

RECENT FINDINGS OF INSECT RESISTANCE AND BEHAVIOURISTIC MODIFICATIONS OF CERTAIN INSECTS IN SOUTH AMERICAN AREAS

Riassunto. — In certi paesi, quali la Guiana inglese ed il Venezuela, l'*A. darlingi* il quale è il principale vettore della malaria in America del Sud, è stata completamente sterminata per mezzo di polverizzazioni di DDT nelle abitazioni.

Questo risultato eccezionale è stato possibile grazie al grado elevato di antropofilismo e di domesticità di questa specie nelle zone summenzionate. Tuttavia in altri paesi, l'*A. darlingi* attacca ugualmente l'uomo e gli animali in gran numero, all'infuori delle abitazioni. Nel Brasile, l'indice di zoofilismo dell'*A. darlingi* è molto più elevato che nella Guiana inglese specialmente all'interno di questo paese. Perciò la popolazione larvaria di questa specie non è attaccata dalla polverizzazione di DDT nelle abitazioni (BUSTAMANTE, 1951). Secondo HESS (1953), queste condizioni epidemiologiche sarebbero molto favorevoli allo sviluppo di resistenze di comportamento.

Non v'è alcun dubbio che il *Culex fatigans* (*C. quinquefasciatus*) presenti una pronunciata resistenza naturale al DDT. Le informazioni non sono concordi quanto alla capacità di questa specie di aumentare la sua resistenza naturale e di sviluppare così una resistenza fisica. Nella Guiana inglese e francese la resistenza innata di questa zanzara al DDT non sembra essersi accresciuta. Secondo GAVALDON, citato da HESS (1952), sembrerebbe che al Venezuela il *Culex fatigans* diventi resistente. Esperienze e buone osservazioni effettuate sul terreno sono necessarie per delucidare questa questione.

Si ammette generalmente che le mosche domestiche siano diventate resistenti al DDT. Al Brasile, in Cile e in Uruguay, sembra che siano ugualmente diventate resistenti al BHC, sia che si usi questo invece del DDT, sia mescolato in piccole quantità di DDT. Nella Guiana francese ed inglese si può sempre aver ragione delle mosche utiliz-

zando il BHC in modo adatto. E' il caso di menzionare particolarmente i risultati delle esperienze di BLASQUEZ in Venezuela e di FERNANDEZ in Uruguay, mosche domestiche provenienti da una città ove il DDT è regolarmente polverizzato, si sono mostrate da 25 a 100 volte più resistenti al DDT che le mosche-testimoni allevate in laboratorio. Nel Venezuela, le esperienze di laboratorio non hanno segnalato alcuno sviluppo di resistenza fisiologica. Il gran numero di mosche esistenti nelle abitazioni trattate con polverizzazioni nel Venezuela potrebbe essere una conseguenza di una resistenza di comportamento (le mosche evitano di riposarsi sulle superfici spruzzate col DDT) e dall'effetto repulsivo dell'insetticida. E' interessante notare che la mosca del Venezuela è la *musca domestica vicina* e quella dell'Uruguay la *musca domestica domestica* (Zone temperate). Nella Guiana francese ugualmente la mosca domestica è della varietà vicina; secondo FLOCK non ha acquisito una resistenza al DDT pari a quella della varietà domestica in Argentina. Sarebbe interessante procedere ad esperienze normalizzate in paesi ove si trovano le diverse varietà di mosche domestiche.

Le informazioni secondo cui le larve di *A. aegypti* diventano resistenti al DDT a Paramaribo, Guiana olandese, merita particolarmente di richiamare l'attenzione perchè questa specie è generalmente considerata come molto sensibile al DDT.

Fra gli altri insetti, le pulci del cane sono state citate come essendo diventate resistenti al DDT nella Guiana inglese. In Colombia è stato segnalato che le pulci del cane e del gatto (*Ctenocaphalides canis*) e gli acari (*Ornithodoros rudis* e *Argas columbarum*) sono diventati resistenti al DDT. Questa ultima specie sarebbe ugualmente resistente al BHC e alla Dieldrina.

Nella Guiana francese è stato segnalato che oltre le pulci, le formiche e le blatte erano diventate resistenti al DDT.

