SOME EFFECTS OF REFRIGERATION ON THE BIOLOGY OF TRICHOGRAMMA IN ARTIFICIAL BREEDING

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It has been observed by various workers that Trichogramma in grain moth eggs cannot be held successfully in ordinary refrigeration for any great length of time. In order to clear up some of the reasons why this cannot be done, the following experiments were carried on. The host used was the grain moth *Sitotroga cerealella* and all material was kept in electric refrigerators. As might be expected with any host, the mortality on prolonged exposure to cold is considerable, but from a practical production standpoint, the actual length of survival is not so important as the percentage surviving and the behavior of the survivors upon emergence. In grain moth eggs, for example, less than 10 per cent of the parasites will survive at 40° F. for more than two months. It is possible, however, to hold eggs with parasites longer at higher temperatures, but the mortality is considerable even at higher temperatures. Attempts to hold them in larval, prepupal, and adult stages at 40° were made, but results were not encouraging.

In the course of these experiments more than 450,000 parasitized grain moth eggs and about 200,000 adult individuals of Trichogramma were examined.

EFFECTS OF REFRIGERATION AT 37° F.

Tables 1, 2

With two days' pre-refrigeration development and eight days' refrigeration the mortality was 12 per cent for the yellow species, *pretiosa*,[1] and 45 per cent for the dark species, *minutum*.[1] Three days' pre-refrigeration resulted in 34 per cent mortality for *pretiosa* and 32 per cent for *minutum*. Four

[1] These names are used throughout for the dark and yellow or light species.

days' pre-refrigeration development and eight days' refrigeration gave 22 per cent mortality for *pretiosa* and 34 per cent for *minutum*. The greatest mortality, 90 per cent for a period of 40 days, took place in the species *minutum* with a pre-refrigeration development of three days. For an equal length of time and with five days' pre-refrigeration development, there was an 84 per cent mortality in the yellow species. The least mortality at the termination of a 40-day refrigeration period was 50 per cent for the dark species (*minutum*) with four days' pre-refrigeration development. Over the same period and having the same number of days of pre-refrigeration development, the mortality of the yellow species (*pretiosa*) was 77 per cent.

EFFECTS OF REFRIGERATION AT 44° AND 46° F.

Tables 3 and 4

After one week of refrigeration at 44° F., the mortality was four per cent when the parasite had been allowed four days of pre-refrigeration development. This is considered to be a normal emergence, for under ordinary conditions without refrigeration, not more than 96 to 98 per cent of parasitized eggs will hatch. At the end of 40 days of refrigeration the mortality was less than 66 per cent and in 60 days all of the parasites were dead.

EFFECTS OF REFRIGERATION AT 47° F.

Tables 5, 6

There is little comparison between the refrigeration results obtained for the dark and yellow species at this temperature. The yellow species survives longer than the dark species and there is less mortality for equal periods of refrigeration. For three days' pre-refrigeration development, 97 per cent of *pretiosa* emerged after one week of refrigeration, as compared with 92 per cent for the dark species. However, at the end of 40 days' refrigeration only 10 per cent of *minutum* emerged, while 48 per cent of the *pretiosa* came through. Four days' of pre-refrigeration development and one week refrigeration resulted in 96 per cent emergence for the yellow and 76 per cent for *minutum*. From the same lot, in 40 days about 50 per cent of the *pretiosa* emerged and only 21 per cent of the dark species. The

mortality was proportionately the same for the two species when comparing the results of two days' pre-refrigeration development with three and four days' pre-refrigeration development.

EFFECTS OF REFRIGERATION AT 49° F.

Table 7

The results at this temperature were more encouraging than at any of the others for exposures of less than one month. After one month, the emergence was 85 per cent for four days of pre-refrigeration development, 86 per cent for three days, and 73 per cent for two days. For one week of refrigeration (in the sequence given above) the percentages of emergence were 92, 91 and 94 per cent.

