OBSERVATIONS ON THE EFFECTIVENESS OF SOME MOTH-PROOFING CHEMICAL COMPOUNDS

by

DANIEL RONALD MUSSER

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INTRODUCTION

It is common knowledge that certain household pests, namely, clothes moths and carpet beetles, cause considerable damage to upholstered furniture, woolen goods, rugs, carpets, furs, felt and fabrics of all kinds. The object of this investigation was to determine the insecticidal value of various moth-proofing chemical compounds, most of which are now used in some form or another against these injurious insects.

The work was stimulated by the increasing economic importance of these insects throughout the world, and by the fact that the application of moth-proofing compounds to infested fabrics is a relatively new commercial process or household practice and one of growing interest to textile and furniture manufacturers as well as to the general public.

The extent of the injury caused by the feeding of these more common clothes pests is evidence of the great need of an efficient and economical moth-proofing treatment. Meckback (1921) estimated the world's total loss of wool due to clothes moths alone at twenty-two and one-half million pound weight per year. The Better Fabrics

League of America, in 1927, estimated the annual loss through moth-damaged fabrics at 100,000,000 dollars, or approximately one-sixth of the value of fabrics produced in this country.

Roark (1931) of the United States Department of Agriculture listed in his "Index of Patented Moth-Proofing Materials" over 700 moth-proofing preparations that had been patented. This large number of diverse materials proposed for proofing wool against insects is an indication that none was completely satisfactory, or that there may be many kinds of successful compounds.

The experimental work from which the data recorded in this paper were taken extended over practically one calendar year. While a year's investigation is no doubt inadequate and many points remain to be investigated, the results obtained gave rather definite indications concerning the insecticidal value of the various moth-proofing compounds tested.

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MATERIALS AND METHODS

The task of obtaining specimens of the more common fabric pests in sufficient numbers to conduct the tests effectively was found to be the limiting factor throughout the experiments.

During 1932-'33, clothes moths and carpet beetles were found to be more plentiful than other insects which infest upholstered furniture and fabrics such as tobacco beetles and drug store beetles. The two kinds of clothes moths used in the experiments were the two more commonly known species consisting of the case-making clothes moth, Tinea pellionella L., and the webbing clothes moth, Tineola biselliella Hummel. The three species of carpet beetles found to be abundant in this vicinity and chosen as the ones to be used in the tests included the black carpet beetle, Attagenus piceus Oliv.; the common carpet beetle, Anthrenus scrophulariae L.; and the varied carpet beetle, Anthrenus verbasci L. No specimens of the tapestry moth, Trichophaga tapetzella L., or the furniture carpet beetle, Anthrenus fasciatus Hbst., were collected, since they do not occur commonly in this section of the country. In most cases the larval form of these insects was collected. It was found relatively easy to keep the larvae flourishing by feeding them undyed wool yarn, woolen cloth, or fleece-wool.

Ice cream cartons of pint size were selected as suitable containers in which to place the sample to be tested. These cartons were absolutely tight-fitting and no repellant odors were coming from the material of which the cartons are made. These small containers were kept in large, closed pasteboard or wooden boxes, since, in their natural habitat, the larvae of these clothes pests prefer darkness. The boxes containing the cartons were kept in the greenhouse insectary, where the temperature ranged from 70° to 85° F. and the relative humidity from 45 to 55 per cent, because this location was the nearest available to the natural habitat of these insects.

In all of the tests, the material treated consisted of small pieces of woolen blankets of the finished and unfinished type. The finished blanket pieces had a fairly heavy, soft nap on both sides, while those of the unfinished blankets were plainly woven together without a nap. The samples of the blankets were obtained direct from the Carolina Cotton and Woolen Mills Company, Spray, North Carolina and the Nashua Manufacturing Company, Nashua, New Hampshire, in order to be certain that they had not been treated previously with some chemical compound.

