TO COMPARE THE RATE OF EGG-PRODUCTION BY THE FLOUR BEETLES TRIBOLIUM C0NFUSUM AND TRIBOLIUM CASTANEUM OYER A RANGE OF TEMPERATURE

THESIS SUBMITTED TO THE UNIVERSITY

OF NEWCASTLE UPON TYNE AS PART

FULFILMENT FOR THE M.Sc. DEGREE.

BY

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SEPTEMBER 1979.

ACKNOWLEDGEMENTS

Thanks are due to Infestation Laboratory, Slough, for their help in supplying *T. confusum*, to Dr. Luff for his encouragement and advice throughout the work, to Professor G.E. Russel for the use of research facilities in his Department, to the Federal Government of Nigeria and Ahmadu Bello University, Zaria for a post-graduate grant.

CONTENTS

INTRODUCTION

Tribolium confusum DUV and *Tribolium castaneum*, are cosmopolitan, occurring all over the world wherever stored products are to be found. These flour beetles are known to attack such a wide variety of foods that they can be said to be practically omnivorous. They have been found feeding in over 100 different food stuffs. The list comprises mainly grain and seeds of various kinds, nuts, flour, meal and other cereal products, but also includes animal matter, wood, vegetables, and various drugs and spices. Fairfield (1943) estimated the total annual loss of food stuffs during growth and storage in the United States to be approximately 2,000 million dollars. Of this, she attributed 300 million dollars to pests of stored cereals. Haeussler (1952) published similar figures, giving the actual amount of grain lost annually as 300 million bushels valued at 500 million dollars at 1951 prices.

Howe (1952) made it clear that *Tribolium castaneum* is the real long term problem of groundnut storage in the Northern Nigeria. It was also stated that the majority of the remaining *Tribolium* species of economic importance in Nigeria were *T. confusum* . Park and Frank (1948) worked on the fecundity and development of the flour beetles, *Tribolium confusum* and *T. castaneum* at three constant temperatures of 24°, 29° and 34°C, it was shown for both species that fecundity increases and length of metamorphosis decreases as the temperature rises. It was further shown that *T. castaneum* has, as a species, a higher fecundity and a faster development than does *T. confusum* at all temperatures studied. There is however, a suggestion that the lowest temperature is relatively more suitable for _T. confusum_ and the highest temperature relatively more suitable for _T. castaneum_.

Howe (1956) showed the effect of temperature and humidity on the rate of development and mortality of _T. castaneum_. Howe's work was devoted mostly to the speed of development and the developmental mortality of _Tribolium castaneum_ over a series of temperatures between 15° to 40°C by steps of 2.5°C and 90% R.H. using wheatfeed as food. It was shown that humidity has no effect on the duration of the egg period. Larvae failed to develop into normal adults at 20°C and also failed at 90 and 30% R.H. at 40°C. At 20°C and 70% R.H., pupae may be formed but they do not become normal adults. It was also shown that groundnuts were much less satisfactory as food than wheatfeed. Howe (1960) published his work on the speed of developmental mortality of _T. confusum_ (Duval) over a series of constant temperatures between 15° and 40°C at 10, 30, 70 and 90% R.H. using wheatfeed. This work showed that eggs did not hatch at 15° or 40°C at any humidity stated. Just as in the earlier experiments with _T. castaneum_, humidity had no effect on the egg period.

Larvae also failed to develop to pupae at 17.5°C, at 10% R.H. at 20°C, and at 10 and 90% R.H. and at 37.5°C. The rate of larval development was however affected by both temperature and humidity, being quickest at the higher humidities and at about 32.5°C. The total developmental period was compared with that of _T. castaneum_ over the range of temperatures and humidity conditions in which both species can grow. The optimum for developmental speed and the maximum and the minimum temperatures at which development is possible were all about 2.5°C lower for

T. confusum than for T. castaneum. The developmental periods for the two species were equally at temperatures between 23 and 27°C, depending on humidity. At lower temperature, Howe showed that T. confusum developed more quickly at lower temperatures and at higher temperatures the more slowly.

The work in this thesis was designed to compare the rate of egg-laying by the flour beetles Tribolium confusum and T. castaneum over the following range of temperatures - 20°, 25°, 30° and 35°C. The following null hypotheses were to be tested in the investigation:-

(a) That, taking the four temperatures together, there is no difference in total fecundity:

(b) That there is no difference in the rate of egg production per week (by the two species taken together) at the four temperatures:

(c) That there is no difference in the number of batches laid by the two species at each temperature and when the four temperatures are taken together:

(d) If (a) and (b) are disproved, that there is no difference between the species with respect to the rate at which the rate of egg-production changes from one temperature to another.