Da quanto precede, risulta chiaro che pochissime esperienze sono state fatte in America del Sud sulla resistenza degli insetti agli insetticidi dal punto di vista della sanità pubblica od altrimenti. In secondo luogo, dato che quasi tutti i programmi di polverizzazione del DDT nelle abitazioni tendono quasi esclusivamente alla lotta contro la malaria, numerosi sono i paesi ove nessuna osservazione è stata fatta su una resistenza possibile agli insetticidi da parte di altri insetti domestici. Tuttavia due fatti importanti emergono dalle informazioni ottenute: 1) il fatto che le Anopheli continuano ad essere sensibili al DDT in tutti i paesi, una sola possibilità di resistenza di comportamento

essendo stata segnalata a proposito di *A. darlingi*; 2) esistono dati non pubblicati a proposito della resistenza di certi insetti quali *A. aegypti* nella Guiana olandese e certe specie di zecche di Colombia.

Résumé. — Dans certains pays, tels que la Guyane anglaise et le Venezuela, l'*A. darlingi*, qui est le principal vecteur du paludisme en Amérique du Sud, a été complètement exterminé au moyen de pulvérisation de DDT dans les habitations. Ce résultat exceptionnel a été possible grâce au degré élevé d'anthropophilisme et de domesticité de cette espèce dans les zones mentionnées ci-dessus. Néanmoins, dans d'autres pays, l'*A. darlingi* attaque pareillement l'homme et l'animal en grand nombre, en dehors des habitations. Au Brésil, l'indice de zoophilisme de l'*A. darlingi* est beaucoup plus élevé qu'en Guyane anglaise et au Venezuela, notamment à l'intérieur du pays. De ce fait, la population larvaire de cette espèce n'est pas affectée par la pulvérisation de DDT dans les habitations. (BUSTAMANTE, 1951). Selon HESS (1953), ces conditions épidémiologiques seraient très favorables au développement de résistances de comportement.

Il n'y a aucun doute que le *Culex fatigans* (*C. quinquefasciatus*) présente une résistance naturelle prononcée au DDT. Les renseignements diffèrent quant à la capacité de cette espèce d'augmenter sa résistance naturelle et de développer ainsi une résistance acquise. Dans la Guyane française et la Guyane anglaise, la résistance innée de ce moustique au DDT ne semble pas s'être accrue. Selon GABALDON, cité par HESS (1952), il semblerait qu'au Venezuela le *Culex fatigans* devienne résistant. Des expériences et de bonnes observations menées sur le terrain sont nécessaires pour permettre d'élucider cette question.

On admet généralement que les mouches domestiques sont devenues résistantes au DDT. Au Brésil, au Chili et en Uruguay, elles semblent également être devenues résistantes au BHC, que celui-ci soit utilisé au lieu du DDT ou qu'il soit mélangé à de petites quantités de DDT. En Guyane française et en Guyane anglaise, on peut toujours se rendre maître des mouches en utilisant le BHC de manière appropriée. Il y a lieu de mentionner particulièrement les résultats des expériences auxquelles BLASQUEZ et FERNANDEZ ont procédé, respectivement, au Venezuela et en Uruguay, résultats que ceux-ci interprètent différemment. En Uruguay, des mouches domestiques provenant d'une ville où du DDT est régulièrement pulvérisé se sont révélées de 25 à 100 fois plus résistantes au DDT que les mouches-témoins élevées en laboratoire. Au Venezuela, les expériences de laboratoire n'ont signalé aucun développement de résistance physiologique. Le grand nombre de mouches exis-

tant dans les habitations soumises à des pulvérisations au Venezuela pourrait être une conséquence d'une résistance de comportement (les mouches évitent de se reposer sur des surfaces vaporisées au DDT) et de l'effet répulsif de l'insecticide. Il est intéressant de remarquer que la mouche du Venezuela est la *Musca domestica vicina* et celle de l'Uruguay la *Musca domestica domestica* (zone tempérée). Dans la Guyane française également, la mouche domestique est de la variété *vicina*. Selon FLOCH, elle n'a pas acquis la même résistance au DDT que la variété *domestica* en Argentine. Il serait intéressant de procéder à des expériences normalisées dans des pays où se rencontrent les différentes variétés de mouches domestiques.

L'information selon laquelle les larves de l'*A. aegypti* deviennent résistantes au DDT à Paramaribo, Guyane hollandaise, mérite particulièrement de retenir l'attention car cette espèce est généralement considérée comme très sensible au DDT.

