls varied from 92.4 per cent. to 100 per cent. and that on thatch remained constant at 100 per cent. After the application of the second round, the bio-assay of the first round was continued in an unoccupied hut treated with one round only in order to ascertain the break-point of residual effectiveness of a single round. This occurred between the 111th day and 125th day after spraying. On the 125th day mortality on mud was 20 per cent. and on thatch 35 per cent. But with the decline in humidity at the beginning of the dry season in October and November, the mortality returned to 100 per cent. on thatch but remained low on mud. When the last test was made on 8 February 1971 in the mid-dry season 193 days after application, the mortality was still 100 per cent. on thatch but nil on mud surfaces.

In the second round the mortality on mud and thatch remained at approximately 100 per cent. throughout the 153-day assessment period.

A test carried out at 207 days after the second round of spraying showed mortality of 33.3 per cent. and 44.8 per cent. on mud and thatch respectively. These mortalities, lower than those obtained in the unoccupied hut reserved for continuation of the first round bio-assays, are attributed to the detrimental effects of fire and smoke and other human activities on the insecticide in the occupied huts used for the bio-assays in the second round.

Special evaluation utilising released and recaptured An. gambiae

As noted under methods a special assessment was made on 27 January 1971, the 27th week after spraying the second round, to determine whether the insecticide was still effective against An. gambiae which had nearly disappeared from the trial area due to adverse dry season conditions. The assessment method consisted of hut releases of colony bred An. gambiae females and recovery by pyrethrum spray and exit-trap captures according to the following procedure.

Twelve exit-traps were suspended on the doors of twelve huts in the evening in both the sprayed and check villages. An. gambiae, marked to distinguish them from natural populations were then released, 50 in each of 10 of the 12 huts in both villages, leaving two of the huts as a further check of naturally occurring mosquitos. At sunrise the traps were removed and spray captures made in all 12 huts. The mosquitos recovered from both the exit-trap and spray captures were collected and counted.

Tables 3 and 4 present the recapture data of the released females in the sprayed and check villages, including the results of spray and exit-trap captures of the very high natural population of An. funestus in the area.

In the sprayed village an average of 1.6 An. gambiae per hut was recovered from the spray capture and 1.3 in the exit-traps for a total of 29 females out of the 500 released in the 10 huts or a recovery rate of 5.8 per cent. There were no unmarked An. gambiae collected and the species was not present in the check huts.

Pyrethrum spray collections in the comparison village yielded 11.9 marked An. gambiae per hut and exit-traps recaptured 1.2 per hut. Total recovery was 131 females, or 26.7 per cent. of the 500 released. The scarcity of naturally occurring An. gambiae in the area was confirmed by the absence of unmarked females in the recapture and the absence of the species in the two check huts in which no mosquitos were released.

The capture data for the naturally occurring An. funestus in the sprayed village averaged only 0.6 females per hut collected in the 10 spray captures and none in the 10 exit-traps. By contrast in the check village an average of 49.3 An. funestus per hut was collected from the spray capture and 18.8 in the exit-traps. Thus, a total of six females only were collected in the treated village compared with 681 in the unsprayed check.

The results of this special assessment in which about five times as many released An. gambiae were recaptured in the check village than in the sprayed village, indicated that OMS-1211 had retained some degree of effectiveness against this species up to the 27th week after the second round of spraying. The data were subjected to statistical analysis by the "t" test ($t = 9.9/2.17 = 4.562$, $p > 1\%$). Therefore, the difference between the mean recaptures in the sprayed and unsprayed villages can be considered as due to the insecticide with a confidence limit above 99 per cent.

In the case of An. funestus the capture data on the high naturally occurring population in the area were 100 times as great in the check village as in the sprayed village which not only further confirmed the continuing effectiveness of the insecticide but demonstrated that An. funestus was more susceptible to the insecticide than An. gambiae.