MATERIALS AND METHODS

Tribolium confusum was obtained in September 1978, from cultures bred at the Pest Infestation Laboratory, Slough. *T. castaneum* was obtained from a laboratory culture kept in the Department of Agricultural Biology of the University of Newcastle upon Tyne.

The rates of egg production were determined over a range of temperatures - 20°, 25°, 30° and 35°C. The incubators were kept at 70 ± 10% relative humidity. The relative humidity was obtained by keeping some water open in plastic boxes in which the insects were incubated. The humidity in the boxes was checked frequently with an electric hygrometer element.

The incubators were kept at ± 1°C for each temperature at which the investigation was being carried out. The temperature in each incubator was checked frequently with the aid of a thermistor thermometer, the temperatures of the incubators being adjusted whenever necessary.

The culture medium was made by mixing about 10% powdered yeast with 90% white plain flour. Both the flour and the yeast were sieved through a sieve of 60 meshes to the inch (about 24 per cm.). This food was spread into a thin layer and conditioned at 70% R.H. The medium was kept in a 2lb. kilner jar in which some pieces of filter paper were placed for the beetles to climb on. Each jar was covered with a piece of filter paper held in place by the sealing ring and the culture was kept in the incubator kept at 25°C. The medium was renewed monthly.

In order to obtain newly-emerged adults for experiments, pupae of these beetles were collected on a 30 mesh sieve. The medium used for experiments was as stated earlier. Before mixing however, the flour was sterilised in an oven at 110°C overnight. The medium was again conditioned at the stated relative humidity. The pupae obtained were sexed. The sexing was based purely on the appearance of the ventral surface of the terminal adbominal segment of the pupae which differs greatly in the males and females. It is on this difference only that the sexes may be distinguished externally, since the appearance of the two sexes in the adult is identical. The form of the genital segment is quite different. The chief characteristic of this segment in the male is a flat disklike depression, whereas in female two conelike appendages, similar in appearance to the urogomphi, but much shorter and relatively thicker, may be distinguished, (Newell E. Good, 1936). The young adults were sexed, using the dark pit on the front femur which is found on the male only, (Hinton, 1942).

80 pairs of pupae of each species were collected. Each pair was put into a glass specimen tube about 2.5 cm. diameter by 5 cm. high. About 8g. of medium was put into each specimen tube. A small piece of paper was put into each tube and then covered with cotton wool. Each specimen tube was numbered. 80 pairs of each species were randomly divided into lots of 20. One lot of 20 pairs of each species was placed in plastic boxes which were in turn placed at 20°, 25°, 30° and 35°C respectively. Each incubator has been pre-conditioned to the required temperature and relative humidity. The plastic boxes were designed in such a way to allow for ventilation and also give access for the humi-

/dity to be checked from time to time, (figure 1).

Each tube was separately sieved at weekly intervals with a 60 mesh sieve to obtain the eggs. The eggs were counted and recorded under each temperature and tube number for each species. The readings were taken right from the first week after the paired pupae were incubated. The flour medium was renewed at the end of every three weeks.

RESULTS

NUMBER OF EGGS LAID

From Table 1 it can be seen that *T. confusum* laid twice as many eggs at 25°C as at 20°C. The eggs laid at 30°C by *T. confusum* almost doubled the number of eggs laid at 25°C, but there were not more at 35° and 30° whereas the numbers laid at 30°, and at 35° each, were three times as many as the eggs laid at 20°C by *T. confusum*.

TABLE 1

The mean number of eggs laid per week

SPECIES	TEMPERATURE			
	20°C	25°C	30°C	35°C
T. confusum	16.83	34.67	64.18	61.21
T. castaneum	26.09	37.32	73.23	75.95

T. castaneum much more eggs at 25° than as at 20°. The number laid at 30° by *T. castaneum* was twice that laid at 25°C but there was a slight increase over the eggs laid at 35° to the eggs laid at 30°. However, the number laid at 30° and 35° respectively were almost three times those laid at 20°C.

There appeared to be a reasonable difference between the species' responses to temperature. An analysis of variance was used to measure its significance. The overall effects of temperature on both species on the rate of oviposition for the periods of observation at 20°, 25°,

30° and $35^{\circ}C$ were as shown in figure II.

EFFECTS OF TEMPERATURE ON EACH SPECIES

Tests were done to see if there was any significant difference between the columns and the rows at each temperature for each species. Each column was made up of the number of eggs laid per week. Each row was made up of the number of eggs laid over a period of observation (for T. castaneum - 6 weeks; T. confusum - 5 weeks duration). Analysis of variance (ANOVA) tables are presented in Tables II - XII.

T. castaneum at 20°C

The figures for the construction of ANOVA table at this temperature were derived from Table XV.