Parmi les autres insectes, les puces du chien ont été mentionnées comme étant devenues résistantes au DDT en Guyane anglaise. En Colombie, il a été signalé que les puces du chien et du chat (*Ctenocaphalides canis*) et les acares (*Ornithodoros rudis* et *Argas columbarum*) sont devenues résistantes au DDT. Cette dernière espèce serait également résistante au BHC et à la Dieldrine.

En Guyane française, il a été signalé qu'outre les puces, les fourmis et les cancrelats sont devenus résistants au DDT.

Il découle tout d'abord de ce qui précède que très peu d'expériences ont été effectuées en Amérique du Sud sur la résistance aux insecticides d'insectes importants du point de vue de la santé publique, ou autrement. En second lieu, étant donné que presque tous les programmes de pulvérisation de DDT dans les habitations tendent à peu près exclusivement à la lutte contre le paludisme, nombreux sont les pays où il n'a pas été fait d'observations sur la résistance possible aux insecticides d'autres insectes domestiques. Néanmoins, deux faits importants ressortent des renseignements obtenus: 1) le fait que les anophèles continuent à être sensibles au DDT dans tous les pays, une seule possibilité de résistance de comportement ayant été signalée au sujet de l'*A. darlingi*; 2) il existe des données non publiées au sujet de la résistance de certains insectes, tels que l'*A. aegypti* en Guyane hollandaise et certaines espèces de tiques en Colombie.

Summary. — In some countries, such as British Guiana and Venezuela, *A. darlingi*, which is the principal vector of malaria in South America, has been completely eradicated through house sprayings with

DDT. This exceptional result was possible due to the high degree of anthropophilism and domesticity of this species in the above-mentioned areas. In other countries, however, *A. darlingi* attacks man and animal alike outside houses in great numbers. In Brazil, the zoophilism index of *A. darlingi* is much higher than in British Guiana and in Venezuela, particularly in the interior of the country. Due to this fact the larval population of this species is not affected by house sprayings with DDT (BUSTAMANTE, 1951). This epidemiological condition would be very favourable to the development of behaviouristic types of resistance, according to HESS (1953).

Undoubtedly, *Culex fatigans* (= *C. quinquefasciatus*) presents a pronounced natural resistance to DDT. Information differs as to the capacity of this species to increase its natural resistance, thus developing an acquired resistance. In French and British Guiana, the innate resistance of this mosquito to DDT has apparently not increased. In Venezuela there is indication that *Culex fatigans* is developing resistance, according to GABALDON, cited by HESS (1952). Experimental work and well conducted field observations are necessary in order to clarify this question.

It is generally agreed that house flies have acquired resistance to DDT. In Brazil, Chile and Uruguay they also seem to have become resistant to BHC, used alternately with DDT or mixed in small doses with DDT. In British and French Guiana flies can still be controlled by adequate use of BHC. Special reference should be made to the results of the experimental work in Venezuela and in Uruguay, by BLASQUEZ and FERNANDEZ respectively, which are in disagreement as to results. In Uruguay, house flies from a city repeatedly sprayed with DDT proved to be from 25 to 100 times more resistant to DDT than control flies bred under laboratory conditions. In Venezuela, laboratory experiments did not indicate any development of physiological resistance. The great number of flies existing in houses sprayed with DDT in Venezuela might be a consequence of a behaviouristic type of resistance (the flies avoid resting on surfaces sprayed with DDT) and of the repellent effect of the insecticide. It is interesting to note that the fly in Venezuela is *Musca domestica vicina* and the one in Uruguay *Musca domestica domestica* (temperate zone). Also in French Guiana the house fly is of the *vicina* variety. According to FLOCH, it did not develop the same resistance to DDT as the *domestica* variety, in Argentina. It would be interesting if standardized experiments could be conducted in various countries with the different varieties of house flies.

Of special interest is the reference to the development of resistance

to DDT by the larvae of *A. aegypti* in Paramaribo, Dutch Guiana, since this species is generally considered highly susceptible to DDT.

Among other insects, dog fleas have been mentioned as having developed resistance to DDT in British Guiana. In Colombia, dog and cat fleas (*Ctenocaphalides canis*) and acari (*Ornithodoros rudis* and *Argas columbarum*) are reported as having developed resistance to DDT. The latter species is said to be resistant also to BHC and Dieldrin.

In French Guiana, cockroaches and ants are reported to have acquired resistance to DDT, in addition to fleas.