The pieces of woolen blankets, used in the experiments, were cut into rectangular samples four inches long and two inches wide. After treating and drying these samples, they were folded lengthwise, five active larvae of the same species confined within the fold of both finished and unfinished samples, and the three open sides closed by means of paper clips. In one corner of each treated sample was attached a tag giving the date, the kind of insect used, and the method of treatment. This information made it possible to keep a record of each test separately, and also avoided any confusion as to the method of treatment of each sample.

After an interval of seven to fourteen days the first examination of the samples was made, and the number of larvae alive or dead, any apparent feeding, and any other important information were recorded. From time to time further examinations of the samples were made and the results recorded. The various tests were continued over a period varying from three weeks to three months in length.

The moth-proofing compounds used in these tests may be grouped in two classes, namely; those which are toxic to the insects when ingested even in very small amounts, and those which act as a repellant to the insects. The first class includes such chemical compounds as sodium fluoride, the silicofluorides, and the arsenical preparations. Included under the second class are such materials as the urea derivatives, quinine derivatives, such as the cinchona alkaloids, and those that contain pyrethrum oils such as Konate. Tests were made with the following compounds:

1. Sodium fluoride) saturated solution in cold water
2. Sodium fluosilicate)

3. "Steuben Chemical Compound" - a hydrofluoric acid solution

4. "Larvex" - contains silicofluoride compounds, the toxic material being sodium fluosilicate

5. "Century Moth-proof" - contains small amounts of sodium arsenite, sodium fluoride, and hydrochloric acid

6. "Berlou Moth-proof" - similar in content to the Century moth-proofing solution

7. "Konate" - contains oil of pyrethrum

The moth-proofing solutions were either sprayed on the fabrics by means of a hand-operated atomizer, or the samples were completely immersed in the solution for a period of ten minutes. The moth-proofing preparation was applied by means of the atomizer in sufficient quantity to moisten thoroughly the entire surface of the samples but not to saturate it. The different methods of treatment of the samples are given in the tables.

REVIEW OF LITERATURE

In an early account of clothes moths, Marlatt (1908) has written that the common species of clothes moths have been associated with man from the earliest times and are thoroughly cosmopolitan. They are all probably of Old World origin, none of them being native to the United States, although they were introduced into this country at an early date.

It is only the larval form of these insects that feeds on fabrics and thereby causes injury. Clark (1919) has estimated that the larva of a clothes moth may destroy a weight of wool approximately twelve times its maximum or full grown weight. Although this is a very small amount, the damage resulting from a heavy infestation of these pests would soon reach a measurable quantity. For instance, it has been estimated that $92\frac{1}{2}$ pounds of wool or other material would be eaten by the progeny of a single moth produced during the period of one year.

In the testing of various moth-proofing compounds, Moore (1930) found it better to use feeding larvae, especially when a toxic material is applied, since with fully grown larvae, damage to the cloth may result from the habit of cutting fibers in the formation of cocoons. This cutting has nothing to do with the feeding habits of the larvae, is not poisonous to the larvae, but permits them to pupate and finally emerge as adults.

The control measures as suggested by Marlatt (1908) represent the earlier methods used to check the ravages of clothes moths and carpet beetles, which are still effective if applied in a thorough manner. "In order to protect carpets, clothes, furs, cloth-covered furniture, etc., they should be thoroughly beaten, shaken, brushed, and exposed as long as practicable to the sunlight in early spring." He recommends that the best method of protection and the one now commonly adopted by dealers in carpets, rugs, and furs, is that of cold storage. A temperature maintained at 40 - 42° F. renders the larval or other stages of these insects dormant, and is thoroughly effective. Back and Cotton (1926) reported that several hours exposure to zero or subzero weather will kill all stages of clothes moths or carpet beetles.

In the experiments conducted by Back and Cotton (1928), they have shown that a temperature of 125° - 140° F. maintained for a period of ten to twelve hours will kill all insects that attack furniture. Chests made of heartwood of red cedar, if in good condition as regards tightness, were found by Back and Rabak (1922) to be effective in protecting fabrics from clothes moth attack.