TABLE II

ANOVA Table for T. castaneum at 20°C

Source of variation	S S	df	M.S.	F. ratio
Rows	6317.02	5	1263.404	24.16 **
Columns	2900.667	16	181.291	11.09 **
Residual	4183.332	80	52.292	-
Total	13400.019	101	-	-

Columns LSD (5%) = 6.945

Rows LSD (5%) = 11.69

The differences between the rows and columns are both highly signi-

/ficant.

There was a significant difference between the eggs laid in the first and second week by the seventeen females. The number increased very sharply and then declined gradually as shown in Figure 11.

There were significant differences between individuals with regards to the mean number of eggs laid during the observed period.

There were high significant differences both in the column means as well as the row means.

<u>T. castaneum at 25°C</u>

The data used in the following ANOVA table were from Table XVI.

<u>TABLE III</u>

<u>ANOVA Table for T. castaneum at 25°C</u>

Source of variation	S S	df	M.S.	F. ratio
Rows	5790.82	5	1158.164	9.014 **
Columns	2802.56	15	186.8373	1.454
Residual	9636.62	75	128.488	
Total	18230.00	95	-	

Columns LSD (5%) = 11.22

Rows LSD (5%) = 18.32

The F. ratio 9.014 is highly significant at 5 and 95 degrees of freedom, therefore there were significant differences in the rows, but not in the columns. There were no significant differences among the row means. There were high significant differences in the column means. The differences occurred between the first and the second weeks and also through the subsequent weeks. But there were no significant differences between second and third; third and fourth, in that order. There were however, differences between weeks 2 and 4; 2 and 5; 2 and 6; 3 and 4; 3 and 5; 3 and 6.

T. castaneum at 30°C

The data for the ANOVA table were calculated from Table XVII.

TABLE IV

ANOVA Table for T. castaneum at 30°C

Source of variation	S S	df	M.S.	F. ratio
Rows	3658.72	5	731.744	5.40 *
Columns	31896.60	17	1876.270	13.846 ***
Residual	11517.85	85	135.504	
Total	47073.187	107	-	-

Columns LSD (5%) = 10.865

Rows LSD (5%) = 18.818

It was at once again evident that there were high significant differences both in the rows and the columns. There were some significant differences in the rows as well as in the columns. Here, unlike at 25°C there was a significant difference between the second and third columns. The other differences in the columns followed just the same pattern as those for 25°C.

T. castaneum at 35°C

The data for the ANOVA table was derived from Table XVIII.

TABLE V

ANOVA Table for T. castaneum at 35°C

Source of variation	S S	df	M.S.	F. ratio
Rows	794.42	5	156.885	4.116 *
Columns	19912.56	16	1244.535	32.243 ***
Residual	3087.84	80	38.598	-
Total	23794.82	101	-	-

Columns LSD (5%) = 6

Rows LSD (5%) = 10

It was immediately apparent that the differences between the columns were highly significant. Significant differences also existed in the rows. There were no significant differences in the row means but there were in the column means. The differences in the column means followed the same pattern as described previously for those at 25°C.

THE EFFECTS OF OVERALL TEMPERATURE ON T. CASTANEUM

All the observed females at all temperatures under investigation were combined for the analysis of variance.

TABLE VI

Eggs produced by T. castaneum at 20°, 25°, 30° and 35°C

Temperature		Observed	No. Observed	Total	Mean
20°C	1	36; 42; ....., 18, 9	102	2662	26.09
25°	2	29; 42; ......, 34, 27	96	3583	37.32
30°	3	39; 58; ....., 84, 56	108	7909	73.23
35°	4	48; 83; ....., 82, 75	102	7747	75.95
		TOTAL	N= 408	G=21901	= 53.68

TABLE VII

ANOVA Table for T. castaneum over the range of temperature

Source of variation	S S	df	M.S.	F. ratio
Temperatures	1212097.515	3	404032.5	764 ***
Residual	213499.2	404	528.46	
Total	1425596.715	407	-	-

There was a very great significant difference at the rate at which the eggs were laid at various temperatures investigated.

The standard errors of the four means from table VI were as indicated in table VIII.

TABLE VIII

Temperature	Mean and Standard Error
20°C	26.09 ± 2.28
25°	37.32 ± 2.35
30°	73.23 ± 2.21
35°	75.95 ± 2.28

There were significant differences in the means of eggs produced between the temperatures.

The egg production followed almost the same pattern (Fig. 11).

TRIBOLIUM CONFUSUM AT 20°C

The data in the ANOVA table were derived from table XIX.

TABLE IX

ANOVA Table for eggs laid at 20°C

Source of variation	S S	df	M.S.	F. ratio
Rows	513.1	4	128.3	5.94 **
Columns	825.0	17	48.529	2.25 *
Residual	1466.4	68	21.565	-
Total	2804.5	89	-	-

Columns LSD (5%) = 4.33

Rows LSD (5%) = 8.22

There were high significant differences both in the columns and in the rows. There were also high significant differences in the column means from week to week. There was a sharp increase in the egg production in the second week and gradually to the third week when egg production declined.

