SOME ASPECTS OF INSECTICIDE APPLICATION IN MALARIA CONTROL PROGRAMMES OTHER THAN THE EFFECT ON THE INSECT VECTORS

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ABSTRACT

Reported side effects arising from the application of DDT emulsion or suspension to buildings to control the anopheline insect vectors of malaria in Papua New Guinea are outlined.

Reports of effects of spraying on the deterioration of sak sak roof thatch from a resultant build up in numbers of larvae of the pyralid moth Herculia nigrivitta *Walk. are rather confusing, although from evidence presented it would appear that* H. nigrivitta *numbers have increased as a result of spraying. This increase could be due to the effects of DDT on non-specific predators which are found in association with* H. nigrivitta *larvae and on tachinid parasites. No satisfactory control measures for* H. nigrivitta *have as yet been devised. Further work is required to obtain information on the pest status, bionomics and habits of* H. nigrivitta, *and on the effects of spraying on* H. nigrivitta *populations and on roofing thatch.*

Reported increases in numbers of the mealybug Planococcus dioscoreae *Williams on yam roots in storage houses in the Maprik Subdistrict in* 1959 *following malaria spraying were investigated and found not to be associated with the spraying. There was little difference between the mealybug infestation in sprayed and unsprayed storage houses, and it was concluded that the main reason for the outbreak was the low density of predatory scymnine coccinellids which could have resulted from a temporary change in the micro-climate or some other cause unrelated to antimalarial spraying.*

The reported build up of bed bug (Cimex hemipterus *F.) populations in sprayed houses would appear to be true, but further more detailed work is required. The reasons for the build up are by no means clear, but resistance to DDT is one possibility.*

Reported build ups in Pediculus humanus humanus *L. numbers were not substantiated.*

DDT residues and possible contamination arising from its use are broadly discussed. No information on the effects of DDT on humans and wildlife in Papua New Guinea as a result of malaria control spraying is available. There is no doubt that direct contamination of water supplies and creeks must occur, even though every possible precaution is taken.

Replacement of DDT by alternate materials is discussed, but rejected on the grounds that DDT is the safest, cheapest and most effective insecticide for indoor residual spraying against malaria vectors. Alternative materials, and there are only two available, are more expensive, less residual in their effects and are not as safe to use as is DDT.

INTRODUCTION

REPEATED application of DDT to native material dwellings to control the anopheline insect vectors of malaria has led to some substantiated and unsubstantiated side effects being reported. Such insects as the sak sak leaf eating pyralid *Herculia nigrivitta* Walk., bed bugs (*Cimex hemipterus* F.), body lice (*Pediculus humanus humanus* L.) and the coccid *Planococcus dioscoreae* Williams, which inhabits yam roots, have been reported as reaching pest proportions following prolonged use of DDT.

Department of Agriculture, Stock and Fisheries' entomologists have looked at some of these problems. Messrs A. Catley and A. G. Basson and Dr E. Hassan have investigated various aspects of *Herculia nigrivitta*; Dr J. J. H. Szent-Ivany was intimately associated with a study on the effect of DDT and dieldrin malaria spraying on the incidence of *Planococcus dioscoreae* on stored yams in the Maprik Subdistrict (East Sepik District) in 1959; and T. V. Bourke and Dr C. S. Li investigated the *Cimex hemipterus* situation.

The effects of possible exposure of humans and animals to residues and contamination of food and water supplies as a result of malaria control spraying are discussed, as are possible toxicological hazards of DDT and possible alternate insecticides to spray team personnel.

HERCULIA NIGRIVITTA

In October 1962, a report was received from the District Commissioner, Sepik District to the effect that: "according to large sections of the community, mainly the Maprik, Kalabu and Wingei areas, when a (native materials) house is sprayed (with DDT) the native morata (sak sak) roof no longer has the life that it had previously".

It appeared that the deterioration of both new and old sak sak roofs had accelerated since malaria control spraying commenced in the area, and whereas before spraying a roof had been expected to last from three to five years, it now lasted only one to two years. This accelerated deterioration was put down to population increase of a caterpillar (subsequently identified by the Commonwealth Institute of Entomology as *Herculia nigrivitta*) resulting from the spraying campaign.