Naphthalene and paradichlorobenzene are said to be effective in killing clothes moths and carpet beetles. However, three things are imperative in this treatment if it is to be successful. First, to use enough of the fumigant; second, to use it in a tightly enclosed space; and third, to use it for a sufficient length of time. Back and Cotton (1928) stated that both naphthalene and paradichlorobenzene are very effective if used in amounts sufficient to cause the eyes and nose to smart when one enters the storage room. The tests made by Herrick and Griswold (1931 and 1933) showed that naphthalene and paradichlorobenzene are toxic to the eggs and larvae of clothes moths and carpet beetles. Best results are obtained when the fumigants are applied in the flake form and scattered loosely among the clothing.

Fumigations, if conducted in tightly constructed fumigating rooms or vaults, result in the quick, effective destruction of insects damaging fabrics and upholstered furniture. Back and Cotton (1928) recommended a number of fumigants that have proved useful in treating furniture. Among them may be mentioned hydrocyanic acid gas, chloropicrin, cyanogen chloride, carbon tetrachloride, carbon disulphide, ethylene dichloride-carbon tetrachloride mixture, and ethylene oxide-carbon dioxide mixture. Two of these, hydrocyanic acid gas and the ethylene dichloride-carbon tetrachloride mixture, are in most common use at the present time. The great drawback to any effective fumigation of fabrics or upholstered furniture is that no fumigant is known that will render the treated piece immune to future infestations.

A combination of fumigation and moth-proofing services as a means of preventing reinfestation after fumigation is recommended by Back (1931). A number of moth-proofing solutions are now available, the most effective of them being the fluoride, cinchona alkaloid, Eulan, and Rotenone solutions. Solutions containing arsenic in any form are not advocated. The use of arsenic in this manner has been disapproved by the American Medical Association (1923), since several cases have been reported where the application of an arsenical moth-proofing preparation to a fabric has resulted in an irritation of the skin upon later use of the fabrics. The experiments conducted by Moore (1930) showed that moth-proofing preparations containing cinchona alkaloids have a much greater repellant effect than those containing arsenic or silicofluorides. His experiments also showed that larvae feeding upon cloth treated with a silicofluoride or with a preparation containing arsenic will die, usually before they have sufficient time to cause appreciable damage.

Minaeff and Wright (1929), in tests made in the laboratories of the Larvex Corporation, have shown that a group of chemicals consisting of different inorganic fluorine compounds are most effective. Two combinations of fluorine moth-proofing formulas were used: First, one based on neutral fluorides or sodium fluorides; and second, one based on complex fluorides or silicofluorides. Sodium silicofluoride was found more effective than sodium fluoride even when the latter was applied in solutions of double concentration. With the sodium silicofluoride combinations best results are obtained in the presence of aluminum ions, which greatly accelerate the process of absorption.

Samples treated with sodium silicofluorides resisted rinsing in water much better than those treated with sodium fluoride. Only after three hours was the fluorine compound sufficiently removed so that larvae would damage the fabric, while samples treated with sodium fluoride lost much of their immunity after only five minutes rinsing. In further tests conducted by Minaeff and Wright, it was shown that wool shows a much stronger affinity to silicofluorides than to neutral fluorides. A one-tenth concentration of sodium fluoride does not give a sufficient moth-proofing, while the same concentration of sodium silicofluoride does. They recommended that Larvex moth-proofing chemical be applied either in concentrated solutions with silicofluoride content of 0.6 per cent and over, or in dilute solutions with silicofluoride content below 0.1 per cent.