There was little or no difference in the row means.

T. confusum at 25°C

The data for the analysis of variance are derived from table XX.

TABLE X

ANOVA Table for T. confusum at 25°C

Source of variation	S S	df	M.S.	F. ratio
Rows	566.78	4	141.695	5.19 *
Columns	4837.60	16	302.350	11.08 **
Residual	1746.39	64	27.287	-
Total	7150.77	84	-	-

Columns LSD (5%) = 5

Rows LSD (5%) = 9.25

There were high significant differences both in the rows and the columns. There were significant differences in the mean columns but there was no significant difference in the row means.

T. confusum at 30°C

The data for the ANOVA table were from table XX.

TABLE XI

ANOVA Table for T. confusum at 30°C

Source of variation	S S	df	M.S.	F. ratio
Rows	5678.76	4	1419.69	11.337 **
Columns	19279.53	16	1204.00	9.622 **
Residual	8013.94	64	125.217	-
Total	32972.23	84	-	-

Columns LSD (5%) = 10.74

Rows LSD (5%) = 19.817

There were great differences both in the columns and in the rows. There was no significant difference in the row means. There were however significant differences in the column means. The variation was in the same pattern as those for the T. castaneum.

T. confusum at 35°C

The data for the analysis of variance were derived from table XXII.

TABLE XII

ANOVA Table for T. confusum at 35°C

Source of variation	S S	df	M.S.	F. ratio
Rows	2561.99	4	640.497	8.9138 **
Columns	10580.18	15	705.345	9.816 **
Residual	4311.23	60	71.854	-
Total	17453.30	79	-	-

Columns LSD (5%) = 8.476

Rows LSD (5%) = 15.01

The differences between the rows and also between the columns are highly significant.

Comparing the column means differences, the columns were significantly different. There was a sharp increase from the second week to the third, up to the fifth week. But there were no significant differences between the means of the second and third weeks columns or from the third to the fourth and fifth weeks respectively. There were however significant differences from the eggs laid when the means for the third column was compared with those at the fourth and fifth columns respectively.

There was no significant difference in the row means.

T. CONFUSUM OVER THE RANGE OF TEMPERATURE

The data were obtained just in the same way as for those of *T. castaneum*

TABLE XIII

Temperature		Observed	No. Observed	Total	Mean
20°	1		90	1515	16.833
25°	2		85	2947	34.670
30°	3		85	5455	64.176
35°	4		80	4897	61.212
		TOTAL	N = 340	G=16814	=49.453

TABLE XIV

ANOVA Table for table

Source of variation	S S	df	M.S.	F.ratio
Between temperature	569641.54	3	189880.516	1056.66***
Residual	60380.89	336	179.705	-
	630022.43	339	-	-

There were great significant differences between the number of eggs laid at different temperatures.

The actual means with their standard error were stated in Table XXIII

TABLE XXIII

Table of temperature means with standard errors for Table XIII

Temperature		Mean and Standard Error
20°C	1	16.83 ± 1.41
25°C	2	34.67 ± 1.45
30°C	3	64.18 ± 1.45
35°C	4	61.21 ± 1.49

It became clear that there were no significant differences in the standard errors but in the means.

INTERACTION

The data used to test for species and temperature interaction were obtained by transforming the data to logarithms before the analysis of variance was carried out.

TABLE XXIV

Transformed data from the weekly means

	20°C	n	25°	n	30°	n	35°	n	Total	N
T. confusum	21.89	18	26.04	17	30.60	17	29.53	16	108.06	68
T. castaneum	23.87	17	24.86	16	33.50	18	31.94	17	114.17	68

TABLE XXV

Anova Table

Source of variation	S S	df	M.S.	Variance ratio
All treatments	7.407	7	1.058	142.64 ***
Species	0.28	1	0.28	37.75 ***
Temperature	7.10	3	2.366	318.98 ***
Interaction	0.027	3	0.009	1.213
Residual	0.942	127	0.007417	-
Total	15.756	141	-	-

From table XXV it became clear that the differences in all treatments, species and temperatures were highly significant, but there was no significant difference in the interaction. This meant that the temperature had the same effects on the two species.

DISCUSSION

Temperature is one of the major environmental factors that affect living organisms. The limits of the favourable range of temperature for egg-production and oviposition have often been found to be of the same order as those for the development of the immature stages, but need not necessarily be similar. Every animal has got its range of temperature at which oviposition can take place. Birch (1945), found that Calandra oryzae had a range of 15° - 34°C.