In grain moth eggs, Trichogramma are capable of withstanding low temperatures for long or short periods, depending on the stage of development at the time of refrigeration. There seems to be a considerable difference between the yellow and dark species in their ability to survive low refrigeration temperatures (Table 8). Of the two, *pretiosa* will survive longer than *minutum* at any single temperature, except 37° F., with a pre-refrigeration development of four days. Here, for a period of two weeks, there was less mortality of *pretiosa* at 37° F. than the dark species, but after that the mortality of *pretiosa* was more rapid at 37° than *minutum*. Furthermore, a comparison of the extreme and mean refrigeration temperatures for *minutum* indicates that it would be more profitable to hold the species for a period of more than two weeks at 37° F. than at 47°, providing four days' pre-refrigeration development has been allowed. During the first two weeks of refrigeration, regardless of pre-refrigeration development, there is less mortality at 47° F. than at 37° F. After two weeks, for two, three and four days' pre-refrigeration development, the mortality increases rapidly at 47° (Table 6). At 37° F. the mortality is slower and more uniform for two and four days' pre-refrigeration development. The rapidity of mortality at 37° F. for three days' pre-refrigeration development is more comparable to the results at 47° F. than either the two or four days' pre-refrigeration developments.

SEX RATIO

Inspection of Tables 1 to 6 will show that low temperatures frequently produce a change in sex ratio. This is probably accompanied by a weakening of individuals (also evident in wing deformation) which results in a further change in the following generation. At higher temperatures this is not so apparent, though some lots kept at 44° and 46° F. showed tendencies in this direction. There was no apparent action upon the individuals of 47° and 49° F. Peterson[2] states that no such effect of temperature can be observed when the parasites are reared in bagworm eggs, but it is abundantly evident that some alteration takes place in the grain moth egg which profoundly affects the vitality and reproductive powers of the individual.

COMPARATIVE RESULTS OF THE REFRIGERATION OF TRICHOGRAMMA IN GRAIN MOTH AND FRUIT MOTH EGGS

In comparing the emergence records of Trichogramma from Oriental fruit moth eggs, it will be seen that the maximum survival of the yellow species was not so high at 45° F. as it was for the dark species. At the end of four weeks 75 per cent of the dark species emerged, while less than 65 per cent of the yellow species survived. After four additional weeks in the refrigerator, or eight weeks from the beginning of refrigeration, 13 per cent of the dark species (*minutum*) emerged and 7 per cent of the yellow species. Furthermore, 5 per cent of *minutum* were still alive at the termination of a 12-week period of refrigeration, while all of *pretiosa* were dead. A one degree rise in temperature from that of 37° F. made some difference in the emergence of the yellow species from fruit moth eggs. However, this may be in part accounted for in the slight difference in humidity at which the two lots of material were refrigerated. The relative humidity for the 37° F. material was 55 per cent and for the 38° F. material 60 per cent. The percentage of mortality at the end of three weeks at 37° F. was 55 per cent, and at 38° F. slightly less than 37 per cent. The mortality in five weeks at 37° F. remained the same, 55 per cent, while there was a decrease at 38° F. to 45 per cent mortality. For the first four weeks the

[2] Peterson, A., *Jr. Econ. Entomology,* 24: 1070–1074. 1931.

mortality of *pretiosa* was less at 45° F. than at either 37° or 38° F. However, during the fifth week the mortality at 45° F. dropped below that at 38° F. Although the minimum percentage of mortality was less at 45° F. than at either 37° or 38° F., there is a more abrupt death rate over the entire period of refrigeration at the higher than at either of the lower temperatures. Trichogramma refrigerated in grain moth eggs at 45° to 46° F. were less susceptible to the low temperatures than when subjected to the same temperatures in fruit moth eggs. On the other hand, the maximum mortality in grain moth eggs for a period of five weeks at 37° F. was greater than in fruit moth eggs at the same temperature for an equal length of time.