From the foregoing it is apparent, on the first hand, that very little experimental work has been carried out in South America on the study of resistance to insecticides by insects of importance from a public health point of view, or otherwise. In the second place, since almost all of the house spraying programmes with DDT refer almost exclusively to malaria control, in many countries no observations were made on the possible resistance of other domestic insects to insecticides. However, two important facts can be noted from the information obtained: 1) the fact that the anophelines continue to be susceptible to DDT in all countries, there being only one reference to the possible development of behaviouristic resistance on the part of *A. darlingi*; 2) unpublished data concerning the resistance of certain insects, such as *A. aegypti* in Dutch Guiana and certain species of ticks in Colombia.

Zusammenfassung. — In einigen Ländern, wie zum Beispiel britische Guyane und Venezuela ist *A. darlingi*, der wichtigste Malaria-Überträger Sud-Amerikas, durch DDT-Bestreuung in den Wohnhäusern ganz vernichtet worden. Dieses aussergewöhnliche Ergebnis ist in den obengenannten Ländern nur der hohen Stufen von Anthropophilismus und Domestizität dieser Art zuzuschreiben. In anderen Gegenden jedoch, stecht *A. darlingi* ausserhalb der Wohnungen gleichfalls Menschen sowie eine grosse Anzahl von Tieren. In Brasil, besonders im Hinterland, ist die Zoophilie-Zahl von *A. darlingi* viel höher als in britischen Guyane und Venezuela. Daher sind die Larven dieser Art nicht durch DDT-Bestreuung in den Wohnungen beeinflusst (BUSTAMANTE, 1951). Nach HESS (1953) sind diese epidemiologischen Verhältnisse für Entwicklung einer Resistenz höchst günstig.

Es ist nicht zu bezweifeln dass *Culex fatigans* (*C. quinquefasciatus*) eine ausgezeichnete natürliche Resistenz gegen DDT aufweist. Die Belehrungen über die Fähigkeit dieser Art ihre natürliche Resistenz zu

erhöhen und auf dieser Weise eine erworbene Resistenz zu entwickeln, stimmen nicht überein.

In den französischen und britischen Guyane hat die angeborene Resistenz dieser Mücke scheinbar nicht zugenommen. Nach GABALDON, von HESS citiert (1952), scheint es dass *Culex fatigans* in Venezuela resistent wird. Um diese Frage lösen zu können, wären in diesen Gegenden Erforschungen und genaue Beobachtungen nötig.

Es wird allgemein zugegeben dass die Hausfliegen gegen DDT resistent geworden sind. In Brasil, Chili und Uruguay sind sie auch scheinbar gegen BHC resistent und zwar wann BHC statt DDT benutzt wird, oder wann BHC mit kleinen Mengen von DDT gemischt ist.

In den französischen und britischen Guyane kann man immer die Fliegen durch geeigneten Gebrauch von BHC bemeistern. Es belohnt sich besonders die Ergebnisse von BLASQUEZ in Venezuela und von FERNANDEZ in Uruguay zu erwähnen die in diesen zwei Ländern verschiedentlich erklärt haben. In Uruguay sind die Hausfliegen, die aus einer Villa stammten, wo DDT regelmässig gegeben wurde, 25 bis 100 mal mehr gegen DDT resistent geworden als die Kontrol-Fliegen, die im Laboratorium gezüchtet wurden. In Venezuela hat man bei Laboratoriumsversuchen keine Erscheinung von physiologischen Resistenz ermittelt. Die sehr grosse Anzahl von Fliegen, die in den Wohnungen bespritzt wurden, könnte in Venezuela eine Folge der Resistenz von der Verhaltung (die Fliegen vermeiden sich auf den bestreuten Oberflächen nieder zu legen) und der repulsiven Wirkung der Insekticiden. Interessant ist es zu bemerken dass, in Venezuela die herrschende Fliege *Musca domestica vicina* ist und in Uruguay ist es *Musca domestica domestica* (gemässigte Zone). Gleichfalls in der französischen Guyane gibt es jedoch *Musca domestica varietas vicina*.

Nach Floch hat diese Fliege nicht dieselbe DDT-Resistenz wie die argentinische *varietas domestica* erworben. Es wäre bedeutungsvoll normalisierte Versuche vorzunehmen, wo sich die verschiedenen Varietäten der Hausfliegen befinden.