The continuing effectiveness of the insecticide against An. funestus was again observed on 25 February and 9 March 1971 at 218 and 230 days after spraying respectively. The combined total of pyrethrum spray and exit-trap captures made on 25 February numbered only two females in the sprayed village in the 10 huts sampled but 242 females were captured in the check village. On 9 March, 15 females were collected in 10 huts in the sprayed village compared with 283 in the check village.

Although natural populations of An. gambiae were still low in the trial area, it is of interest to note that 18 females were collected in the pyrethrum spray and exit-trap captures compared with 78 in the unsprayed village. Thus, there was some continuing insecticidal effect against this species as well.

CONCLUSIONS

The entomological assessment in this trial carried out in an area of high densities of An. gambiae in the wet season and continuing high densities of An. funestus in both the wet and dry season demonstrated a pronounced residual effect persisting for at least 33 weeks against these species when applied in two rounds. Of the two species, An. funestus was much more susceptible for a longer period.

Despite the persistent residual properties of the insecticide it was concluded from the entomological assessment that OMS-1211 does not deter malaria vectors from entering houses to feed and rest and even though the survival rate is low, the probability exists that malaria transmission would continue to occur, at least in the season of high densities of An. gambiae.

There was some evidence from bio-assay tests and exit-trap captures in the second round that under conditions of high rainfall and humidity during the peak period of rainfall in the wet season there is some loss of insecticidal effectiveness which is partially restored when humidity decreases.

Under conditions of the seasonal prevalence of malaria vectors and weather patterns in the Kaduna area, the most effective scheduling of two rounds of OMS-1211 should provide for a first round spray before the onset of the wet season in April. This should be followed by a second round by mid-July, 15-16 weeks later in order to ensure fresh deposits and build-up of OMS-1211 before the peak wet months of August and September when An. gambiae reaches its highest densities. The extended persistence of a pronounced insecticidal effect against An. funestus (the only important vector in the dry season in most areas of Kaduna) may possibly preclude the necessity of re-applying OMS-1211 until near the end of the dry season in March and April when An. gambiae again re-appears in rising densities.

ACKNOWLEDGEMENTS

The Project staff is grateful to Miss D. Miller, Commissioner for Health and Social Welfare for her interest in the activities of this unit, to Dr A. I. Atta, Permanent Secretary and to Dr Z. Q. Shaikh, Chief Medical Officer of Health, Ministry of Health and Social Welfare, North Central State, and to Mr A. A. Amodu, Director of the Nigerian Institute for Trypanosomiasis Research for the support, co-operation and facilities that enabled this study to be made.

We wish to acknowledge also the invaluable supervisory services rendered by Mr A. E. Agber and the technical services of Mr S. J. Obanewa and for the contribution of the other National staff assigned to the unit from the Ministry of Health and Social Welfare, North Central State.

TABLE 1. FIRST AND SECOND ROUND[a] SPRAY OPERATIONS DATA - STAGE V TRIAL OMS-1211[b] 50% WDP AT RIDDO HAUSA - LEMAN VILLAGE NEAR KADUNA, NIGERIA, 1970

Type structure	No. structures each round		Average No. sq. metres each round		Total metres sprayed each round	
	1	2	1	2	1	2
Large house	27	27	109	109	2 993	2 943
Medium "	133	133	61	61	8 113	8 113
Small "	33	33	37	37	1 221	1 221
Kitchens	37	37	23	23	851	851
Animal houses	35	35	18	18	630	630
Granaries (eaves only)	108	-	6	-	648	-
School/Church	1	1	500	500	500	500
Others[c]	34	34	15	15	510	510
	408	300			15 386	14 768

Amount of insecticide used and calculated dosage

	Round 1	Round 2
No. pump charges at 800 g	80	75
Total kg 50% wdp	64	60
Total kg active ingredient	32	30
Less 10% wastage	3.2	3
Amount effectively sprayed	28.8	27
Dosage rate estimated in g/m^2	1.87	1.83

[a] Dates of spraying: first round, 30 April to 4 May; second round 22 to 23 July.