Although *pretiosa* does better in grain moth than in fruit moth eggs at 45° to 46° F. (Table 9), it can be seen by examination of Table 11 that the results are apparently reversed when the dark species is refrigerated at 45° to 47° F. in the eggs of grain and fruit moths. In this case the minimum mortality in grain moth eggs was 65 per cent, and in fruit moth eggs 25 per cent, at the end of four weeks' refrigeration, although the two are not strictly comparable because of differences of humidity. The maximum mortality in 12 weeks in fruit moth eggs was 95 per cent, while in grain moth eggs it was 98 per cent in nine weeks. Humidity, although important, apparently was not a limiting factor so far as these results are concerned.

WING DEFORMITY IN TRICHOGRAMMA

The dark and the light species of Trichogramma are subject to varying degrees of wing deformity, both before and during periods of hibernation. This condition is at a minimum when the species are reared continuously under laboratory conditions. However, although the ratio of increase is variable during the numerous periods of hibernation investigated for both species, the percentage of increase in wing deformity is continual throughout the range of hibernation investigated for each strain of the two species of Trichogramma under discussion. Table 12.

As a rule there is but one adult Trichogramma per grain moth egg when handled under conditions suitable for mass production in the laboratory. Nevertheless, there are sometimes two in-

dividuals per egg (but to our knowledge never any more than two) when the grain moths from which the eggs for Trichogramma investigations were obtained were reared in wheat. The wing deformity of only those individuals that have developed and emerged from monoparasitized eggs will be considered in detail at this time. It may be mentioned here that, although Trichogramma will oviposit a number of times in a grain moth egg, there is apparently only enough room and available food for the complete development of two individuals. When the number of parasites an egg contains far surpasses its capacity for supplying food, all the progeny as well as the host perish prematurely. The condition of superparasitism is more prevalent in the dark (*minutum*) than in *pretiosa,* due to the fact that there are a greater number of females to each male in the dark than in the yellow species and likewise because the dark species is more prolific. Superparasitism may be accentuated by providing a great number of parasites with a small number of host eggs. Likewise, it may be reduced to a minimum by reversing the order of the above procedure. Trichogramma are apparently unable to detect existing parasitism in host eggs, or if they do detect it they disregard it. Observations have been made on females ovipositing in previously parasitized eggs in which the parasite developing from the initial oviposition has reached the pupal stage.

It may be seen by the accompanying table (12) that for the first two weeks of hibernation the percentage of deformity is higher in *minutum* than in the light species. However, after that time there is no significant difference between the percentages of wing deformity of the two species. There are varying degrees of deformity for equal periods of hibernation between the several strains of the same species and between the various strains of the two species. Notwithstanding these facts, the average of the total number of observations, including all the strains of the *pretiosa,* shows approximately 25 per cent less wing deformity than does that of *minutum.*

As the wing deformitly of individuals from duoparasitized eggs is at a minimum, a differentiation has been made in the table between the percentage of wing deformity in the total number of adults from the monoparasitized and duoparasitized eggs, and in

the adults from the monoparasitized eggs only. The dark species is of strikingly higher percentage in this respect than is the light species. The wing deformity of the males in both species is greatly in excess of that of the females; only twice in 56 investigations did the percentage of wing deformity in the females exceed that of the male; once in the dark (*minutum*) and once in the light species (*pretiosa*). Although there are fewer males for every female in the dark species than in the light, the percentage of deformity runs higher in the males of the former species than in that of the latter. Furthermore, the percentage of wing deformity is higher among the females of *minutum* than among the females of *pretiosa*.

CONCLUSIONS

(1) Trichograma species reared in grain moth eggs are affected by refrigeration in the following ways. (a) At temperatures below 47° F. mortality is gradual and increases with the length of exposure. There is some survival with refrigeration extended to 72 days, but the percentage is so small that it is worthless for production purposes. (b) The sex ratio is upset when temperatures below 47° F. are employed, the change being more evident in the generation following than in the generation emerging from refrigerated eggs. (c) Wing deformity is directly proportional to length of refrigeration and indicates a general weakening of the individuals.