Die Nachricht nach der die Larven von *A. aegypti* DDT-resistent in Paramaribo, niederländische Guyane, werden, verdient unsere besondere Aufmerksamkeit denn diese Art allgemein als sehr DDT-empfindlich wird. Zwischen den anderen Insekten sind Hundeflöhe in der britischen Guyane sehr resistent geworden. In Columbien ist es angemeldet worden dass, Flöhe von Hunde und Katzen (*Ctenocaphalides canis*) sowie Milben (*Ornithodorus* und *Argas columbarum*) sehr DDT-resistent geworden sind. Die letzteren sollen auch BHC-und Dieldrine-resistent sein.

In der französischen Guyane ist gemeldet worden dass, ausser Flöhe, auch Ameisen und Blatten gegen DDT unempfindlich geworden sind.

Aus dem obengesagten geht zunächst hervor dass, in Sud-Amerika sehr wenige Untersuchungen über Resistenz der Insekten gegen Insektiziden durchgeführt wurden, sei es für gesundheitsschädliche wie für andere Insekten.

Zweitens, da das ganze Programm der DDT Bestreuung in den Wohnungen fasst ausschliesslich die Malariabekämpfung bezweckt, viele sind die Länder wo gar keine Beobachtungen über die mögliche Resistenz anderer Haus-Insekten gegen Insektiziden gemacht worden sind. Trotzdem, sofern, aus den gemachten Erfahrungen ragen zwei wichtige Tatsache hervor, und zwar:

1) die Tatsache dass, Anophelen in allen Ländern gegen DDT empfindlich zu sein bestehen; eine einzige Resistenz ist bei *A. darlingi* gemeldet worden;

2) es gibt Angaben über Resistenz einiger Insekten, wie *A. aegypti* in der niederländischen Guyane und einige Arten von Milben aus Columbien, die nicht veröffentlicht worden sind.

With the exception of the house fly, which apparently has acquired resistance to DDT in all countries where this insecticide has been applied inside houses on a wide scale in the course of anti-malaria programmes, there are very few references to other insects in South America having acquired resistance to DDT.

To our knowledge, only HESS (1953) has published anything about resistance to DDT of insects other than flies. This author refers to the presence of fleas (*Pulex irritans*) and *Culex fatigans*, resistant to DDT in Peru and Venezuela, respectively. The same author also refers to observations by ALVARADO, in the Argentine, and BUSTAMANTE et al., in Brazil, regarding captures of *Anopheles darlingi* on the outer walls of houses sprayed on the inside with DDT. He suggests that this may represent «a behaviouristic type of resistance».

Prior to preparing the present report, the author wrote to all those in South America who are mainly responsible for house spraying programmes for control of malaria and other diseases transmitted by insects. In addition, all Brazilian services and institutes conducting investigations on insects of importance to public health and agriculture, were consulted. The information obtained is presented below. One country only did not furnish the required information.

FRENCH GUIANA (FLOCH, 1953). — No resistance has been observed among *Aedes aegypti* and *Anopheles darlingi*, both continuing to show exceptional susceptibility to DDT.

Culex fatigans, although disappearing for a few weeks after the first house spraying with DDT, giving the impression that eradication had been achieved, returned later. However, there is reason to doubt that this is a case of real resistance. A control programme directed against this mosquito was carried out in Cayenne. Frequency of this mosquito has decreased considerably, thanks also to the use of BHC sprayed inside houses. Resistance initially observed does not seem to have increased.

A similar phenomenon was observed with respect to *Musca domestica* which, although it did not disappear from Cayenne, is now well controlled. This is in contrast to observations made in European countries (Corsica, for instance), and in the Argentine, where domestic flies abound in incredible numbers after house sprayings. FLOCH wonders whether this fact may be explained on the basis that the fly found in French Guiana is *Musca domestica vicina* whereas the fly in Europe and the Argentine is *Musca domestica domestica*.

Bed bugs and sand fleas (*Sarcopsylla penetrans*) have been « eradicated » from French Guiana, although the insecticide has been applied only inside dwellings.

Fleas, cockroaches and ants, which had disappeared almost completely after the first spraying, have returned, showing a much greater resistance than when DDT was first applied.

BRITISH GUIANA (GIGLIOLI, 1953). — Insecticides with residual effect are used mainly to control *A. darlingi* and *A. aegypti*. These species are anthropophilous and endophilous and highly susceptible to DDT. Both are completely eliminated by house sprayings with DDT and larvae disappear within two or three weeks after application of the insecticide. There is no possibility of their developing any resistance, because eradication of the species in a treated area is rapid and complete. Observations on other insects were incidental and based on general observations rather than systematic ones, as in the case of *A. darlingi* and *A. aegypti*. After 5 to 7 years use of DDT, only house flies and dog fleas developed resistance following the first 2 or 3 years control. For these insects, resistance is limited to DDT and when nuisances develop control is also maintained by the appropriate and intermittent use of BHC. However, on the coast of British Guiana the house fly never presented any serious problem.