[b] O - (2,5 - dichloro - 4 - iodophenyl) O, O - dimethyl phosphorothioate. Also known as Iodofenphos and Ciba C-9491.

[c] Market stalls and temporary shelters.

TABLE 2. RESULTS OF ANALYSIS OF OMS-1211, STANDARD FORMULATION 50% WDP

Date of arrival		18.3.70
Dates of analyses		13-23.4.70
Batch Nos.		840837 46890-93
Active ingredient % w/w		50.3[a], [d] (49.9-50.7)
Suspensibility[b] % in distilled water without pre-treatment		98.8[d] (95.5-99.8)
Suspensibility[b] % in hard water after accelerated storage		76.0[d] (64.5-84.4)
Sieve test after accelerated storage,[c] % retained on	(i) BS200 mesh	0.02[d] (0.01-0.05)
	(ii) BS325 mesh	0.04[d] (0.01-0.11)
Alkalinity as NaOH % w/w		0.01[d]

[a] Bromide-bromate oxidation method.

[b] A suspension containing 2.5% w/v of active ingredient was employed.

[c] At 54 ± 1°C for 24 hours under an even pressure of 25 gf/cm^2.

[d] A single value given is the average of six samples. The figures in parenthesis show the lowest and highest values found.

TABLE 3. SPRAY CAPTURES OF AN. GAMBIAE AND AN. FUNESTUS FEMALES IN A VILLAGE (RIDDO HAUSA) RESIDUALLY SPRAYED WITH TWO ROUNDS OMS-1211 COMPARED WITH AN UNSPRAYED CHECK VILLAGE (RIDDO HAYI) KADUNA, NIGERIA 1970

Date 1970	Days After Spray	Anopheles gambiae						Anopheles funestus					
		Sprayed village			Check village			Sprayed village			Check village		
		Average per hut[a]	Fed and gravid		Average per hut	Fed and gravid		Average per hut[a]	Fed and gravid		Average per hut	Fed and gravid	
			Total	%		Total	%		Total	%		Total	%
Pre-spray													
1/4		0.8	8	8/8[b]	0.3	3	3/3	22.1	221	100.0	60.7	587	96.7
22/4		3.7	37	100.0	2.6	26	100.0	9.6	95	98.8	39.3	381	96.9
First round													
12/5	10	0.1	1	1/1	40.0	400	100.0	0.1	1	1/1	33.6	336	100.0
26/5	24	0.8	7	7/8	14.7	139	94.5	0.7	5	5/5	16.3	151	93.2
9/6	38	0.1	1	1/1	24.1	241	100.0	0.1	0	-	27.9	272	98.1
23/6	52	0.4	4	4/4	16.1	161	100.0	0.2	2	2/2	20.5	204	99.5
7/7	66	0.2	2	2/2	6.0[e]	60	100.0	0.2	1	1/1	7.5[e]	71	94.4
21/7	81	1.2	11	11/12	29.2	291	99.6	0.7	3	3/3	26.1	258	98.8
1st round average:		0.46	-	-	21.0	-	-	0.33	-	-	21.9	-	-
Second round													
6/8	15	0.2	2	2/2	18.3	180	98.3	0.3	3	3/3	25.4	245	96.4
20/8	29	1.1	11	11/11	42.9	417	97.2	0.5	2	2/2	56.2	539	95.9
3/9	43	0.7	7	7/7	19.5	188	96.3	0.0	-	-	33.7	325	97.3
17/9	57	3.5	33	94.2	66.7	630	94.4	1.2	8	8/12	100.1	905	90.4
29/9	69	4.7	44	93.6	40.9	373	91.2	0.1	0	-	62.7	604	96.3
15/10	85	2.3	23	100.0	23.1	221	95.6	0.1	9	9/10	32.2	301	93.4
28/10	98	0.5	4	4/5	8.5	81	95.3	0.7	2	2/2	44.8	430	95.9
11/11	112	0.2	0	0	0.1	8	8/10	0.7	5	5/5	20.6	190	92.2
25/11	126	0.1	1	1/1	0.8	8	8/8	0.2	2	2/2	14.9	145	97.3
10/12	141	0.0	-	-	0.2	2	2/2	0.5	5	5/5	37.9	376	99.2
22/12	153	0.0	-	-	0.2	2	2/2	0.3	3	3/3	16.9	167	98.9
2nd round average:		1.19	-	-	27.6	-	-	0.32	-	-	40.4	-	-
Release & recapture													
27/1/71	189	1.6	16[c]	-	11.9	119[c]	-	0.6	5[d]	5/6	50.9	509[d]	100.0