(2) There are some differences in the ability of the two species considered to survive exposure to cold.

(3) Results of a comparison of refrigeration of the parasite in Oriental fruit moth and grain moth eggs indicate (a) that mortality in general is greater with short exposures in fruit moth eggs than in grain moth eggs. (b) At 37° F. mortality of *pretiosa* is less in Oriental fruit moth eggs after 30 days than in grain moth eggs. (c) There is some indication that mortality is lower with *pretiosa,* the yellow species native to Connecticut, than with *minutum,* both in grain moth and fruit moth eggs. (d) The survival in grain moth eggs for *pretiosa* is greater than fruit moth eggs at the same temperature, but less in grain moth eggs for *minutum;* the latter results, however, are not strictly comparable because of differences of humidity.

TABLE 1

TRICHOGRAMMA REFRIGERATED AT 37° F.; HUMIDITY, 60 PER CENT

Dark Species (Louisiana Strain)

Number days retained in refrigerator	Minimum length of life cycle	Per cent egg hatch after refrigeration	Per cent females	Sex ratio	
				Males	females
	2 days' pre-refrigeration development				
8	7⅓ days	55	84	1	5.2
16	7⅓ "	50	83	1	4.8
25	7⅛ "	50	72	1	2.5
39	7½ "	20	50	1	1.0
	3 days' pre-refrigeration development				
8	7⅓ days	69	75	1	3.0
18	7⅓ "	57	75	1	3.0
24	7½ "	26	72	1	2.5
38	7½ "	10	35	1	1.0
	4 days' pre-refrigeration development				
9	7⅓ days	66	80	1	4.0
18	7⅓ "	53	80	1	4.0
28	7½ "	50	75	1	3.0
37	7⅓ "	50	50	1	1.0

TABLE 2

TRICHOGRAMMA REFRIGERATED AT 37° F.; HUMIDITY, 60 PER CENT

Yellow Species (Conn. Strain)

Number days retained in refrigerator	Minimum length of life cycle	Per cent egg hatch after refrigeration	Per cent females	Sex ratio	
				Males	females
	2 days' pre-refrigeration development				
8	6¾ days	88	62	1	1.6
1 card 16	6⅔ "	82	57	1	1.3
26	6⅔ "	60	50	1	1.0
40	6⅔ "	30	50	1	1.0
	3 days' pre-refrigeration development				
8	6¾ days	66	63	1	1.7
1 card 19	6⅔ "	64	62	1	1.6
25	6⅚ "	40	50	1	1.0
39	6⅔ "	21	35	1	1.0
	4 days' pre-refrigeration development				
8	6¾ days	78	62	1	1.6
1 card 18	6¾ "	66	55	1	1.2
26	6⅔ "	35	55	1	1.2
38	6⅔ "	23	50	1	1.0
	5 days' pre-refrigeration development				
9	6⅔ days	67	64	1	1.7
1 card 18	6⅔ "	40	63	1	1.7
26	6¾ "	26	57	1	1.3
37	6¾ "	16	50	1	1.0

TABLE 3

TRICHOGRAMMA REFRIGERATED AT 44° F.; HUMIDITY, 85 PER CENT

Number days retained in refrigerator	Minimum length of life cycle	Per cent egg hatch after refrigeration	Per cent females	Sex ratio	
				Males	females
	Pretiosa, Yellow Species (Conn. Stock)				
7	6⅔ days	98	73	1	2.7
14	6½ "	77	76	1	3.1
21	6½ "	68	79	1	3.7
28	6⅔ "	55	78	1	3.3
38	6⅚ "	37	50	1	3.7
45	6⅔ "	9	0	1	3.7
54		1		1	1
60		0		0	0
	Pretiosa, Yellow Species (Mass. Strain)				
7	6⅔ days	96	65	1	1.7
17	6¾ "	73	58	1	1.3
24	6⅚ "	73	62	1	1.6
32	6⅚ "	60	61	1	1.7
38	6⅔ "	30	63	1	1.7
45		27	64	1	1.7
49		23	64	1	1.6
	Pretiosa, Yellow Species (Ohio Strain)				
7	6⅔ days	96	66	1	1.9
16	6⅔ "	78	63	1	1.7
23	6⅝ "	75	60	1	1.5
32	6 5/12 "	55	62	1	1.6
38	6 7/12 "	35	59	1	1.5
45	6⅔ "	20	63	1	1.7
49	6⅚ "	19	63	1	1.7