A study on the toxicity of fluorine compounds was made by Marcovitch (1928). In laboratory experiments with clothes moth larvae, he showed that they readily succumbed when fed on raw wool which had been dipped in a 1 to 200 solution of sodium fluosilicate. A gallon of Larvex, sold on the market at four dollars, contains about one ounce of sodium fluosilicate, worth less than one cent. An effective home-made "Larvex" may be produced by dissolving one ounce of sodium fluosilicate in one gallon of water. A numeral toxicity value for certain fluorine and arsenical compounds, as worked out by Marcovitch, was as follows:

Sodium fluosilicate - -	34.5
Sodium arsenite - - -	13.1
Sodium arsenate - - -	4.8
Sodium fluoride - - -	4.0

For insects and lower organisms, sodium fluosilicate is more toxic than sodium arsenite and at least eight times more toxic than sodium fluoride. On the other hand, to man and the higher animals the arsenicals are at least nine times more toxic than sodium fluosilicate and thirty times more toxic than sodium fluoride. The fluorine compounds do not seem to be repellant to insects, and are therefore in many cases, more effective than arsenicals. The arsenical and fluorine compounds are much more effective under high temperatures, especially above 100° F.

Eulan, which contains an inorganic fluorine compound, is a colorless, odorless, non-irritating, non-poisonous, and non-inflammable solution. Meckback (1921) is the originator of the Eulan moth-proofing compounds. Eulanized cloth is said to withstand steaming, naphtha cleaning, and a reasonable amount of washing. Treatment with a Eulan solution does not affect subsequent dyeing or other treatment, nor is the handle, color, or appearance of goods affected. One and one-half ounces of Eulan are dissolved in one gallon of water, or one pound in ten gallons, by boiling for five to ten minutes. Herfs (1933) listed the following new preparations of Eulan now placed on the market:

Eulan New	- (for use in the dyebath 4%)
Eulan NK	- (for aftertreatment)
Eulan NKF Extra	- (used for furs)

White (1929) made tests with Eulan F Extra and Eulan A, and both proved to be satisfactory moth-proofing solutions.

In the experiments conducted by Jackson and Wassel (1927), they found that the cinchona alkaloids or their compounds in either water or petroleum naphtha solution are commercially suitable for treating materials by immersion in or by spraying with the solution. Cinchona alkaloid oleates have had a successful history as moth-proofing agents over a period of six years. Petroleum naphtha solutions of the cinchona alkaloid oleates are true moth repellants, and protect treated materials even in the presence of a choice of moth food. The properties of cinchona alkaloids which make them valuable as moth repellants are as follows: They are (a) salt forming organic chemicals, (b) bitter substances, (c) intestinal irritants, (g) germicides and antiseptics, (e) astringents, and (f) local anesthetics.

These workers have shown that petroleum naphtha penetrates wool fibers much more readily than acetone or water solutions, and that the cinchona alkaloids have basic properties which make them attach themselves to a woolen fiber like a dyestuff. After many tests, quinidine salts, a fatty acid compound of the cinchona alkaloids, have so far proved to be the most economical to use industrially, considering the initial cost, evaporation loss, fire hazard, and penetration. The most useful "dry solvent" is a special heavy petroleum naphtha, sufficiently volatile that it evaporates in a short time from materials treated.

In conducting these experiments with the cinchona alkaloid compounds, Jackson and Wassel (1927) found that there are eight desirable properties which a desirable moth-proofing material should possess.

1. It should either repel or poison clothes moths carpet beetles, and other insects infesting fabrics, or render the fibers proof against larval damage.

2. It should not affect adversely the physical properties of the textile fibers.

3. It should be odorless.

4. It should not be removed by dusting.

5. It should not discolor the goods or form any combination with any dye stuffs already in the fiber which would be harmful to the cloth.

6. It should be simple in its application and adhere evenly to the fiber treated like a dyestuff.

7. It should be non-poisonous to human beings in the small amount of toxic materials which are employed, and should not have any irritating effect on the skin .

8. It should be available commercially at a reasonable cost.

The use of Rotenone as an insecticide is described by Turner (1932). He found that Rotenone deteriorated quickly in the presence of soap and water, but was apparently stable when it was dissolved directly in oil-soluble sulfonate. As a contact insecticide, Rotenone in small amounts was highly toxic to several insects. However, it was not so effective when applied to insect eggs. Rotenone is a highly effective stomach poison for insects.