Culex quinquefasciatus (= *Culex fatigans*) is much less susceptible to DDT than *A. darlingi* and *A. aegypti*. Six months after the first application of DDT this species becomes as abundant as before spraying. *C. fatigans* presents a certain problem, partly due to its higher resistance and partly due to its pronounced preferences with regard to breeding places and feeding habits. For these reasons, only a small portion of this mosquito population enters into contact with the insecticides. Nevertheless, the average number of *C. fatigans* captured inside houses is today considerably less than before the introduction of DDT.

GIGLIOLI stresses the point that the term resistance has been used indiscriminately for primary or innate natural resistance as well as for resistance acquired through previous exposure to the insecticide. He suggests the introduction of distinct terms for each of these forms of resistance. He also warns that in some insect species, with partial domestic habits, resistance is probably only apparent and due to continuous invasion from the outside. He illustrates this fact by mentioning the case of the cockroaches *Periplaneta americana* and *Phyllodromia germanica* (?) which were reduced enormously in houses sprayed with DDT and when now seen outside houses usually suffer the effect of intoxication by DDT. There is no indication that the continued use of DDT has failed in controlling cockroaches.

Bed bugs and ticks on dogs, which previously represented real plagues, have now practically disappeared. In districts where control measures were interrupted for periods of 3 to 4 years, bed bugs are reappearing but continue to be highly susceptible to DDT.

Other insects, such as *Tunga penetrans*, ants, silver fish, horn beetles (*Polistis canadensis amazonicus*), scorpions, spiders and centipedes remain in insignificant numbers inside houses. Head lice are still very abundant but continue highly susceptible to DDT.

On the whole, DDT continues to be very popular among the natives of the country « who consider it the best thing ever given to them by the white man ».

DUTCH GUIANA or SURINAM (WOLFF, 1953). — *Culex quinquefasciatus* (= *C. fatigans*) and larvae of *Aedes aegypti* have shown resistance to DDT in Paramaribo, capital of Surinam. No details were furnished.

VENEZUELA (BERTI, 1953). — There is no indication of physiological or behaviouristic resistance of anophelines in this country.

Laboratory experiments conducted by Dr. J. BLASQUEZ do not reveal any physiological resistance to DDT by the *Musca domestica vicina* which is the common house fly in this country. However, the flies which were greatly reduced after the first house sprayings with DDT, have now become as abundant as before the sprayings. The lack of success in controlling this insect with DDT seems to be due to its behaviouristic resistance. Although the subject has not been satisfactorily explained as yet everything seems to indicate that flies tend to avoid resting on surfaces sprayed with DDT. Dr. BLASQUEZ' experiments also indicate that the insecticide acts as a repellent for flies not previously exposed to DDT and it is possible that this effect is more pronounced among flies in treated zones.

GABALDON (1953) has nothing to add to the above information.

COLOMBIA. — According to CONCHIA Y VENEGAS (1953), DDT has been used since 1946 in the control of malaria, using 2 g per square metre. Approximately 300,000 houses were sprayed in 1952. The proven vector species in Colombia are *A. darlingi*, *A. albimanus*, *A. punctimacula*, *A. pseudopunctipennis*, *A. nuneztovari*, *A. (K)neivai*, *A. eiseni* and *A. mediopunctatus*. To date no resistance to DDT has been observed among any of these anophelines.

Culex fatigans has shown resistance to DDT in all localities where house sprayings with DDT have been carried out (Cartagena, Medellin, Tumaco, Buenaventura, Montesia, Sincelejo and others).

Acari are in general resistant to DDT, especially *Ornithodoros rudis*, according to experiments in the slaughterhouse and pig-pens of Medellin, and *Argas columbarum*, which showed resistance to DDT, BHC and Dieldrin in houses of Tunja.

Ctenocephalides canis, a flea that infests dogs and cats and attacks man, showed resistance to DDT in Bogota. In Popayan, fleas also proved resistant. However, the species was not determined.

The author did not explain whether the resistance encountered among the abovementioned insects was natural or acquired.

