portion; 'spiraculum' with *three* projections and *two* clefts in between; a mucus pit, in some, in front of the 'spiraculum'; scales in the dermis. The skull (Text-Fig. 2) shows a temporal gap on account of the incomplete growth of the squamosal (*sq.*); a post-frontal is wanting; palatine (*pal.*) separate from maxilla (*max.*); palatine teeth 11, maxillary 8, prevomerine 9 and premaxillary 9; the maxillary and palatine teeth rows are unequal, the latter extending behind the choana more than the former; the lower jaw carries two rows of teeth, the inner row short; the stapedial artery pierces the columella (*sf.*); the ceratohyals and the first two pairs of ceratobranchials are connected mesially by basihyal and copula 1 and 2 respectively; the fourth ceratobranchial is small and articulates at the middle of the third ceratobranchial; the gill clefts are between the second and the third and the third and fourth arches respectively.

I. glutinosus (Linné): Larva studied 130 mm. long with a tail fin shorter than in *monochrous* and with a dorsal lobe as in *monochrous*; snout length more than the interorbit; yellow bands on the sides extending from the sides of the head; head shows two eyes with a tentacular orifice in front of each eye, but in a larva measuring 101 mm. this orifice is not yet formed; sensory openings on the head; the cloacal opening interrupts five annuli; 3-4 postanal annuli and a short postanal portion; 'spiraculum' shows only *two* projections with a cleft between them.

The skull shows a temporal gap on account of the incomplete growth of the squamosal; a postfrontal wanting; palatine and maxilla separate; stapedial artery pierces the columella; the hyobranchial apparatus is as in *monochrous* and the only gill slit is noticed between the third and fourth ceratobranchials.

Thus when the yellow bands have not yet appeared in *glutinosus*, the *monochrous* larvæ can be differentiated from the former by the possession of (1) a 'spiraculum' showing three projections and two clefts and of (2) a snout shorter than the interorbit. In older larvæ, the annuli become clearer and in *monochrous*, the anus interrupts seven annuli.

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1. Gadow H., "Amphibia and Reptiles," *Camb. Nat Hist.*, 1923, London. 2. Sarasin, P., and F., *Ergebn naturwiss. Forsch. Ceylon. Wiesbaden*, 1890, 2. 3. Deraniyagala, P. E. P., *Ceylon J. Sci.*, 1933, **B17**, 231. 4. Boulenger, G. A., *Cat. Batr. Grad.* (British Museum). 1882, II edn 5. Norris, H. W., and Hughes, S. P., *J. Morph*, 1918, **31**, 489.

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ERADICATION OF INSECT PESTS OF STORED GRAINS RATHER THAN THEIR CONTROL*

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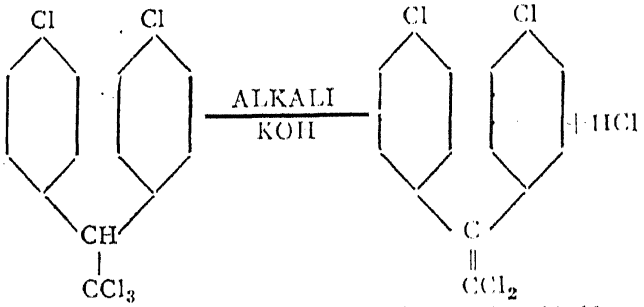
I. General