TABLE 3 (*Continued*)

Number days retained in refrigerator	Minimum length of life cycle	Per cent egg hatch after refrigeration	Per cent females	Sex ratio	
				Males	females
		Pretiosa, Yellow Species (West Texas)			
7	7 1/6 days	90	56	1	1.2
16	7 1/4 "	67	63	1	1.7
23	7 1/2 "	54	63	1	1.7
32	7 1/6 "	25	75	1	3
38	7 2/3 "	13	68	1	2.1
45		6	80	1	4
49		5	78	1	3.5
		Minutum, Dark Species (Georgia Strain)			
7	7 1/3 days	75	83	1	4.8
14	7 1/3 "	73	83	1	4.8
21	7 1/2 "	55	79	1	3.7
28	7 1/6 "	55	85	1	5.6
34	7 5/6 "	54	80	1	4.0
41		24	70	1	2.3
45		22	66	1	1.9
		Minutum, Dark Species (Louisiana Strain)			
7	7 1/3 days	70	80	1	4
15	7 1/3 "	70	82	1	4.5
23	7 1/4 "	68	83	1	4.8
30	7 1/8 "	58	80	1	4.0
37	7 1/8 "	28	83	1	4.8
43	7 5/6 "	22	84	1	4.8
50		16	90	1	9.0*

Note:—Temperature and humidity of parasite incubator – 80° F. and 75 per cent R. H.

* The sudden increase in sex ratio is due to the fact that there are few individuals to work with.

Pre-refrigeration development, 4 days.

TABLE 4

TRICHOGRAMMA REFRIGERATED AT 46° F.; HUMIDITY, 85 PER CENT

Pretiosa, Yellow Species

Number days retained in refrigerator	Minimum length of life cycle	Per cent egg hatch after refrigeration	Per cent females	Sex ratio	
				Males	females
	2 days' pre-refrigeration development				
8	6¾ days	96	63	1	1.7
15	6⅔ "	92	63	1	1.7
22	6⅚ "	92	63	1	1.7
30	6 7/12 "	65	69	1	2.2
36	6¾ "	33	69	1	2.2
44	6⅚ "	39	54	1	1.1
69	6½ "	0	0	0	0
	3 days' pre-refrigeration development				
7	6⅔ days	97	70	1	2.3
14	6¾ "	93	76	1	3.1
21	6⅚ "	85	75	1	3
28	6⅔ "	60	78	1	3.5
35	6¾ "	50	73	1	2.7
43	6¼ "	58	75	1	3
71	6½ "	2	100	0	1
90		0	0	0	0
	4 days' pre-refrigeration development				
7	6¾ days	96	71	1	2.3
14	6 1/12 "	92	63	1	1.7
23	6¼ "	90	72	1	2.3
31	6 1/12 "	90	75	1	3
37	6¾ "	86	75	1	3
45	6⅔ "	84	81	1	4.2
70	6¾ "	1	0	0	0
89		0	0	0	0

TABLE 5

TRICHOGRAMMA REFRIGERATED AT 47° F.; HUMIDITY, 85–90 PER CENT

Minutum, Dark Species (Louisiana Strain)