Back and Cotton (1929), in discussing the effectiveness of various moth-proofing solutions and the claims made for them, said that laboratory experiments of the United States Department of Agriculture have indicated that no usable solution is now on the market that will "permanently and absolutely render treated fabrics moth-proof". However, it is equally true that some of the better solutions, if properly used, do impart a moth resistance to fabrics that can be of real practical value. The effectiveness or ineffectiveness of a moth-proofing solution depends a great deal on the manner and thoroughness of application. Solutions must be applied so that all parts of the fabric are saturated, that is, every fiber must be thoroughly soaked with the solution. Therefore, moth-proofing solutions cannot be recommended unless applied by immersion or with the aid of a power spraying machine. Back and Cotton (1927) stated that moth-proofing or mothresisting solutions belong to that class of products that fail to yield results in the hands of the average person because of ignorance, misinformation, or carelessness.

Any firm claiming complete moth-proofness for an indefinite time as a result of the use of its product deserves to have its claim looked upon with suspicion. This danger of false advertising, such as manufacturers guaranteeing that one application of their moth-proofing compound will prevent moth damage for life, is commented on by Back and Cotton (1929). These writers considered that moth-proofing solutions had not as yet made good all the claims made for them by the manufacturers. However, more companies are using the solutions today than formerly, and more are offering guarantees of moth immunity. It remains to be seen whether the laboratory experiments that have been conducted will be borne out by practical experience in the business world and in the home.

EXPLANATION OF TESTS

The presence of live larvae after a considerable exposure to the treated fabrics was noted in several of the tests and may be explained in two ways. First, the carpet beetle larvae, especially those of the varied carpet beetle, are known to be carnivorous and will devour their own kind. In this manner, one or two vigorous larvae could exist for several months. Second, the larvae of these fabric pests, especially those of the clothes moth, may pass into a period of dormancy or inactivity lasting as long as eight to twenty-four months. During this period the larvae will neither feed nor move about appreciably. Later, however, they will become active, feed, and continue their growth.

Throughout all the tests, the results indicate that the larvae of the carpet beetles fed more often and caused more damage to the fabrics than did the larvae of the clothes moths. Eleven instances of feeding were recorded for larvae of the three species of carpet beetles and only five for larvae of the two species of clothes moths in these tests in which the moth-proofing compounds were applied. Therefore, it appears likely that the larvae of the carpet beetles are more hardy and vigorous and more resistant to the toxic or repellant properties of the moth-proofing solutions tested.

The greater attractiveness of the larvae to the finished type of fabric is indicated by the fact that in all the tests in which the various moth-proofing compounds were applied, only two instances of larval feeding on samples of the unfinished type of fabric were observed as compared to fourteen instances on samples of the finished type of fabric.

Table I. Efficiency tests using five larvae each of the more common clothes pests on fabrics treated with the Steuben Chemical Compound, a hydrofluoric acid solution.

Dates	Test No.	No. of samples	Method of application	Finished Fabrics: Webbing clothes moths		Finished Fabrics: Case-making clothes moths		Finished Fabrics: Black carpet beetles		Finished Fabrics: Common carpet beetles		Finished Fabrics: Varied carpet beetles		Unfinished Fabrics: Webbing clothes moths		Unfinished Fabrics: Case-making clothes moths		Unfinished Fabrics: Black carpet beetles		Unfinished Fabrics: Common carpet beetles		Unfinished Fabrics: Varied carpet beetles	
				alive	dead	alive	dead	alive	dead	alive	dead	alive	dead	alive	dead	alive	dead	alive	dead	alive	dead	alive	dead
Nov. 19				0	5	0	5	0	5			0	3,2m*	0	4,1m	0	5	0	4,1m				
Feb. 11	1	11	Immersed	1	4	0	5																
				0	5	0	5																
Jan. 7																							
Mar. 7	2	6	Sprayed	0	3,2m	0	5	0	5	0	5	0	3,2m					0	4,1m				
Dec. 1			Immersed	0	5	1	4	0	5			0	5										
Feb. 14	3	8	then dry-	2	3											0	5	0	5	0	5		
			cleaned																				
Dec. 22			Immersed	0	5	3	2	1	4			0	5										
Mar. 9	4	7	then	0	5											3	2	3	2				
			washed																				
Nov. 25	5	12	Untreated	0	5	5	0	3	2			3	2m	1	4	0	5			0	4,1m	0	3,2m
Feb. 25			(check)	2	3	3	2																
				2	1,2m	1	4																

*m - larvae rated as missing when they could not be found, either due to being devoured by other larvae or to their disintegration after death.

