

In view of the rapid development of the cities of the interior, and of the difficulties faced by some areas in jumping from the oxcart to the airplane age, few schools have adequate installations in such places. They generally use adapted buildings which present many material difficulties for remodeling into satisfactory accommodation.

Small improvements have been made, however, in order to make school-children conscious of sanitary principles. Provisions are made to protect the water supply and to install sanitary privies and toilets. Water-filtering devices are provided and the students are instructed to use individual drinking cups. School desks, benches and the blackboard are placed so as to provide good lighting.

Seasonal Variations in Susceptibility to DDT of *Anopheles maculipennis* in Iran

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The effect of seasonal changes on the susceptibility of mosquitos to residual insecticides has not yet received the attention it deserves. This applies particularly to the process of hibernation, when the physiology of the mosquitos suffers such important alterations as the interruption of ovarian development and the formation of fat body. We do not yet know the extent to which these changes can alter the susceptibility level of a mosquito species.

During a recent visit to Iran, where we carried out a series of tests to assess the susceptibility to insecticides of the local anophelines, we had the opportunity of making comparative tests with *Anopheles maculipennis*, using summer females with full ovarian activity and females entering hibernation having fat body and interrupted ovarian development. This was done in areas where residual insecticides had not been used. Though the period of our observations—from July to October 1956—was comparatively short, a great diminution was observed in the susceptibility level of the species after the start of hibernation. The general results of the susceptibility survey in Iran will be presented in the report to WHO of the Malaria Advisory Team, but in view of the scarcity of information on seasonal changes in susceptibility of mosquitos a separate discussion of our observations on summer and hibernating females seems warranted.

The susceptibility tests which are discussed below were made following the method described by Busvine & Nash.^a They were carried out in the field, in localities where mosquitos were captured and very often in the stables or houses where they had been caught, so that the traumatism caused by transport of the mosquitos and the resulting mortality was

^a Busvine, J. & Nash, R. (1953) *Bull. ent. Res.* 44, 371; (1954) *Wld Hlth Org. techn. Rep. Ser.* 80, 30

reduced to a minimum. As can be seen from our results, presented in the table, the mortality in the controls was very low and this seems to indicate that the handling of the mosquitos was satisfactory, though it should be added here that *A. maculipennis* is a comparatively robust species and gives little trouble in susceptibility tests.

On the basis of average mortalities (adjusted after Abbott's formula) the following median lethal concentrations (LC_{50} 's) have been numerically estimated.

Locality	Date (1956)	DDT (LC_{50})
Lotleil (Caspian region)	31.7 & 5.8	0.9
	22.10	16.4
Isfahan (Armenian district of Julfa).	22-25.9	1.8
	15.10	6.0
Isfahan (near river)	24 & 25.9	2.3
	15 & 16.10	6.7

Our first observations on the effect of hibernation on the susceptibility of *A. maculipennis* were made in Isfahan, which had not been sprayed with residual insecticides. Ansari, Baghdiantz & Samimi (unpublished report of Malaria Institute, Teheran, 1956) had drawn attention to the possibility of an increase of tolerance to DDT in *maculipennis* during the month of October when hibernation begins in the Isfahan area, but the fact that no test had been carried out during the summer in the locality examined in October made an adequate comparison difficult. The advisory team had the opportunity of making such a comparison in Isfahan town, where we obtained an LC_{50} of 1.8 with mosquitos from a capture-station in the Armenian district of Julfa, and of 2.3 with mosquitos from a capture-station near the river where a certain number of females were already developing fat body. These observations were made between 22 and 25 September. In tests carried out on 15 and 16 October (i.e., no more than 20 days later), we obtained an LC_{50} of 6.0 in the capture-station in the Armenian district, where some females still showed fresh blood, and an LC_{50} of 6.7 in the capture-station near the river, where all the females were developing fat body. The differences between the September and October LC_{50} 's, which are statistically significant, show clearly to what extent the beginning of hibernation may alter the susceptibility level of an anopheline species.