[a] Average of 10 huts per village.

[b] When less than 20 mosquitos collected the mortalities are shown as a fraction with the number collected as the denominator.

[c] Total number of An. gambiae recovered in early (0700 hours) spray capture out of 500 released in 10 huts previous day at 1800 hours.

[d] Naturally occurring An. funestus.

[e] Data probably affected by adverse weather conditions.

TABLE 4. EXIT TRAP CAPTURES OF AN. GAMBIAE AND AN. FUNESTUS IN STAGE V VILLAGE SCALE RESIDUAL SPRAY TRIAL OF OMS-1211 AT RIDDO HAUSA-LEMAN NEAR KADUNA, NIGERIA, 1970

Date 1970	Days after spray	Anopheles gambiae						Anopheles funestus					
		Sprayed village			Check village			Sprayed village			Check village		
		Average[a] per hut	Total fed and gravid	Mortality %[b] 24 hrs	Average per hut	Total fed and gravid	Mortality % 24 hrs	Average[a] per hut	Total fed and gravid	Mortality % 24 hrs	Average per hut	Total fed and gravid	Mortality % 24 hrs
Pre-spray													
1/4		1.1	9	0.0	0.6	6	0.0	12.1	71	18.3	47.7	258	22.4
22/4		3.6	18	0.0	2.6	4	0.0	36.6	141	17.5	18.6	112	11.6
First round													
12/5	10	0.2	0	-	7.3	68	1.4	0.3	0	-	12.8	121	1.6
26/5	24	0.3	2	1/2	24.7	197	0.0	0.1	1	1/1	12.5	99	0.0
9/6	38	0.8	8	8/8	8.9	49	2.0	0.2	1	1/1	21.2	148	12.1
23/6	52	0.6	3	2/3	8.0	72	1.3	1.6	10	4/10	9.5	76	0.0
7/7	66	0.0	-	-	0.6	6	0.0	0.2	1	0.0	1.4	7	0.0
21/7	81	1.5	6	3/6	10.4	72	1.3	1.6	2	1/2	20.5	148	9.4
1st round average:		0.56	3.1	14/16	9.8	77.3	0.86	0.66	2.5	7/15	12.9	99.8	5.6
Second round													
6/8	15	0.7	6	5/6	2.7	18	1/18	0.3	2	2/2	2.3	2	0.0
20/8	29	3.1	26	76.9	20.1	127	7.8	0.9	6	2/6	17.8	94	0.8
3/9	43	7.2	46	84.7	13.6	111	0.0	1.9	6	6/6	48.3	444	2.0
17/9	57	15.9	86	66.2	40.4	188	0.0	4.7	13	12/13	89.9	507	3.3
29/9	69	14.1	60	43.3	26.4	198	0.0	0.6	2	2/2	11.1	63	0.0
15/10	85	4.8	44	81.8	6.3	15	0.0	1.7	8	8/8	26.2	96	35.4
28/10	98	0.1	0	-	2.9	11	1/11	0.8	0	-	11.2	75	16.0
11/11	112	0.0	-	-	1.3	10	2/10	0.0	-	-	10.9	79	56.9
25/11	126	0.0	-	-	0.2	0	-	0.3	3	0.0	0.8	3	0.0
10/12	141	0.0	-	-	0.1	1	0	0.2	0	-	3.4	32	53.1
22/12	153	0.0	-	-	0.0	-	-	0.0	-	-	4.4	29	75.8
2nd round average:		0.40	24.3	67.7	10.3	61.7	2.00	1.0	3.6	55.0	20.5	147.9	11.3
Release & recapture													
27/1/71	189	1.3	13	7/13	1.2	12	2/12	0.0	-	-	21.3	203	49.0