No feeding occurred when the fabrics were immersed in the Steuben Chemical Compound using the recommended diluted solution of 1 to 9, 1 degree Baume. In the second test in which the fabrics were sprayed with this compound, a slight amount of feeding was noticed on only one sample.

When the fabrics were dry-cleaned after the application of the Steuben Compound, a slight amount of feeding was apparent on two samples. However, when the fabrics were thoroughly washed after being treated, feeding was more evident and occurred on three samples, two of the finished and one of the unfinished fabrics. In the dry-cleaning treatment, Stodard's solvent, a gasoline preparation was used; while in the washing treatment, the fabrics were thoroughly washed in warm water using Crystal White laundry soap.

The number of dead larvae and the slight amount of feeding occurring in the check test gave sufficient evidence to indicate that these insects, in their natural habitat, feed very little during the winter months.

Table II. Efficiency tests using five larvae each of the more common clothes pests on fabrics treated with a saturated solution of sodium fluoride, a fluorine compound.

Dates	Test No.	No. of samples	Method of application	Finished Fabrics										Unfinished Fabrics									
				Webbing clothes moths		Case-making clothes moths		Black carpet beetles		Common carpet beetles		Varied carpet beetles		Webbing clothes moths		Case-making clothes moths		Black carpet beetles		Common carpet beetles		Varied carpet beetles	
				alive	dead	alive	dead	alive	dead	alive	dead	alive	dead	alive	dead	alive	dead	alive	dead	alive	dead	alive	dead
Jan. 7	1	10	Immersed	0	5	1	4	0	5	0	5	0	5	0	4,1m*			0	5			1	4
Mar. 7				0	5	0	5																
						1	4	1	4			3	2									3	2
May 30	2	8	Sprayed			0	5	3	1,1m			5	0										
July 14						2	3																
Jan. 10	3	14	Untreated	1	3,1m	3	2	5	0	3	2	4	1m	0	5	1	4	2	2,1m	1	4	3	1,1m
Mar. 10			(check)	2	3	4	1	4	1			5	0										

*m - larvae rated as missing when they could not be found, either due to being devoured by other larvae or to their disintegration after death.

Table III. Efficiency tests using five larvae each of the more common clothes pests on fabrics treated with a saturated solution of sodium fluosilicate, a silico-fluoride compound.

Dates	Test No.	No. of samples	Method of application	Finished Fabrics: Webbing clothes moths alive	dead	Case-making clothes moths alive	dead	Black carpet beetles alive	dead	Common carpet beetles alive	dead	Varied carpet beetles alive	dead	Unfinished Fabrics: Webbing clothes moths alive	dead	Case-making clothes moths alive	dead	Black carpet beetles alive	dead	Common carpet beetles alive	dead	Varied carpet beetles alive	dead
Feb. 21	1	12	Sprayed	0	5	1	4	0	5			0	5					0	5			0	1,4m
Apr. 21						3	2	0	5			2	3									0	2,3m
						0	5	3	1,1m*														
May 29	2	10	Sprayed			0	5	0	5	1	4	4	1										
July 14						0	5	5	0			3	2									2	1,2m
						2	3	1	1,3m														
June 10	3	5	Sprayed			0	5	2	3														
July 12			then dry-			1	4	0	4,1m													0	3,2m
			cleaned																				
June 10	4	5	Sprayed			3	2	2	3														
July 12			then																			4	1m
			washed			1	4	4	1														
Jan. 10	5	14	Untreated	1	3,1m	3	2	5	0	3	2	4	1m										
Mar. 10			(check)	2	3	4	1	4	1			5	0	0	5	1	4	2	2,1m	1	4	3	1,1m

*m - larvae rated as missing when they could not be found, either due to being devoured by other larvae or to their disintegration after death.