Mr A. P. Dodd, former Director of the Biological Control Branch of the Department of Lands, Queensland, who was in the area on a private trip during October 1962, inspected the problem. He concluded that *H. nigrivitta* larvae were certainly responsible for the damage recorded and suggested that spraying could be upsetting the naturally occurring parasites and predators, thus causing a build up of *H. nigrivitta* with a consequent increase in damage.

Catley (1962) carried out further investigations and reported that whilst little was known about the insect's biology, it did appear that eggs were laid on the dried sago leaf thatching and that the young larvae fed on the dried leaves, preferring to hide either in the curled over leaves or between layers of thatching. Leaves were bound together with silk to form a protective shelter for the larvae which, when fully fed, pupated at the feeding site.

Larvae did not attack green leaves and even recently browned ones, about six weeks after cutting, were free from attack. Leaves older than six weeks were rapidly infested. Very old thatching did not appear to be attractive to larvae and was not eaten unless the number of larvae were such that competition forced them to accept the less palatable thatching. Feeding was continuous throughout the day, but increased at night. Large quantities of dark brown, dried frass were continually voided by the larvae as they fed and was most noticeable on the floors of infested houses. The adults, small blackish-brown moths, were also to be found hiding under the thatching during the day.

Catley did not observe any predators actually attacking larvae, but concluded that non specific predators such as ants (*Technomyrmex* sp., *Iridomyrmex* sp. and other unidentified species), cockroaches, lacewing (Chrysopidae) larvae, pseudo-scorpions, spiders and lizards found in association with *H. nigrivitta* larvae, probably exercised considerable control under natural conditions.

Unfortunately all are very susceptible to chlorinated hydrocarbon insecticides and it appeared that the DDT residues on the walls

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of the houses had been instrumental in reducing their numbers to a very low level. In fact in many of the sprayed houses it was difficult to find signs of any life other than *H. nigrivitta* larvae, whereas in unsprayed houses the inside walls were generally covered with a mat of spider webs and *Technomyrmex* runways.

Tachinid parasites (? *Sturmia* sp. or ? *Winthemia* sp.) and "stung" *H. nigrivitta* larvae bearing tachinid eggs on the head or thorax were commonly seen in both sprayed and unsprayed houses, with the incidence appearing to be greater in sprayed houses.

There was no indication that *H. nigrivitta* larvae were resistant to DDT, but rather that their feeding habits did not bring them into contact with the insecticide. DDT, when used as a wettable powder, is not absorbed into the leaf tissue and is therefore located only on the surface of the thatching on the inside of the walls. As mentioned previously, *H. nigrivitta* larvae feed either within the curled leaves or between layers of thatching and not on the DDT treated surfaces. Once the leaf is eaten away to the DDT treated side, feeding ceases at that site and they begin to feed at another site.

Catley also stated that another factor which could influence control of *H. nigrivitta* by the DDT spray was smoke from fires lit inside the houses. The deposits of DDT on the walls of treated houses are soon covered by deposits from the smoke and become ineffective.

In contrast, Hassan (personal communication) was of the opinion that in the Northern District at least, smoke fumes protect thatching from *H. nigrivitta* damage. This observation supports those of Moorhouse (1964) who found that in Malaysia damage was most severe on outside porches, eaves and other unenclosed places, moderately severe in smoke-free living rooms and was minimal in kitchens where open fires were used.

Catley suggested two methods of control—fumigation of sprayed houses with lindane smoke bombs when spraying was carried out and the use of volatile additives such as dichlorvos in the standard DDT spray.

Basson (1963) investigated the problem further and also experimented with lindane smoke bombs. He confirmed Catley's observations on the life history and behaviour of *H. nigrivitta* and also observed that some unsprayed houses in the Apua hamlet of Maprik Village which were being used for mosquito collection purposes were as severely damaged as sprayed houses. Basson concluded that in areas where prolonged spraying with DDT had been carried out, the *H. nigrivitta* population had built up to such level that new, unsprayed houses were at risk of infestation soon after they were erected.

Experimental use of lindane smoke generators did not result in death of larvae and Basson suggested that the only way to protect newly built houses was to treat them with a persistent insecticide shortly after erection or to include treatment during the building of the house.