[a] Average of 10 huts per village.

[b] When less than 20 mosquitos collected the mortalities shown as a fraction with the number collected as the denominator.

TABLE 5. HUMAN BAIT CATCHES INDOORS AND OUTDOORS IN A TRIAL VILLAGE (RIDDO-HAUSA-LEMAN) SPRAYED WITH OMS-1211 COMPARED WITH THE RATE IN AN UNSPRAYED CHECK VILLAGE (RIDDO HAYI) NEAR KADUNA, NIGERIA, 1970

Date 1970	Days after spray	Anopheles gambiae								Anopheles funestus							
		No. females				Average per bait[a]				No. females				Average per bait			
		Sprayed		Check		Sprayed		Check		Sprayed		Check		Sprayed		Check	
		In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out
Pre-spray																	
27/4		14	5	7	17	7.0	2.5	2.3	8.5	116	20	110	81	58.0	10.0	36.6	40.5
First round																	
11/5	9	2	6	68	35	2.0	3.0	34.0	12.5	0	3	47	44	0.0	1.5	23.5	22.0
25/5	23	14	9	103	8	7.0	9.0	51.5	8.0	3	0	17	1	1.5	0.0	8.5	1.0
6/7	66	7	6	36	21	3.5	3.0	18.0	10.5	0	1	21	11	0.0	0.5	10.5	5.5
20/7	81	1	5	36	44	0.5	2.5	18.0	22.0	4	0	39	14	2.0	0.0	19.5	7.0
Average/bait First round		6.0	6.5	60.7	24.5	3.0	3.2	30.2	12.2	1.7	1.0	31.0	40.2	0.85	0.5	15.5	20.1
Second round																	
5/8	15	6	6	74	9	3.0	3.0	37.0	4.5	0	2	42	7	0	1.0	21.0	3.5
19/8	29	15	27	32	71	7.5	13.5	16.0	35.5	8	2	32	20	4.0	1.0	16.0	10.0
2/9	43	17	7	122	43	8.5	3.5	61.0	21.5	1	0	61	11	0.5	0.0	32.5	5.5
16/9	56	37	28	108	101	18.5	14.0	54.0	50.5	1	6	160	96	0.5	3.0	80.0	48.0
25/9	68	75	109	98	108	37.5	54.5	49.0	54.0	4	6	67	20	2.0	3.0	35.5	10.0
14/10	86	23	42	44	76	11.5	21.0	22.0	38.0	8	2	1.3	27	4.0	1.0	6.6	13.5
26/10	97	5	18	22	44	2.5	9.0	11.0	22.0	6	12	47	30	3.0	6.0	23.5	15.0
10/11	111	1	5	5	2	0.5	2.5	2.5	1.0	4	10	60	59	2.0	5.0	30.0	29.5
25/11	126	0	0	3	2	0.0	0.0	1.5	1.0	1	1	20	19	0.5	0.5	10.0	9.5
Average/bait Second round		19.8	26.9	55.3	50.7	9.2	13.4	27.6	25.3	3.6	4.5	55.2	31.0	1.8	2.2	27.1	15.5