Number days retained in refrigerator	Minimum length of life cycle	Per cent egg hatch after refrigeration	Per cent females	Sex ratio	
				Males	females
	2 days' pre-refrigeration development				
8	$7\frac{1}{12}$ days	85	80	1	4
16	$7\frac{1}{2}$ "	76	80	1	4
25	7 "	50	82	1	4.5
39	$6\frac{3}{4}$ "	22	80	1	4
	3 days' pre-refrigeration development				
8	$7\frac{1}{6}$ days	92	86	1	6.1
18	$7\frac{1}{6}$ "	74	84	1	5.2
24	$7\frac{1}{12}$ "	40	82	1	4.5
38	7 "	10	82	1	4.5
	4 days' pre-refrigeration development				
9	$6\frac{5}{6}$ days	76	83	1	4.8
18	$6\frac{2}{3}$ "	71	84	1	5.2
28	$6\frac{7}{8}$ "	35	83	1	4.8
37	$6\frac{1}{2}$ "	21	83	1	4.8

TABLE 6

TRICHOGRAMMA REFRIGERATED AT 47° F.; HUMIDITY, 85–90 PER CENT

Pretiosa, Yellow Species (Conn. Strain)

Number days retained in refrigerator	Minimum length of life cycle	Per cent egg hatch after refrigeration	Per cent females	Sex ratio	
				Males	females
	2 days' pre-refrigeration development				
8	$6\frac{1}{2}$ days	98	70	1	2.3
16	6 "	90	67	1	2.0
26	$5\frac{3}{4}$ "	70	70	1	2.3
40	$5\frac{1}{6}$ "	50	70	1	2.3
63	—	13			
	3 days' pre-refrigeration development				
8	$6\frac{2}{3}$ days	97	65	1	1.8
16	$6\frac{1}{12}$ "	84	70	1	2.3
25	6 "	70	70	1	2.3
39	$5\frac{3}{4}$ "	48	67	1	2.0
62					
	4 days' pre-refrigeration development				
8	$6\frac{2}{3}$ days	96	63	1	1.7
18	$6\frac{1}{2}$ "	74	70	1	2.3
26	$6\frac{1}{3}$ "	70	67	1	2.0
38	6 "	50	63	1	1.7
61					
	$4\frac{5}{6}$ days' pre-refrigeration development				
9	$6\frac{7}{8}$ days	89	64	1	1.7
17	$6\frac{2}{3}$ "	82	64	1	1.7
28	$6\frac{1}{2}$ "	68	65	1	1.8
39	6 "	35	65	1	1.8
62		2			

TABLE 7

TRICHOGRAMMA REFRIGERATED AT 49° F.; HUMIDITY, 85 PER CENT
Pretiosa, Yellow Species

Number days retained in refrigerator	Minimum length of life cycle at 80° F. minus development in refrigeration at 49°	Per cent egg hatch after refrigeration	Per cent females	Sex ratio	
				Males	females
	2 days' pre-refrigeration development				
7	6¾ days	94	58	1	1.4
14	5 "	90	59	1	1.4
21	2⅝ "	80	57	1	1.3
29	2½ "	73	51	1	1.0
	3 days' pre-refrigeration development				
7	7 days	91	64	1	1.7
14	5¾ "	90	65	1	1.8
21	4½ "	90	64	1	1.7
28	3 "	86	57	1	1.3
	4 days' pre-refrigeration development				
8	7 days	92	50	1	1.0
15	6⅔ "	92	23	1	2.5
22	4⅔ "	88	45	1	1.2
29	3⅔ "	85	43	1	1.3

Note:—2 days' pre-refrigeration development—parasites emerged in refrigeration in 30 days.

3 days' pre-refrigeration development—parasites emerged in refrigeration in 33¼ days.

4 days' pre-refrigeration development—parasites emerged in refrigeration in 35 days.

2 days' pre-refrigeration development—parasites are in the larval stage.

3 days' pre-refrigeration development—parasites are in the early prepupal stage.

4 days' pre-refrigeration development—parasites are in the late prepupal stage.

5 days' pre-refrigeration development—parasites are in the pupal stage.