THE urgency of the need of an effective control of harmful insects was felt in the World War when every effort was directed to produce more food and to save as much as possible from the ravages of insects in order to avert the threatening world-wide food shortage. With unceasing search and never getting disappointed with their efforts in the advancement of science and perfection of the known and discovered things, the scientists were able to bring to light the spectacular insecticidal properties of the two substances, *viz.*, Dichlorodiphenyltrichloroethane and Benzenehexachloride which remained undiscovered till then. The application of these has not been perfected and still needs careful investigation. However, on the basis of whatever achievements have been affected uptil now, it can be safely predicted that the control of the agricultural crop pests is definitely going to be revolutionised and become less complicated. We hope that time is not far off when we shall claim eradication of insect plagues rather than their control. Already a good deal of contribution has been made by the scientists all over the world but the prohibitive cost and the non-availability of the insecticides have restricted their trial and use in India. Such factors are, however, considered of little importance and value when the study of the scope of a new insecticide is in progress. For instance, methyl bromide was considered to be a costly fumigant till 1938 (fumigation properties discovered in 1934-35) but its inherent valuable properties made it possible after some time to procure it at cheaper and economical price, thereby helping in its extensive use in the present days. In India these new insecticides have been tested extensively against mosquitoes, flies, sand-flies, lice, etc. Their use in agriculture is slowly finding its way and co-ordinated attempts have so far been instituted to find out their practical application in the control of

*A simple method for the control of insect pests of stored grains and potato tuber-moth by the use of DDT and 666 has been evolved.

stored grain pests. The urgency of their use in this line was realised when it was made known to the public that the stored food-grains in India are undergoing an undetectable loss of 3·375 million tons of food, sufficient to feed 6 million persons for full one year. A meeting of all Entomologists in India was called by the Food Department, Government of India, to plan out the proper application of the chemicals (DDT and 666) in respect of combating the stored grain pests. The Entomologist from the Ordnance Laboratories, Cawnpore, while reviewing his researches about the application of the insecticides as debris disinfectants and in whitewash† for disinfecting godowns, put forth his interesting conclusions on whitewashing of godowns for the control of stored grain pests. These inferences were, however, identical to those of the writer arrived at independently as a result of research on similar lines at the Imperial Agricultural Research Institute, New Delhi, under the then Director, Dr. Hem Singh Pruthi. These are:—

(1) Lime inactivates the two insecticides causing dehydrohalogenation. The chemical change is rapid in DDT and is as follows:



Dichlorodiphenyltrichloro-ethane *Dichlorodiphenyldichloro-ethylene*

(2) Chalk, although a neutral substance, has got the limitations of being costly and not easily available. Further it does not form a good wash.

(3) The particles of chalk and lime cover to a considerable degree the minute particles of DDT and 666, never allowing the covered particles to play their role.

(4) Particle size plays fundamental part in case of all nerve poisons. The most effective size is 5 microns. This much size of the particles can be obtained on evaporation of the solvent from the solution or emulsion.

It is, therefore, quite evident from the above that the whitewashing experiments would be of little use for the chances of killing insects to an appreciable degree are remote. The only possibility for the application of these insecticides on the walls is to apply them as spray in petrol, kerosin oil, etc. The writer consequently considered it worthwhile to give up the idea of pursuing the whitewashing treatment. To support the contention further, it may be added that few insects crawl on the walls of a godown packed with bags of grains unless the grains are disturbed, the temperature is very high, the insects are in enormously large numbers or the percentage of infestation exceeds fifty. Some of the conditions enumerated above appear at a stage when grains become totally unfit for consumption thereby rendering the treatment of little use, while the remaining ones that occur occasionally are difficult to secure. Hence again the utility of the treatment is not encouraging. It may, however, be mentioned at this stage that whitewashing could be employed for disinfection of empty godowns where insect-free produce is likely to be stored. The possibility of disinfection under the above conditions can be ruled out to some extent for it is easy to disinfect by sulphur fumes or HCN, this treatment will not only be convenient but effective also. However, with all the points unpropitious whitewashing may be adopted for treating underground godowns or *khattis*, where fumigation is a problem. But seldom there is necessity of disinfecting an improvised bin as the damage in it is always negligible. Here too, the spraying of a solution or emulsion would be advisable.