In view of these findings we decided to repeat the same kind of observations in Lotleil, a village in an untreated area in the Caspian region near the town of Resht, where we had obtained, on 31 July and 5 August, an average *maculipennis* LC_{50} of 0.9. The village was visited again on 22 October and we then obtained an LC_{50} of 16.4. Here the difference between the summer results and those obtained in October when hibernation had started and nearly all the females had fat body, was even wider, and this, we believe, was probably because considerably more time had elapsed between the two observations than in the case of Isfahan. We should like to point out, however, that the difference observed in the Caspian region is not statistically significant. It should be added here

SUSCEPTIBILITY TESTS ON A. MACULIPENNIS WITH DDT BY BUSVINE METHOD (UNSPRAYED LOCALITIES)

Locality	Lotleil (Caspian region)		Isfahan (Armenian district of Julfa)				Isfahan (near river)				
	31.7	5.8	22.9	23.9	25.9	15.10	24.9	25.9	15.10	16.10	
Date (1956)			22.10								
Relative humidity during exposure*	63	65	71	38	29	29	33	29	29	19	
Temperature	81.5°F (27.5°C)	82°F (27.8°C)	66°F (18.9°C)	76°F (24.4°C)	72°F (22.2°C)	74°F (23.3°C)	66°F (18.9°C)	71.5°F (21.9°C)	74°F (23.3°C)	66°F (18.9°C)	67°F (19.4°C)
during exposure*	—	—	—	61.5°-86°F (16.4°-30°C)	55°-66°F (12.8°-18.9°C)	60°-86°F (15.5°-30°C)	55°-67°F (12.8°-19.5°C)				
range during observation											
0.5% concentration	158	—	—	103	27	71	69				
1% concentration	130	11	62	62	28	74	73				
2% concentration	97	15	81	81	37	63	67				
4% concentration	—	13	127	127	38	84	75				
control	100	10	114	114	19	73	73				
0.5% concentration	62	—	—	7	0	3	0				
1% concentration	65	2	20	20	3	19	2				
2% concentration	85	6	45	45	6	31	4				
4% concentration	—	4	101	101	14	55	22				
control	11	0	0	0	0	0	0				
0.5% concentration	39	—	—	7	0	4	0				
1% concentration	50	18	32	32	11	26	3				
2% concentration	88	40	56	56	16	49	6				
4% concentration	—	31	80	80	37	66	29				
Control mortality (%)	11	0	0	0	0	0	0				

* in the various tests of each series

** of DDT in non-volatile oil

that, as can be seen in the table, the variation in temperature under which the tests were carried out is comparatively small, and it could hardly explain the great difference observed in the results, which was probably caused by the physiological changes taking place in the mosquitos at the beginning of hibernation. One such change is the development of fat body—a process which may have a direct bearing on the increase of insecticide tolerance in hibernating mosquitos. Wiesmann,^b making a comparative study of susceptible and resistant houseflies, found that the metabolism of lipids plays a very important part in the development of resistance to insecticides, and that in *Musca domestica* an increase of fats means an increase of resistance. It is thus possible that the increased tolerance to DDT which we observed in *A. maculipennis* was a result of the development of fat body.

Whatever the explanation may be, our observations show the importance that should be attached to hibernation when studying the susceptibility of mosquitos. We believe that there is need for systematic observations to be carried out throughout the year with anophelines from temperate zones to find out to what extent the LC_{50} of a species is altered by seasonal changes taking place in the mosquito, and particularly by the process of hibernation. We believe also that, in view of the differences in susceptibility observed with *maculipennis* in Iran over a period of only three months, care should be taken when interpreting the results of tests made at different times of the year even when they are carried out with the same mosquito species and in the same locality.

Before concluding, we should like to add that the term *A. maculipennis* is applied in this paper to several forms of the *maculipennis* group. We found that, in the area of Lotleil in the Caspian region, both *A. maculipennis maculipennis (typicus)* and *A. melanoon subalpinus* were present, the former being the predominant species. A third form of the *maculipennis* group with mixed characters of *typicus* and *subalpinus* was also present in the area. In Isfahan, *typicus* appeared to be the predominant species but another form was present there, and according to Professor Raffaele (personal communication, 1956), to whom material was sent for examination, this second form should be considered as *messeae*.

It is not likely, however, that there will be marked differences in susceptibility between the above-mentioned forms of *maculipennis*. On the contrary, all the information available indicates that in untreated areas the various forms of the *maculipennis* group have very similar LC_{50} 's when tested under the same conditions.

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^b Wiesmann, R. (1956) *New observations on the resistance of Musca domestica L. to DDT*. In: *Proc. Third int. Congr. Phytopharm., Luxembourg*, p. 69

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