Jeffery, in an unpublished report to the Director, Department of Public Health dated 1st November, 1968, reported that BHC when applied at the rate of 0.5 g/m^2 to experimental sak sak roofs persisted for up to 12 weeks with a high kill rate, even when mixed with DDT (2 g/m^2). Dichlorvos, when applied to experimental sak sak roofs as a 0.005 per cent spray (no actual rate of active ingredient application given) gave the same results as the BHC treatment.

In Malaysia, dieldrin applied at the rate of 400 mg/m^2 to sak sak reduced damage but did not provide a satisfactory answer to the problem (Moorhouse 1964). The toxicological hazards associated with the use and residues of dieldrin would preclude its use under Papua New Guinea conditions.

H. nigrivitta has also been investigated in Malaysia (Cheng 1963, Moorhouse 1964), but the results of these two investigations appear to conflict in some respects. Larvae collected by Moorhouse in Selangor were found to be resistant to DDT (but moderately susceptible to both BHC and dieldrin), whilst those collected in Sabah by Cheng escaped the DDT by avoiding DDT treated sak sak surfaces. The Sabah larvae refused to eat DDT treated material, but those from Selangor readily ate DDT treated sak sak.

The only parasite recorded by both Cheng and Moorhouse was the hymenopterous pupal parasite *Antrocephalus* sp. (Chacididae). This parasite has not been recorded from Papua New Guinea.

From field observations Cheng (1963) concluded that most of the unsprayed houses whilst they also had rotting roofs, as did the sprayed ones, had more *H. nigrivitta* larvae present in their sak sak roofs. Moorhouse (1964) was fairly definite in that his field observations confirmed reports that sprayed sak sak roofs were being rapidly destroyed by *H. nigrivitta* larvae.

Further work is being conducted by the Departments of Public Health and Agriculture, Stock and Fisheries in Papua New Guinea to obtain information on the pest status, bionomics and habits of *H. nigrivitta*, and of the effects of spraying with DDT on *H. nigrivitta* populations and on roofing materials (mainly sak sak).

PLANOCOCCUS DIOSCOREAE

In 1959, there were reports from the Maprik Subdistrict of a population build up of a mealybug (subsequently described by D. J. Williams (1960) as a new species, *Planococcus dioscoreae*) on yam roots in storage houses as a result of spraying with DDT and dieldrin for malarial mosquito control. Dr Szent-Ivany visited the area in June 1959 to study the problem, as officers of the malaria control team were concerned that the outbreak in the yam houses could have resulted from spraying the walls of the houses with DDT and dieldrin, thus selectively killing the natural enemies of the mealybug without affecting the mealybug.

Investigations (Szent-Ivany 1959) showed, however, that there was little difference between the mealybug infestation in sprayed and unsprayed storage houses, and it was concluded that the main reason for the outbreak was the low density of predatory scymnine coccinellids, which could have resulted from a temporary change in the micro-climate or some other cause unrelated to anti-malarial spraying.

OTHER INSECTS

Prior to 1970, reports were received from time to time of the stimulation both of bed bugs (*Cimex hemipterus* F.) and of body lice (*Pediculus humanus humanus* L.) in sprayed houses. In 1970, the opportunity was taken to have a preliminary look at DDT resistance in strains of *C. hemipterus* collected from Maprik (East Sepik District) and Gurakor (Morobe District). The bugs at Maprik had been exposed to at least 25 DDT sprayings (at six-monthly intervals), whilst those at Gurakor had nil exposure. Samples of bugs were forwarded from both localities and cultured in the laboratory at Popondetta. For resistance testing, replete adult bugs (they had been fed 24 hours beforehand) were exposed to DDT treated filter papers which were placed in stoppered 4 x 1 inch glass livestock tubes. The filter papers were positioned in such a way that they formed the inner walls of the tubes. Results of the trial are shown in *Table* 1.

There is certainly some indication that DDT resistance was present in the Maprik sample.

Table 1.—Mortality of *C. hemipterus* adults exposed to treated DDT papers

Bugs*	Treatment—DDT per cent	Mortality (per cent) after	
		24 hours	48 hours
Maprik	1.0	—	25
(+25 treatments)	2.5	33.3	75
	5.0	33.3	75
	7.5	33.3	83.3
	10.0	25.0	100
Gurakor	1.0	41.7	66.7
(nil-exposure)	2.5	41.7	75.0
	5.0	83.3	100
	7.5	83.3	100
	10.0	75.0	100

*Twelve bugs used per treatment.