TABLE 8

EMERGENCE OF TRICHOGRAMMA FROM ANGOUMOIS GRAIN MOTH EGGS (*Sitotroga cerealella* OLIVER) RERIGERATED AT DIFFERENT TEMPERATURES

49° F. Pre-refrigeration development in days						46° F. Pre-refrigeration development in days						44° F. Pre-refrigeration development in days						37° F. Pre-refrigeration development in days								
2		3		4		2		3		4		2		3		4		2		3		4		5		
*	**	*	**	*	**	*	**	*	**	*	**	*	**	*	**	*	**	*	**	*	**	*	**	*	**	
Pretiosa, Yellow Species																										
7	94	7	91	8	92	8	96	7	97	7	96					7	96	8	88	8	66	8	78	9	67	
14	90	14	90	15	92	15	92	14	93	14	92					16	78	16	82	19	61	18	66	18	40	
21	80	21	90	22	99	22	92	21	85	23	90					23	75	26	60	25	40	26	35	26	26	
29	73	28	86	29	85	30	65	28	60	31	90					32	55	40	30	39	21	38	23	37	16	
						36	33	35	50	37	86					38	35					55	12			
						44	30	43	48	45	84					45	20					64	5			
						69	0	71	2	70	1					49	19					72				
								90	0	89	0					60	0									
Minutum, Dark Species																										
												47° F.										37° F.				
												*	**	*	**	*	**		*	**	*	**	*	**		
												8	85	8	92	9	76		8	55	8	69	9	66		
												16	76	18	74	18	71		16	50	18	57	18	53		
												25	50	24	40	28	35		25	50	24	26	28	50		
												39	22	38	10	37	21		39	20	38	10	37	50		

Note:—* Number days of refrigeration. ** Percentage of emergence.
Refrigeration humidity 70–90 per cent.
Pre-refrigeration and post-refrigeration development of Trichogramma at 80° F. and 75 per cent. R. H.

TABLE 9

COMPARISON OF THE MORTALITY OF THE YELLOW SPECIES (*Pretiosa*) AFTER FIVE WEEKS' REFRIGERATION IN GRAIN MOTH AND ORIENTAL FRUIT MOTH EGGS

Host eggs	Temperature	Per cent mortality	Temperature	Per cent mortality
Grain moth	45°–46° F.	14	37° F.	77
Fruit moth	45°–46° F.	54	37° F.	57

TABLE 10

MORTALITY OF TRICHOGRAMMA FROM FRUIT MOTH EGGS REFRIGERATED AT 45° F. AND 60 PER CENT RELATIVE HUMIDITY AND SEX RATIO OF ADULT PARASITES EMERGING THEREFROM

Number days refrigeration	Per cent emergence	Per cent females emerging	Sex ratio	
			Males	Females
	Pretiosa, Yellow Species			
8	78	63	1	1.7
18	78	60	1	1.5
26	65	58	1	1.3
32	50	60	1	1.5
48	11	58	1	1.3
58	7	50	1	1.0
	Minutum, Dark Species			
29	75	77	1	3.3
42	23	80	1	4.0
58	13	82	1	4.5
82	5	80	1	4.0
Refrigerated at 37° F. and 55 per cent relative humidity				
	Pretiosa, Yellow Species			
12	54	58	1	1.3
22	45	60	1	1.5
30	45	71	1	2.4
33	45	60	1	1.5
Refrigerated at 38° F. and 60 per cent relative humidity				
	Pretiosa, Yellow Species			
6	70	50	1	1
19	63	50	1	1
25	59	50	1	1
35	55	50	1	1

TABLE 11

COMPARISON OF YELLOW AND DARK TRICHOGRAMMA REFRIGERATED IN GRAIN MOTH AND ORIENTAL FRUIT MOTH EGGS

Grain moth eggs			Fruit moth eggs		
Number days refrigerated	Humidity	Per cent emergence	Number days refrigerated	Humidity	Per cent emergence
		Pretiosa, Yellow Species, 45°–46° F.			
1– 7	90%	95	1– 8	60%	78
7–14	"	92	8–18	"	78
14–23	"	90	18–26	"	65
23–31	"	90	26–32	"	50
31–45	"	84	32–48	"	11
		Minutum, Dark Species, 45°–47° F.			
1–28	90%	35	1–29	60%	75
28–37	"	21	29–42	"	23
37–60	"	2	42–58	"	13
60	"		58–82	"	5
		Pretiosa, Yellow Species, 37° F.			
1– 8	60%	78	1–12	55%	54
8–18	"	66	12–22	"	45
18–26	"	35	22–30	"	45
26–38	"	23	30–33	"	45