The number of eggs laid during an animal's lifetime may be strongly influenced by components in the environment other than temperature, notably moisture, food and the number of other animals present in the environment. The rate of egg-production depends upon these also, and, in addition, is influenced by the age of the animal. Good N. E. (1936), showed that the increasing age of females of both Tribolium confusum and T. castaneum gradually led to a decrease in the rate at which eggs were produced. This investigation has also shared the same trend because at all temperatures investigated there was a gradual decrease in the rate of egg production after the second or third week, (figure 11).

Birch (1945), studied the oviposition of two beetles commonly found in stored grain, Calandra oryzae and Rhizopertha dominica and was able to measure the influence of temperature. Birch found that the number of eggs laid reached a maximum at a median temperature of 26°C for the sparser population and 29° for the denser one. At temperatures above and below this, fewer eggs were produced. Almost in the same way the rates of egg production were greatest at 30°C and there was little or no increase at 35°C in both species of Tribolium considered either separately or when combined. It could be stated on this basis that the fecundity of insects tends toward a maximum at a moderately high temperature, which may be relatively near the upper limit of the favourable range.

From this investigation the two species of Tribolium responded similarly to the range of temperature. But T. castaneum produced significantly more eggs at the lower temperature (20°C). The rate of oviposition rose to a peak in the second week and dropped from then to the sixth week sharply whereas the response of T. confusum was more even from the second week to the fifth. T. confusum had the most marked peak in egg production at 35°C, with a very sharp drop from the third to the fifth week.

The fact that T. castaneum had a higher rate of egg production regardless of the temperatures involved, confirmed the point suggested previously from studies conducted at 29°C (Park, 1948, Park and Davis, 1945).

The work done here, however, suggests that the difference between the two species of Tribolium is primarily a specific difference, T. castaneum possessing a higher rate of oviposition than T. confusum, since there was no interaction.

The differences between the means for the entire period of investigation, when compared species by species at each temperature, are all highly significant statistically as shown from the various analyses of variance carried out. It was unfortunate that lack of time prevented measurement of the fecundities of the progeny reared from eggs laid at each experimental temperature.

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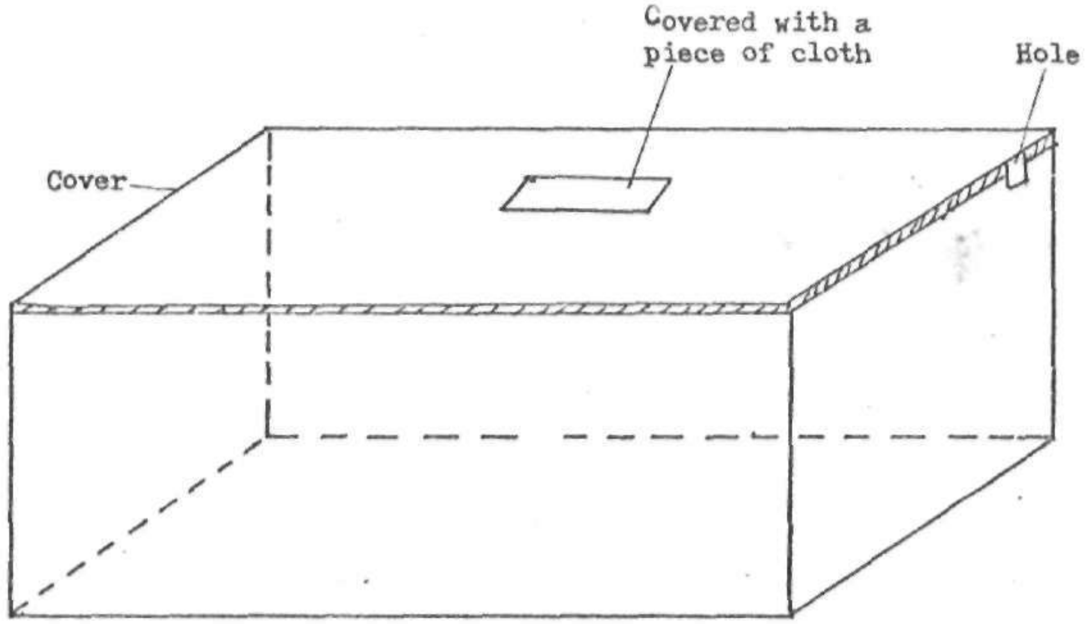