In April 1970, a further trial was commenced to follow the effects of spraying versus no spraying on numbers of *C. hemipterus*. Two villages—Aluki and Apo—in the Morobe District were selected and bed bugs counted in 10 randomly selected houses in each village. The houses in Aluki village were then sprayed with DDT (2 gm/m²) by one of the malaria spray teams operating in the District, whilst the other village was left unsprayed. Prior to this sampling and spraying, neither village had been sprayed as the villages were in an area which had not then been included in Papua New Guinea's Malaria Control Programme. In theory, it was hoped that both villages would be sampled for *C. hemipterus* in the same randomly selected houses one to two days before spraying and then at one, four, eight, 16 and 24 weeks after spraying, and that the houses in Aluki village would be sprayed every six months with DDT. Unfortunately, Aluki was sprayed with a DDT/malathion mixture in October 1970 and again in May 1971. However the results of the trials are shown in *Table* 2.

From the table it can be seen that spraying did lead to a build up in *C. hemipterus* numbers, but the reasons for this are by no means clear.

This trial should be repeated under more stringently controlled conditions.

To overcome the problem of build up of *C. hemipterus* following DDT spraying, Malaria Services added malathion to the spray mixture at the rate of 0.2 g/m².

As *Pediculus humanus humanus* live in such a well protected habitat, the possibility of any population build up as a result of spraying with DDT must be remote. Reported build ups could not be substantiated.

MAMMALS, EXCLUDING MAN

Periodical reports have been received of deaths of cats following prolonged spraying with DDT during malaria control programmes with a supposedly resultant increase in numbers of rats. There may be some truth in this as cats have been seen to devour cockroaches, beetles and other insects, spiders and geckoes which were obviously suffering from DDT poisoning.

Table 2.—Numbers of *Cimex hemipterus* in 10 randomly selected, fixed sampling houses in a sprayed and an unsprayed village

Date	Village	
	Aluki (sprayed)	Apo (unsprayed)
14.4.1970	20*	
22.4.1970	0	
30.4.1970	0	
14.5.1970	0	
14.6.1970	0	
19.8.1970	0	
14-15.10.1970	0†	0
28.10.1970	0	0
24.11.1970	0	0
21.12.1970	0	0
23.2.1971	13.3	0
20-21.4.1971	25.6‡	2
14.5.1971	1.4	0
7.6.1971	0	0
7.7.1971	0	0
6.9.1971	1.4	0
5.11.1971	56.3§	0
14.12.1971	44.4	0
15.2.1972	16.7	0

*Village sprayed on 15th April, 1970 with DDT.
†Village sprayed on 21st October, 1970 with DDT/malathion.
‡Village sprayed on 6th May, 1971 with DDT/malathion.
§Village sprayed on 15th November, 1971 with DDT/malathion.

This continuous ingestion of DDT contaminated food must result in an increase in residues within the cats, but it remains to be proved whether it leads to a level whereby a cumulative "acute" level is reached. Ingestion of DDT could also result from the cats rubbing against the treated surfaces and then licking DDT from their fur.

RESIDUES AND CONTAMINATION

Over the past decade pesticide residues have received a lot of attention from legislators, government agencies, and scientific and extension workers. The use of cyclodiene and other hydrocarbon insecticides on livestock in Australia has been banned, with the exception of the permitted limited use of DDT for the control of buffalo fly (*Haematobia exigua* (de Meij.)) in Queensland, as a result of the occurrence of insecticide residues in meat and meat products from treated animals. Residues in milk and dairy produce have arisen from the application of the same group of insecticides to pastures and forage crops in Australia, and their use on pastures has either been banned (cyclodienes) or drastically reduced (DDT, lindane).

Where DDT is currently employed in Australia it is far cheaper than any alternative insecticides that would be acceptable. Alternatives which are available are generally less persistent and thus require more frequent applications and they are often more toxic to man (Australian Academy of Science 1972). Usually little information is available on the long term effects—residues, contamination, etc. —of alternatives. DDT and two of its chief metabolites DDE and TDE* are lipoid soluble and tend to accumulate in body fat, even in the body fat of people without occupational exposure to DDT. It appears that equilibrium is reached between the intake of DDT and the excretion of the sum of its metabolites in approximately one year, if the amount ingested remains constant (Hayes *et al.* 1958). At low dose levels metabolism to the less toxic DDE appears to be quantitively greater.