The writer thus restricted his attempts in finding out an easy method by which an attack of insects to sound and healthy grains may be warded off effectively and also infestations present to a certain degree may be eliminated with special reference to storage in bags. Holding of grains in bags is convenient and hence unavoidable and indispensable although unfortunately the damage due to insects is considerable because of the easy access of the pests. The experiments together with the inferences are set forth in the following pages.

II. Experiments

Gunny bags, half of the standard size, were treated with the following solutions and emulsions of DDT and 666.

(1) *Seven, 14 and 28 per cent. mixtures in Kerosin oil.*—100 c.c. of each mixture was used for treating inner and outer surfaces of four bags.

(2) *0·35, 0·7 and 1·4 per cent. mixtures in water.*—2000 c.c. of the preparation was used to soak four bags. The poisons were first diluted with chalk so as to remove their stickiness and also to help in their uniform dispersion.

(3) *Kerosin oil emulsion containing 0·35, 0·7 and 1·4 per cent. poisons.*—2000 c.c. of the preparation was utilised in treating four bags. Kerosin oil emulsion was prepared by using gum as emulsifier.

(4) *DDT and 666 emulsions*‡ were prepared as follows: DDT or 666 25 gms., Toluene or Benzene 33·35 gms., Turpentine 33·35 gms., Water 0·6 gms., Soap 2·8 gms. Alcohol 4·9 gms. The stock solution was first diluted with four times water and then the whole quantity made upto 7000 c.c. Only 2000 c.c. of the emulsion thus prepared was used in treating four bags only.

In all there were 22 treatments and one control. Each treatment was replicated four times. The minimum dose tried was 1·7 gms. of the poisons per bag. The bags were treated on 24|25-3-1945 and then thoroughly dried up in shade. Five seers of insect-free jowar (*Andropogon sorghum*) grains were put in each

† DDT and 666 were used in white wash at the rate of 2·5, 5·0, 10·0 and 15·0 mgrms. per sq. ft.

‡ This treatment was done in August when the ready material was made available by the Director, Malarial Institute, Delhi.

bag on 31-3-1945 and kept in a godown heavily infested with all the species of insect pests of stored grains by keeping infested grains in corners. The control lots were kept away at a distance of more than five feet from the treated ones. Two more treatments were added after a lapse of one month where DDT and 666 carried in chalk were mixed with grains at the rate of 1 in 10,000. On 16-4-1945, 25 adults of each *Sitophilus oryzæ* Linn., *Rhizopertha dominica* Fab., *Tribolium castaneum* Hbst., *Corcyra cephalonica* Staint., *Sitotroga cerealella* Oliv., and *Latheticus oryzæ* Waterh., were introduced in one replication of each treatment. The observations were taken fortnightly till the 15th of May and later on after a lapse of full one month.

III. Results

Record of the sweepings are given below in a tabular form:—

Date of observation	Sweeping from the area where treated bags were kept								Sweepings from the area of control lots
	Wt. of dead insects in grams	Percentage of insects in the sweepings (by number)							Wt. of dead insects in gms.
		S.o.	R.d.	T.c.	L.o	S.c.	L.s.	Misc.	
16 4-1945	9·2	58·0	3·4	6·3	12·6	12·5	4·1	3·1	0
30-4-1945	15·3	59·1	4·7	15·2	8·6	11·2	0·1	1·1	0·2
15-5-1945	24·35	27·6	5·1	20·4	8·1	2·1	33·6	3·1	0
30-5-1945	21·5	14·1	11·1	36·0	14·7	3·2	13·8	7·1	0·1
30-6-1945	15·6	6·8	22·4	28·5	20·2	5·6	12·3	4·2	0
30-7-1945	7·5	2·1	30·5	23·7	16·3	12·5	4·1	10·8	0
30-8-194·	5·3	0·2	62·1	14·3	11·4	10·2	0·5	1·3	0
30-9-1945	2·4	—	—	—	—	—	—	—	0

(S.o.—*Sitophilus oryzæ*; R.d.—*Rhizopertha dominica*; T.c.—*Tribolium castaneum*; L.o.—*Latheticus oryz*. S.c.—*Sitotroga cerealella*; L.s.—*Læmophlæus* spp.; Misc.—*Corcyra cephalonica*, *Silvanus surinamensis*, *Alphitobius* sp., etc.)