Fig. 1 The plastic box

EGGS PRODUCED AT 20°C BY T. CASTANEUM

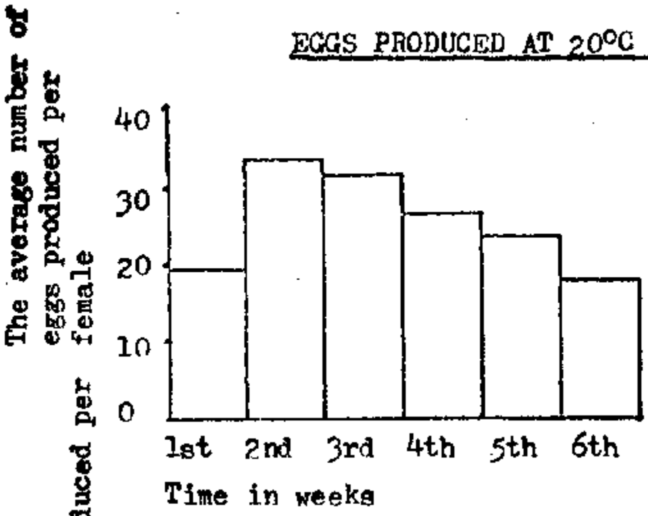

Figure 2

EGGS PRODUCED AT 25°C BY T. CASTANEUM

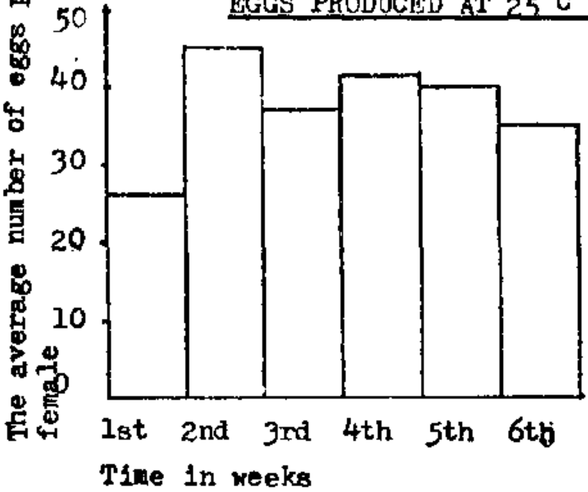

Figure 3

EGGS PRODUCED AT 30°C BY T. CASTANEUM

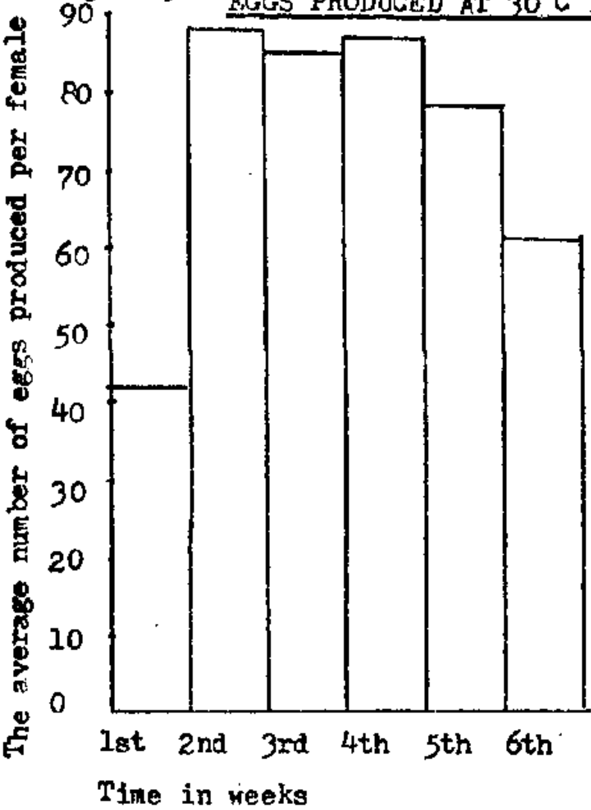

Figure 4

EGGS PRODUCED AT DIFFERENT TEMPERATURES

BY T. CASTANEUM