The concentration of DDT in adipose tissue of humans in various Australian States over varying periods between 1965 and 1971 inclusive are given in Appendix 2 of the Australian Academy of Science's report (1972).

Elsewhere overseas, Canada, West Germany, Japan, Netherlands, New Zealand and the United States of America have drastically restricted and/or partially banned the use of DDT. The West German Bundestag recently passed an act forbidding the manufacture, import, export, marketing or purchasing of DDT within that country.

The position in Papua New Guinea and most other developing countries where malaria causes a high morbidity and mortality in most population groups is that DDT is the only material which has the desired residual effect and exhibits a low toxicity to the applicators and general public. It is also the cheapest and most effective insecticide available for controlling this disease.

The effect of DDT on humans and wildlife as a result of exposure to residues arising from malaria control spraying has received little attention in Papua New Guinea. The contamination of food and water supplies has not, to my knowledge, received any attention in Papua New Guinea. Both indirect and direct contamination of water supplies and creeks must occur, even though every possible precaution is taken. Keenleyside (1962), Rudd (1964) and Frith (1965) have discussed the direct and indirect effects on fish of DDT contamination and residues.

TOXICOLOGICAL HAZARDS

DDT is looked upon as being a relatively safe insecticide, having oral and dermal LD_{50} of 113-118 and 2500 mg/kg body weight (in rats) respectively (Martin 1968). Hayes (1971) summarizes the safety record of DDT (in part only) as follows: "The safety record of DDT for man is truly remarkable—several hundred thousand metric tons per year have been used for agriculture, forestry, public health and other purposes. People have been exposed in almost every way conceivable. For typhus control, the entire population of villages and large cities have had the 10 per cent powder blown into their clothing as they wore it. For malaria control, millions of men, women and children have had the interior walls of their homes sprayed year after year at the rate of

* The chemical nomenclature for DDT and its metabolites is:

DDT—1, 1, 1-trichloro-2, 2-di-(4-chlorophenyl) ethane.

DDE—1, 1-dichloro-2, 2-di-(4-chlorophenyl) ethylene.

TDE—1, 1-dichloro-2, 2-di-(4-chlorophenyl) ethane.

2 g/m². For food protection, such a variety of plants and animals eaten by people have been treated that, apparently without exception, every person sampled in recent years in Europe, Asia, Africa, Australia and the Americas contains a trace of DDT in his blood and in every tissue. Some of those who manufacture, formulate or apply DDT have had no other work for over 20 years and all of them have greater exposure than the general population of their countries. Yet, in spite of the prolonged exposure of the entire population of the world and the heavy occupational exposure of a substantial number, the only confirmed cases of poisoning by DDT have been the result of massive accidental or suicidal ingestion," (Hayes 1971).

DDT in solution can be absorbed through the skin. A single ingestion of 10 mg/kg produced illness in some but not all subjects. Convulsions have occurred when the dosage level was 16 mg/kg or greater. However, dosages as high as 285 mg/kg have been taken without fatal results (Hayes 1955).

To my knowledge no fatalities attributable to DDT have been recorded from Papua New Guinea.

Extensive screening trials seeking alternative insecticides for indoor residual spraying against malaria vectors have been carried out by various laboratories as a part of the W.H.O. Programme for Testing and Evaluating New Insecticides (W.H.O. 1967, Wright 1971, Wright *et al.* 1969). Out of some 1,300 or so compounds which have been examined only six—malathion, propoxur, fenitrothion, dichlorvos, Mobam (R) and Landrin (R)—have shown promise as residual adulticides against malaria vectors, although the period of residual activity of each is less than that of DDT (W.H.O. 1967). The substitution of any of these materials, if they were proved safe to use under field conditions, would substantially increase the cost of a malaria control programme. Factors contributing to this cost increase would be an increase in the price of the compound *per se*, the increased frequency of treatment, the need for monitoring of spraymen to detect excessive exposure, and closer supervision and training of field teams.