[a] No. of baits = 2 In 2 Out

TABLE 6. COMPARISON OF PAROUS RATES OF AN. GAMBIAE AND AN. FUNESTUS COLLECTED IN NIGHT BITING CAPTURES IN A VILLAGE SPRAYED WITH TWO ROUNDS OF OMS-1211 (RIDDO HAUSA)[a] AND IN AN UNSPRAYED CHECK VILLAGE (RIDDO HAYI) NEAR KADUNA, NIGERIA, 1970

	Anopheles gambiae				Anopheles funestus			
	First round[b]		Second round[c]		First round		Second round	
	Sprayed	Check	Sprayed	Check	Sprayed	Check	Sprayed	Check
Indoors	45.4 (22)[d]	75.0 (80)	59.6 (99)	72.2 (155)	2/6 (6)[e]	72.8 (70)	62.5 (32)	72.6 (150)
Outdoors	56.5 (23)	64.7 (68)	61.1 (108)	74.6 (130)	0/1 (1)	75.6 (41)	61.5 (39)	72.2 (126)

[a] Dates of spraying: First round 30.4.70; second round 22.7.70.

[b,c] Period of observations: First round 81 days: April-July.
Second round 126 days: August-November.

[d] Figures in parenthesis indicate the sum of the mosquitos dissected in each round. In the sprayed village, where numbers were small, all mosquitos collected were dissected. In the check village, an average sample of 20 mosquitos was dissected.

[e] Percentage parous shown as a fraction when numbers total less than 20, with number collected as denominator.

TABLE 7. BIO-ASSAYS OF MUD AND THATCH SURFACES SPRAYED WITH OMS-1211 AT RIDDO HAUSA, NIGERIA USING INSECTARY BRED ANOPHELES GAMBIAE FED FEMALES

Date[a] 1970	Days after treatment	24 hour % mortality[b]		Temperature during exposure °C	Humidity during exposure °C
		Mud walls	Thatched roofs		
First round					
13/5	11	95.7 (47)[c]	100.0 (46)	30.6	81.0
27/5	24	92.4 (79)	100.0 (82)	28.0	70.0
10/6	38	100.0 (90)	100.0 (90)	27.5	74.0
24/6	52	97.5 (40)	100.0 (40)	29.0	53.0
9/7[d]	68	100.0 (60)	100.0 (60)	21.0	90.0
7/8	97	80.5 (36)	100.0 (36)	25.0	69.0
21/8	111	88.8 (36)	100.0 (36)	25.0	69.0
4/9	125	20.0 (40)	35.0 (40)	26.5	66.0
17/9	138	7.5 (80)	32.5 (80)	24.5	76.0
13/10	164	36.6 (60)	73.3 (60)	26.5	59.5
28/10	179	21.2 (68)	100.0 (72)	26.0	41.0
26/11	218	0 (60)	100.0 (60)	28.0	22.0
8/2/71	293	0 (40)	100.0 (40)	29.0	18.0
Second round					
7/8	16	100.0 (72)	100.0 (72)	25.0	69.0
21/8	30	100.0 (72)	94.4 (72)	25.0	69.0
4/9	44	95.0 (40)	100.0 (40)	26.5	66.0
17/9	57	100.0 (40)	100.0 (40)	24.5	76.0
13/10	83	96.6 (60)	100.0 (60)	26.5	59.5
28/10	98	100.0 (60)	100.0 (60)	26.0	41.0
26/11	127	100.0 (60)	100.0 (60)	28.0	22.0
22/12	153	96.6 (60)	100.0 (60)	29.0	16.0
15/2/71	207	33.3[e] (57)	44.8 (58)	30.0	16.0

[a] Date of spraying: First round 30.4-4.5.70; Second round 22/23.7.70.

[b] Control mortalities were all below 5%.

[c] The numbers of mosquitos exposed are given in parenthesis.

[d] After 9/7 bio-assays were made in an unoccupied house and served to compare one round against two rounds.

[e] Average of two unoccupied houses, one in which no fires were used gave a mortality of 70.8% on thatch