Injury to the samples was observed in two cases in the tests with sodium fluoride. Two or three small holes were cut through two of the samples of finished fabrics which were sprayed with the solution. Very conclusive evidences of feeding were apparent on the untreated material used as a check. Ten out of the fourteen samples used in the check test showed the results of larval feeding.

In all the tests using sodium fluosilicate, the solution was sprayed on the fabrics. The first test was continued over a period of two months, and the second test extended over a month and a half's time. No feeding occurred in either test, although a considerable number of larvae, especially those of the carpet beetles, were still alive in the first two tests after a fairly long exposure to the treated fabrics.

The results of the test in which the fabrics were dry-cleaned after being sprayed with sodium fluosilicate indicate that this compound adheres well to the fiber, and that the dry-cleaning treatment apparently does not affect adversely the moth-proofing properties of this compound. However, the thorough washing of the fabrics, after being treated in a similar manner, removed a sufficient portion of the compound from three samples so that larval feeding occurred.

Table IV. Efficiency tests using five larvae each of the more common clothes pests on fabrics treated with the Century moth-proofing compound, an arsenical preparation.

Dates	Test No.	No. of samples	Method of application	Finished fabrics: Case-making clothes moths: alive	dead	Finished fabrics: Black carpet beetles: alive	dead	Finished fabrics: Varied carpet beetles: alive	dead	Unfinished fabrics: Case-making clothes moths: alive	dead	Unfinished fabrics: Black carpet beetles: alive	dead	Unfinished fabrics: Varied carpet beetles: alive	dead
Mar. 6	1	10	Sprayed	1	4	1	4	5	0			1	4	3	2m*
June 6				0	5	0	5	1	2,2m						
				0	5										
				0	5										
June 9	2	9	Untreated	4	1	5	0	5	0			3	2	3	1,1m
July 10			(check)	5	0	4	1	3	2						
				2	3										

*m - larvae rated as missing when they could not be found, either due to being devoured by other larvae or to their disintegration after death.

Table V. Efficiency tests using five larvae each of the more common clothes pests on fabrics treated with Berlou moth-proofing solution, an arsenical preparation.

Dates	Test No.	No. of samples	Method of application	Finished Fabrics						Unfinished Fabrics					
				Case-making clothes moths		Black carpet beetles		Varied carpet beetles		Case-making clothes moths		Black carpet beetles		Varied carpet beetles	
				alive	dead	alive	dead	alive	dead	alive	dead	alive	dead	alive	dead
				0	5	4	1	4	1m*			2	2,1m	2	1,2m
June 26	1	10	Sprayed	1	4	2	3	0	5						
July 14				0	5										
				0	5										
June 9	2	9	Untreated	4	1	5	0	5	0			3	2	3	1,1m
July 10			(check)	5	0	4	1	3	2						
				2	3										

*m - larvae rated as missing when they could not be found, either due to being devoured by other larvae or to their disintegration after death.

Slight evidences of feeding were apparent on three samples of the finished fabrics on which the Century moth-proofing compound was applied, and on two samples which were sprayed with Berlou moth-proof. However, on each of the five samples on which feeding occurred, all the larvae were killed, thus showing the toxicity of this material on the fabrics.

Table VI. Efficiency tests using five larvae each of the more common clothes pests on fabrics treated with "Larvex" moth-proofing solution, a silicofluoride compound.

Dates	Test No.	No. of samples	Method of application	Finished Fabrics						Unfinished Fabrics					
				Case-making clothes moths		Black carpet beetles		Varied carpet beetles		Case-making clothes moths		Black carpet beetles		Varied carpet beetles	
				alive	dead	alive	dead	alive	dead	alive	dead	alive	dead	alive	dead
Mar. 23	1	10	Sprayed	0	5	2	2,1m*	3	1,1m	1	4	1	4	3	2m
				0	5	0	4,1m	1	4						
May 23				0	5										
June 9	2	9	Untreated	4	1	5	0	5	0			3	2	3	1,1m
July 10			(check)	5	0	4	1	3	2						
				2	3										

*m - Larvae rated as missing when they could not be found, either due to being devoured by other larvae or to their disintegration after death.