Only malathion has so far passed all the criteria necessary before a material is recommended for field use. Malathion, as has been mentioned earlier, has been added to the DDT mixture being used in Papua New Guinea's malaria control programme to control bed bugs. Monitoring of whole blood cholinesterase levels was carried out at six-monthly intervals by the Department of Public Health. Results showed no deviation from normal amongst malaria staff using malathion over a period of 12 to 18 months. Malathion, an organophosphorus insecticide with oral and dermal LD_{50} figures of 1400-1900 and 4000 mg/kg respectively is looked upon as being a relatively safe insecticide (Ben-Dyke *et al.* 1970). However extensive field use of trichlorphon, another organophosphorus insecticide with LD_{50} figures of 650 and 2800 mg/kg respectively, would suggest that monitoring of spraymen using supposedly "safe" organophosphorus insecticides under semi-enclosed or enclosed conditions must be both regular and thorough (Bourke *et al.* 1971).

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REFERENCES

AUSTRALIAN ACADEMY OF SCIENCE (1971). "The Use of DDT in Australia." *Reports of Aust. Acad. Sci.*, 14 (February 1972).

BASSON, A. G. (1963). Control of sac sac moth. Report on visit to Maprik Subdistrict 13th to 23rd March, 1963. Unpub. Report, D.A.S.F., Konedobu.

BEN-DYKE, R., SANDERSON, D. M. AND NOAKES, DIANA N. (1970). Acute toxicity data for pesticides (1970). *Wld Rev. Pest Control*, 9:119-127.

BOURKE, T. V., MORRISON, W. B. AND MACARTNEY, BETTY K. (1971). Effect of prolonged spraying with trichlorphon on blood cholinesterase levels of sprayers. *Papua New Guin. agric. J.*, 22:151-163.

CATLEY, A. (1962). Report on visit to Maprik Subdistrict 4th to 9th November, 1962. Unpub. Report, D.A.S.F., Konedobu.

CHENG, F. Y. (1963). Deterioration of thatch roofs by moth larvae after house spraying in the course of a malaria eradication programme in North Borneo. *Bull. Wld Hlth Org.*, 28:136-137.

FRITH, H. J. (1965). New perspectives in insect control. Pesticides and wildlife. *Aust. J. Sci.*, 28: 226-228.

HAYES, W. J. (1971). The degree of hazard to man of DDT as used against malaria. WHO/VBC/71. 251, 18 pp.

HAYES, W. J. (1959). "Pharmacology and toxicology of DDT." Chapter VI, 9-247. In: *DDT, the insecticide dichlorodiphenyltrichloroethane and its significance.* Paul Muler (ed.) Vol. 2, Birkhauser Village, Basel.

HAYES, W. J. (1955). Present status of our knowledge of DDT intoxication. *Am. J. publ. Hlth*, 45: 478-485.

KEENLEYSIDE, M. (1962). *Can. Fish Cult.* No. 24:17 (as quoted in Frith (1965)).

MOORHOUSE, D. E. (1964). Enhanced damage to attap roofs by the caterpillars of *Herculia nigrivitta*, following house-spraying with DDT. *Med. J. Malaya*, 19:56-57.

RUDD, R. L. (1964). Pesticides and the Living Landscape. Wisconsin University Press.

SZENT-IVANY, J. J. H. (1959). Outline of entomological work at Headquarters 1958-59. Unpub. Report, D.A.S.F., Konedobu.

WILLIAMS, D. J. (1960). A new species of *Planococcus* Ferris (Coccoidea: Homoptera) on yams in New Guinea. *Pap. New Guin. agric. J.*, 13: 39-40.

W.H.O. (1967). Safe use of pesticides in public health. 16th Report of the W.H.O. Expert Committee on Insecticides. *Tech. Rep. Ser. Wld Hlth Org.*, 1967, 356.

WRIGHT, J. W. (1971). The WHO programme for the evaluation and testing of new insecticides. *Bull. Wld Hlth Org.*, 44:11-22.

WRIGHT, J. W., FRITZ, R. F., HOKING, K. S., BABIONE, R., GRATZ, N. G., PAL, R., STILES, A. R. AND VANDEKAR, M. (1969). *Ortho*-isopropoxyphenyl methylcarbamate (OMS-33) as a residual spray for control of anopheline mosquitoes with special reference to its evaluation in the WHO programme for evaluating and testing new insecticides. *Bull. Wld Hlth Org.*, 40:67-90.

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