FRANCO (1953) informs that in the region of the eastern Llanos no resistance has been observed to date among *A. darlingi*, nor among any of the other anophelines encountered in that region. House sprayings with DDT were started in April 1948, using only 1 gramme of DDT per square metre. As of the middle of 1949, this dose was increased to 2 grammes. FRANCO informs that both *Culex* and the domestic fly acquired resistance to DDT. No details are furnished, however.

GAST GALVIS (1953) informs that at the Carlos Finlay Institute in Bogota no observation whatsoever has been made on this subject.

PERU. — FERNANDEZ (1953) informs that no indications of resistance to DDT or other insecticides with residual effect have been observed among the anopheline vectors of the country (*A. pseudopunctipennis* and *A. punctimacula*), nor among the culicines. Flies show a distinct resistance in localities treated more than once with DDT, chlordane and BHC.

SILVA (1953), representative of the Fourth Zone of the Pan American Sanitary Bureau, confirms the general information regarding the existence of flies resistant to DDT in areas treated with DDT, not only in Peru but also in Bolivia, Ecuador, Colombia and Venezuela. However with the exception of the previously mentioned experiments carried out in Venezuela, no special studies have been made on this subject. SILVA further informs that in the Andean region on the frontier between Peru and Bolivia, a 10% DDT powder is used for controlling lice. To date there is no information that resistance to DDT has been encountered among these insects.

BOLIVIA (MOSCOSO CARRASO, 1953). — Application of DDT inside houses (2 grammes per square metre) resulted in a great reduction in the incidence of malaria in the treated areas. Although no special experiments or observations have been carried out to this effect, there is nothing to indicate that the local vectors (*A. darlingi* and *A. pseudopunctipennis*) have acquired any resistance to DDT. In some areas the results are not as good as could be desired, probably due to the unfavourable influence of uncontrolled population nuclei existing in the proximities. According to the opinion of the inhabitants in treated areas, « the first house spraying with DDT gave the best result. Later sprayings have had little effect on flies and triatomas ».

CHILE (NEGHEME, 1953). — No resistance phenomena have been observed with regard to *Anopheles pseudopunctipennis*, because this mosquito was rapidly eliminated. Recurring foci of larvae and nymphae encountered annually in some sectors neighbouring Peru, are easily eliminated with DDT and petroleum.

An increase has been observed in the number of flies resistant to DDT. This is due to the fact the initial doses of DDT applied in the previously malarious valleys were very small (200 mg per square metre). The initial dose was gradually increased and at the end of 2

years amounted to 2 grammes per square metre. This fact favoured the selection of flies resistant to DDT. In order to destroy as many resistant flies as possible, BHC was applied alternately with DDT. The flies disappeared during one or two months after sprayings with BHC, but after that period reappeared.

No resistance to BHC has so far been observed among triatomas

ARGENTINA. — ALVARADO (1953) informs that, with the exception of flies, no resistance to insecticides has been encountered among other insects. Local anophelines continue to be just as susceptible to DDT as they were before the house spraying campaign was started seven years ago.

ROMANA (1953) had had no experience on the subject of insects acquiring resistance to modern insecticides.

CASTRO (1953) of the Institute of Sanitary Entomology in Buenos Aires, does not know of the existence of investigations on this subject in Argentina.

URUGUAY. — VERISSIMO (1953) observed resistance of the house fly to DDT, BHC and Chlordane, which are the insecticides used in this country. LOPEZ FERNANDEZ (1950) confirmed experimentally the resistance of flies to DDT, verifying that specimens coming from a city that had been sprayed several times with DDT (RIVERAI, were 25 to 100 times more resistant to DDT than control specimens bred under laboratory conditions.

PARAGUAY. — JAVALOYES Y GONZALES (1953) informs that no observations have been carried out in this country on the resistance of insects, but that everything indicates that anophelines continue to be susceptible to DDT. SILVA PINTO (1953), who is acting as consultant to the malaria programme of OFSANPAN in Asuncion, has no information on resistance to insecticides among insects in Paraguay.