In a couple of days after putting the bags in the godown, it was observed that the insects were dying in large numbers on and in the vicinity of each bag of the treated lot. A good number of insects were seen in a state of paresis and the peculiar effect of DDT or 666 causing the stretching of wings and legs as a result of nerve poisoning was also noticed in all the dead and paralysed adults. It will be seen from the above table that the mortality percentage increased immediately but declined slowly till the end of September when very few insects died. On examining the heap of infested grains (used as a source of infestation for the room), it was observed that practically the infestation was nil as compared to the one in March on account of regular drain of insects to the experimental lots.

On 15-10-1945, the grains in each bag were weighed and examined for percentage of infestation. It was interesting to note that no living or dead insect could be collected from the treated lots. Even in case of those bags where insects were actually introduced for the sake of infestation in the grains neither the damage nor any living insect could be observed. Similar observations were recorded in replications where the poisons were used as preservatives, but here the number of dead insects inside the bags was very large. Examinations of the control lots on the other hand revealed that they were full of living insects and the grains had suffered heavily to an extent of 50-70 per cent.

For further confirmation of observations as regards the annulling of development where infestations were made in the bags, some insects numbering 50, each of *Sitophilus oryzæ*, *Rhizopertha dominica*, *Tribolium castaneum*, *Corcyra cephalonica* and *Sitotroga cerealella* were caged in dishes, size 4″ × 2″, containing grains over DDT or 666 powder put in similar dishes, separating the two dishes by means of muslin cloth. The insects were not allowed to come in direct contact with the poisons. It was observed that all the insects died in 7-14 days' time whereas in the control lots they lived on without mortality.

It is, therefore, evident from above that DDT and 666 give out vapours which also kill insects; hence both the poisons appear to act as contact poisons as well as slow fumigants.

IV. Discussion

It is established that DDT and 666 would be of little use in whitewash where the intention is to reduce infestations by warding off insect attack. From the foregoing experiments and results, it is evident that if bags are treated with these poisons, grains remain safe not only from the outside infestations but the infestations already present can also be annulled as the poisons act as slow fumigants as well. Of all the treatments, the application of kerosin oil mixture is easy to perform and yields promising results. It was found out by experience that while treating bags more attention is required to be directed at corners and sewn areas which appear to be vulnerable points. The least dose tried was 1·7 gms. per half the size of a standard bag, *i.e.*, 3·4 gms. per bag which remains effective for 6 months and it has been learnt that the effectiveness persists almost unimpaired even after a lapse of full twelve months. The cost of the treatment works out at 2·1 annas per bag and this figure is very low in comparison to the average loss (Re. 1 per bag of grains) sustained through insects. The cost can be further reduced by experimenting with low doses and correlating them with period for effectiveness. The other treatments have got a disadvantage of entailing extra four or five days because of drying of individual bags but are useful in not leaving any undesirable smell. In this respect

insecticides dissolved in petrol, benzene, etc., would be better if applied with a spray pump. However, it rests with individual convenience as to which treatment can be employed but it would be advisable if only one treatment is followed universally. The suggested treatment as it stands, appears to entail a huge amount of labour, etc., and will be difficult to practise in all channels of grain movements because of the conservativeness unless some law is enacted to force people to undertake the treatment. The movements of bags which are indispensable in trade, is the factor that renders this treatment complicated.