Table VII. Efficiency tests using five larvae each of the more common clothes pests on fabrics treated with Konate moth-proofing solution, an oil of pyrethrum compound.

Dates	Test No.	No. of samples	Method of application	Finished Fabrics: Case-making clothes moths alive	dead	Black carpet beetles alive	dead	Varied carpet beetles alive	dead	Unfinished Fabrics: Case-making clothes moths alive	dead	Black carpet beetles alive	dead	Varied carpet beetles alive	dead
				1	4	0	5	0	5			1	4	0	5
March 21	1	10	Sprayed	0	5	2	3	3	2m*						
Apr. 21				1	4										
				2	3										
June 9															
July 10	2	9	Untreated	4	1	5	0	5	0			3	2	3	1,1m
			(check)	5	0	4	1	3	2						
				2	3										

*m - larvae rated as missing when they could not be found, either due to being devoured by other larvae or to their disintegration after death.

The results recorded in those tests in which Larvex and Konate moth-proofing solutions were used, combined with the fact that no evidences of feeding were apparent in either of the tests, indicate that the application of these two compounds was fairly effective in preventing the injury caused by these fabric pests.

Since the Konate moth-proofing solution acted mainly as a repellant, the larvae confined on samples treated with this solution eventually died of starvation rather than feed on the treated fabrics. This compound is non-poisonous and does not contain any arsenical or fluorine compound. However, this moth-proofing solution has one disadvantage in that after the fabrics have been "Konated", the surface of the cloth is left quite oily for a time so that dust and other foreign materials may readily adhere to it.

Larvex contains a small amount of sodium fluosilicate which is a toxic material. Fabrics treated with this solution will quickly kill these clothes pests if feeding occurs, or will render the fabrics sufficiently distasteful to the larvae so that starvation results.

SUMMARY AND CONCLUSIONS

The results of the tests, which were concerned with the investigation and determination of the insecticidal value of various moth-proofing chemical compounds, indicate that the compounds tested offered approximately complete protection to the treated fabrics against clothes moths and carpet beetles. In many cases, this protection either caused directly the death of the insects confined within the treated samples or resulted in their starvation.

Dry-cleaning and washing removed a sufficient portion of the Steuben Chemical Compound and the sodium fluosilicate from the fabrics to permit the larvae to cause appreciable damage. Similar tests were not conducted with the other moth-proofing compounds used.

The results of the dry-cleaning and washing tests indicate that life time guarantees or claims of clothes moth or carpet beetle protection upon one application of any particular moth-proofing compound are to be looked upon with suspicion.

Complete immersion of the fabrics gave slightly better protection than the application of the moth-proofing solution as a spray. The application of moth-proofing solutions by means of immersion or with the aid of a power-spraying machine is recommended.

The finished type of fabrics was damaged by the larvae to a greater extent than the fabrics of the unfinished type.

The toxic moth-proofing materials, which consisted of the arsenical and fluorine compounds, usually killed the larvae of these clothes pests when feeding occurred.

The moth-proofing solutions which contain an arsenical compound should not be used due to their toxic effects upon human beings.

Larvae of the clothes moths were killed more quickly by the moth-proofing compounds tested than were the larvae of the various species of carpet beetles, the latter being apparently more resistant to the toxic or repellant effects of these compounds.

From the results of the experiments, it appears that the general public could advantageously purchase sodium fluosilicate in bulk, prepare a saturated solution in distilled water, apply it thoroughly either by immersion or spraying, and obtain a high degree of success in the protection of clothing and carpets against these fabric pests, in addition to large economies over purchasing proprietary compounds.

The methods used in testing these moth-proofing compounds are believed to have been satisfactory and can be recommended for adoption where similar tests are to be made.

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