TABLE 12

WING DEFORMITY IN TRICHOGRAMMA
HIBERNATION TEMPERATURE 38°–46° F.
HUMIDITY 60–85 PER CENT
Pretiosa, Yellow Species

Period of hibernation, days	Average of the total per cent adults with deformed wings	Corrected per cent of adults with deformed wings	Per cent males with deformed wings	Per cent females with deformed wings	Period of prehibernation development at 80° F.
		Connecticut stock			
0	6.9	4.7	4.5	3.8	0.0
5	11.0	7.0	9.0	6.0	5.0
10	7.4		9.0	7.4	5.0
16	18.0	17.0	11.0	17.0	5.0
28	25.0		42.0	23.0	5.0
		Massachusetts stock			
0	3.1		4.2	1.9	0.0
7	5.0		10.0	3.0	4.0
17	18.7	18.0	18.0	9.0	4.0
23	25.0		32.0	13.0	4.0
30	50.0		66.0	33.0	4.0
40	86.0		87.0	76.0	4.0
		Ohio stock			
0	2.5	1.3	2.2	0.3	0.0
7	10.0		8.0	3.0	4.0
15	16.0	8.1	25.0	20.0	4.5
23	34.0		41.0	26.0	4.5
30	29.0		66.0	22.0	4.0
45	86.0		91.0	64.0	4.5
99	93.0		100.0	85.0	4.5
		West Texas stock			
0	7.2	0.9	7.0	0.5	0.0
10	5.6	3.8	9.9	3.8	4.0
20	15.0	7.0	20.0	7.0	4.0
34	26.0		50.0	9.0	4.0
41	50.0		81.0	45.0	4.0
57	67.0		90.0	62.0	4.0
71	55.0		98.0	55.0	4.0
92	100.0		100.0		4.0

TABLE 12 (*continued*)
Minutum, Dark species

Period of hibernation, days	Average of the total per cent adults with deformed wings	Corrected per cent of adults with deformed wings	Per cent males with deformed wings	Per cent females with deformed wings	Period of prehibernation development at 80° F.
		Georgia stock			
0	11.3	5.8	25.2	3.9	0.0
12	16.6		21.1	9.0	4.0
18	38.0		43.0	33.0	4.0
25	53.0	52.5	50.0	34.0	4.0
36	64.0	63.0	87.0	50.0	4.0
100	83.0		100.0	83.0	4.5
		Louisiana stock			
0	16.0	7.7	24.0	7.2	0.0
6	17.0	9.0	24.0	2.0	4.0
10	25.0	18.0	44.0	18.0	4.0
15	37.0		48.0	28.0	4.0
20	54.0	50.0	66.0	51.0	4.0
41	50.0		74.0	50.0	4.0
61	68.0		10.00	63.0	4.0
75	50.0		10.00	50.0	4.0
		Arizona stock			
0	44.0	7.5	16.0	6.1	0.0
10	5.6	3.8	25.0	4.0	4.0
15	16.0		25.0	8.3	4.0
40	20.7		32.0	11.0	4.0
56	25.0		50.0	16.0	4.0
70	50.0		50.0	50.0	4.0
		Canada stock			
0	17.0	7.1	30.0	5.0	0.0
10	20.0	16.0	37.0	9.0	4.0
15	29.0	34.0	91.0	15.0	4.0
20	40.0	37.0	50.0	23.0	4.0
41	35.0		50.0	36.0	4.0
57	50.0		50.0	40.0	4.0
73	83.0		63.0	83.0	4.0
87	100.0		100.0	100.0	4.0