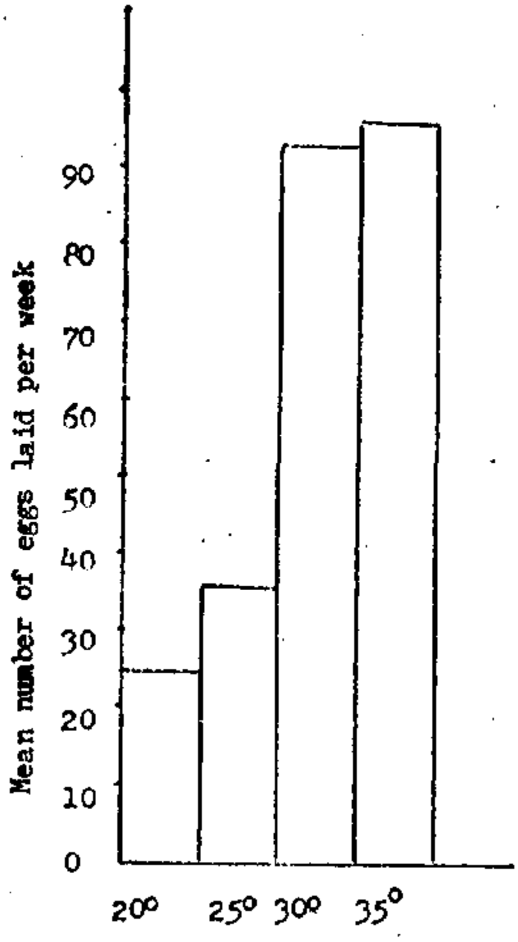

Figure 5

T. CONFUSUM AT 20°C

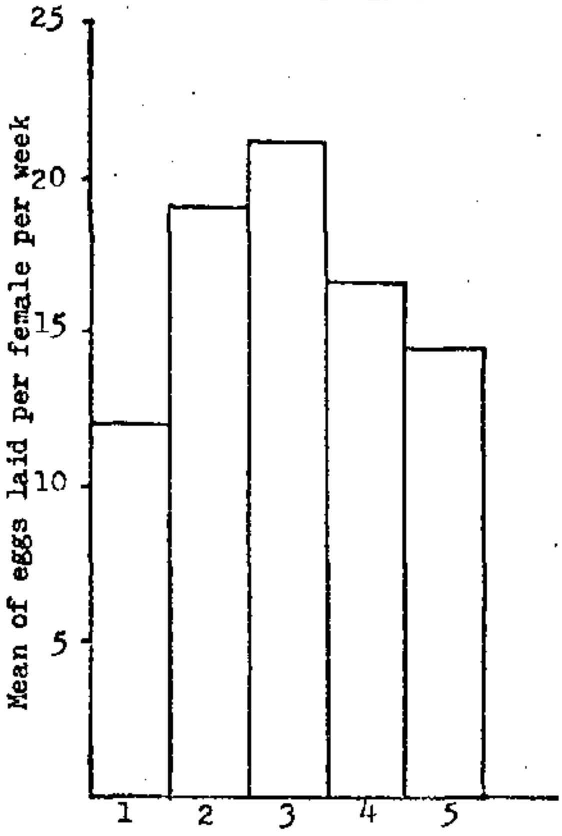

Fig. 6 Time in weeks

T. CONFUSUM AT 25°C

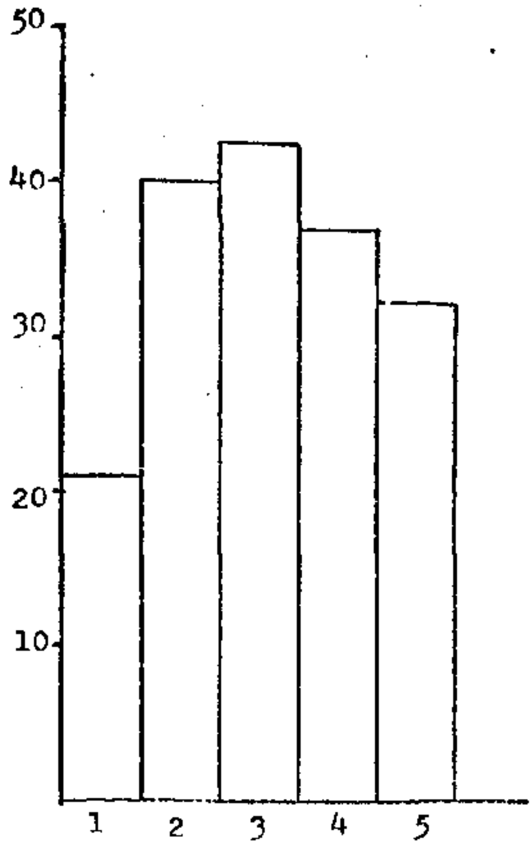

Fig. 7 Time in weeks

THE MEAN OF EGGS LAID BY T. CONFUSUM AT 35°C

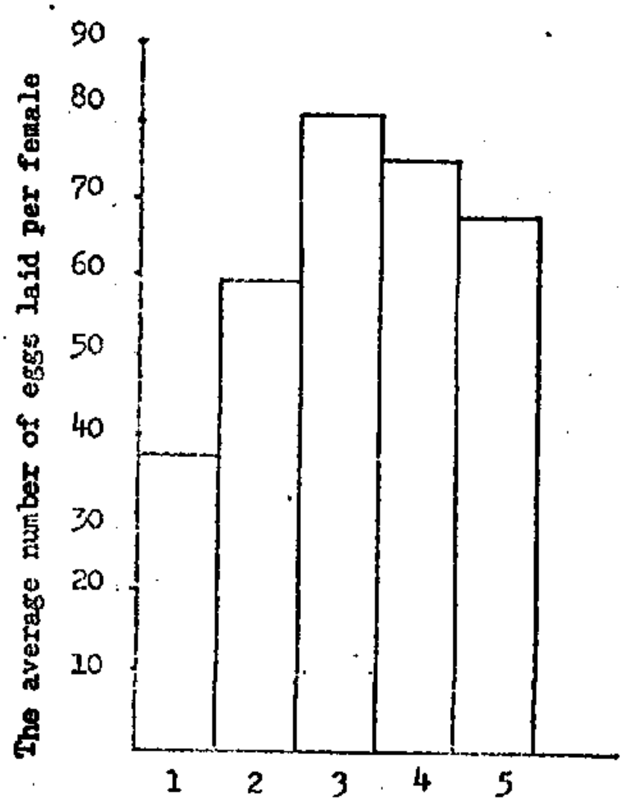

Fig. 8 Time in weeks

THE MEAN OF EGGS LAID BY T. CONFUSUM AT 35°C