BRAZIL. — Shortly after the second or third house spraying with DDT in malarious areas, flies were encountered showing resistance to the insecticide. Today resistance to DDT is a general phenomenon among house flies in all treated areas. No special studies have so far been made on this problem and we are not in a position to ascertain whether this is a case of physiological or behaviouristic resistance, or both. Apparently, resistance is more marked in certain areas than in others. In order to try to overcome the resistance to DDT shown

by the house fly, we have added a small dose of BHC (100 mg of gamma isomere per square metre) to the insecticide applied in certain malarious urban areas. Control obtained with the first spraying of this mixture inside houses was good. With subsequent treatments, however, flies increased again. Only during the first or second week following spraying with the insecticide could a reduction be observed in the fly population. This reduction could only be due to the repellent action of the solution and the insecticides, especially the BHC. SCHIAVI (1949) of the Malaria Prophylactic Service of the State of São Paulo, verified that mortality among flies collected in localities that had been repeatedly treated with 2 gramme DDT per square metre was considerably lower than among flies collected in untreated localities, when exposed to contact with surfaces experimentally treated with DDT.

Culex fatigans presents considerable natural resistance to DDT. Observations being conducted by Rachou of the Serviço Nacional de Malaria in areas not previously sprayed with DDT, indicate that this mosquito is less susceptible to DDT than to Dieldrin, and especially to BHC. In a zone treated with DDT the reduction obtained in the indoor density of *Culex fatigans* was lower than in zones treated with Dieldrin or BHC. Technicians of the Serviço Nacional de Malaria in charge of the anti-malaria house spraying programme generally believe that *C. fatigans* has acquired resistance to DDT. The same impression is shared by the technicians of the Malaria Prophylactic Service of the State of São Paulo, according to information received from Unti, director of that Service (1953). However, we have no accurate data on which to base with certainty any statement to the effect that *C. fatigans* has acquired resistance to DDT.

BHC has been used since 1950 to combat triatomas in houses. So far there is no indication that they have acquired resistance to this insecticide. This refers to work done by the Serviço Nacional de Malaria as well as by the Malaria Prophylactic Service of the State of São Paulo. Triatomas present an innate resistance to DDT.

Although no special observations have been made, there is no reference or indication that other domestic insects have acquired resistance to DDT in this country.

Neither do agricultural pests so far seem to have acquired resistance to insecticides. COSTA LIMA (1953), professor at the National School of Agriculture, has no knowledge of any insects of importance to agriculture having acquired resistance to insecticides. Some agronomists connected with this Ministry made experiments at Campo Grande, Federal Dis-

trict, in order to verify if fruit flies were developing resistance to DDT, but without arriving at any conclusions.

The Institute of Biology in São Paulo also has no data that agricultural pests have developed resistance to modern insecticides. However, GIANNOTTI and PUZZI (1951) of this Institute observed a phenomenon of biological disequilibrium, characterized by the increase in population of a certain pest as a consequence of the treatment of plantations with insecticides. These authors sprayed orange trees with a water suspension containing wettable powders of DDT and BHC. They verified that DDT increased the population of *Chrysomphalus ficus* about ten times, and BHC about three times. They attribute the results mostly to the elimination of the natural enemies of this pest.

To date, nothing has been observed to indicate physiological resistance (HESS, 1952) among any of the *Anopheles* species acting as malaria vectors in Brazil.

BUSTAMANTE et al. (1951) verified the presence of numerous specimens of *Anopheles darlingi* on the external walls of houses that had been sprayed on the inside with DDT in the area of Engenheiro Dolabela, State of Minas Gerais. HESS (1952), as already mentioned in this report, considers this fact as an example of possible behavioural resistance of *A. darlingi* to DDT. We lack data to confirm whether this finding really signifies a form of resistance.

In the same area it was verified that in two houses, one treated experimentally inside with DDT and the other left untreated as control, the specimens of *A. darlingi* that entered the houses remained only for a short while, almost all leaving the house during the night (BUSTAMANTE et al., 1952). Before the sprayings with DDT *A. darlingi* was easily captured inside houses in this area until late in the day. This observation is an indication of the existence of a form of behavioural resistance. It could be explained by GABALDON'S ideas (1953) of the natural selection of races of the same species, existent in a given area, as a result of the introduction of insecticides. According to him, the mosquitoes which left the untreated house in the above-mentioned experiments, would represent a variety or race that enters the house to feed but comes to rest on the outside, thus escaping contact with the insecticide. The mosquitoes which fed and rested inside houses would have been eliminated by the insecticide and supplanted by the others. This hypothesis, however, needs confirmation through new experiments to be made shortly.

ACKNOWLEDGEMENTS

The author presents his thanks to all colleagues who were kind enough to supply the requested information, without which this report could not have been written.

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