To simplify and make the treatment attractive by removing the possible shortcomings, it can, however, be suggested for transience that big sheets of gunny cloth may be treated and used as cover for individual stacks. These sheets should also be spread under each stack so as to eliminate access of insects through creeping along the floor. This type of modification in the treatment is bound to be equally effective, especially in case of insect infestations in grains lying in open heaps in a godown or *khatti*. The scope of this treatment can be extended over receptacles like *dholi, bokhari, kothi*, etc. In such receptacles generally the top layers get infested and these can be easily protected by using a cover of treated gunny cloth. As an additional precaution, an extra sheet can be kept at a distance of four inches below the top, this will add to the efficiency of the treatment. In the Punjab and some other parts of India where *theka, theki, palla, palli*, etc., prepared out of gunny cloth, are in vogue to store 20-200 maunds of grains, the application of poisons as suggested in this paper, can be advocated with advantage. For rendering godowns immune to insect access, barriers of treated gunny cloth can be put on windows and ventilators and further doors and gates can be provided with curtains of the some; the use of fine wire-gauge can thus be eliminated. Spraying DDT or 666 emulsion inside godowns will further add to security against insect ravages.

Spreading of treated gunny over grain heaps appears to work nicely against *khapra*. In laboratory trials, *khapra* grubs have been found very resistant to the poisons but their beetles are very susceptible.

It may also be indicated that by adoption of this treatment, *i.e.*, use of treated gunny cloth, there will be a great relief from the nuisance of potato tuber moth, *Gnorischema operculella* and bruchids. Only a thin gunny cloth as a cover will suffice for an effective control. A trial on a small scale was conducted at the Imperial Agricultural Research Institute, New Delhi, and encouraging results were obtained.

The application of DDT and 666 presented in the paper has given marvellous results in the control of a number of pests and needs further investigations as to its scope against similar insects. It is also suggested that the findings contained in this paper may be tested on a large scale keeping at least 200-400 bags in a test, in places where facilities exist, *e.g.*, at Government Farms and results watched for full one season. The following different treatments can be included in the proposed trial:

(1) Treated gunny bags only.
(2) Treated gunny bags covered with treated gunny cloth.
(3) Untreated gunny bags covered with treated gunny cloth.
(4) Godowns provided with treated cloth barriers at windows, ventilators and doors.
(5) Spraying of walls with DDT or 666 emulsion.

The author is confident that if due attention is paid to develop the suggested line of action there is no reason why we should not claim eradication of certain pests. However, at present the seed storage and the bulk storage as well appear to become simple and efficient against insect plagues.

V. Conclusions

Pursuing of experiments with DDT or 666 in whitewash appears to be of little advantage. Spraying of emulsions or solutions of DDT or 666 is better substitute for white-washing of godowns where the object is to provide an inimical surface to pests of stored grains.

DDT and 666 act as slow fumigants also; this property helps in dealing away with small infestations present in bags or storage receptacles.

Infestations of stored grain pests can be easily and efficiently eliminated by the use of bags treated with emulsion or solution of DDT or 666. Treated gunny cloth can be employed as cover for stack of bags with equally good results in case the bag treatment is inconvenient to practise.

The scope of the proposed application of DDT and 666 can be intelligently extended over to grains stored in various receptacles in vogue.

Barriers of treated gunny cloth can be put on doors, windows and ventilators of a godown thereby eliminating the use of fine wire-gauze.

Troubles of potato tuber moth are easily remedied by merely covering stored potatoes with a treated gunny cloth.

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1. Mackie, D. B., "Methyl bromide–its expectancy as a fumigant," *Jour. Econ. Ent.*, 1938, **31**, 70–79. 2. Nasir, M. M. "DDT, 666 and Insect Pests of Stored Grains," *Curr. Sci.*, 1946, **4**, 98–99. 3. Nasir, M. M., and Manzoor, A., *Jowar. Its Pests and Storage*, in press. 4. Pruthi, H. S., and Nasir, M. M., "Tests with DDT and 666 as Agricultural Insecticides in India—I. For stored grains,' *Indian Farming*, 1945, **6**, (2), 506–10.

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