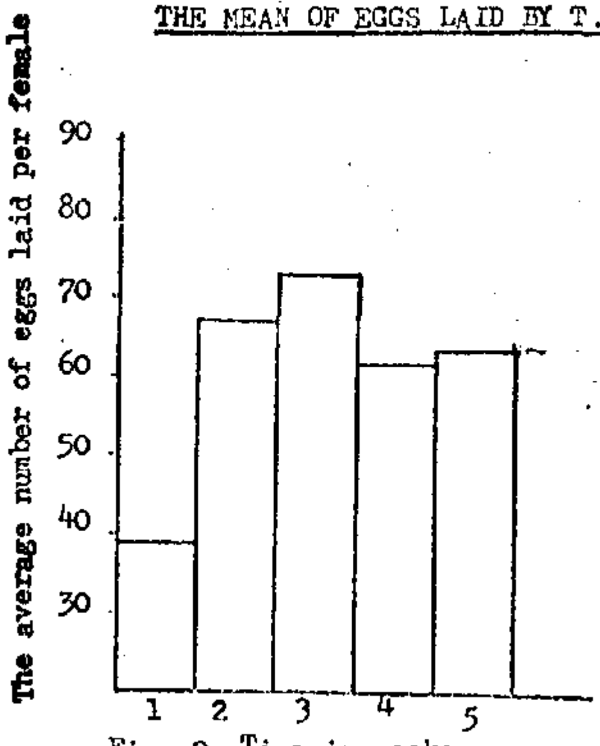

Fig. 9 Time in weeks

THE RATE OF EGG-PRODUCTION BY T. CONFUSUM AT DIFFERENT TEMPERATURES

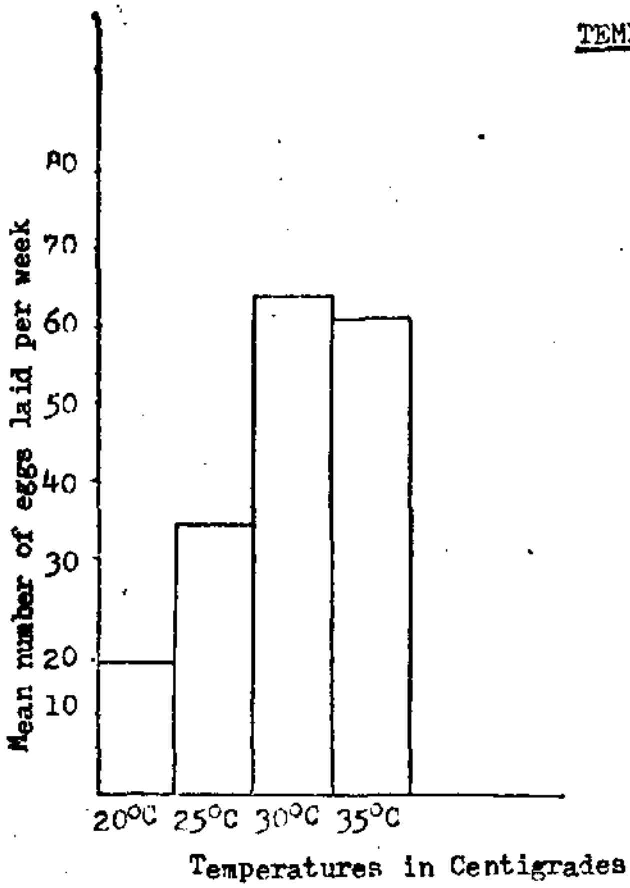

Figure 10

Mean Rate of Oviposition of T. confusum and T. castaneum for 5 and 6 weeks of observation Respectively at Temperatures of 20°, 25°, 30° and 35° C

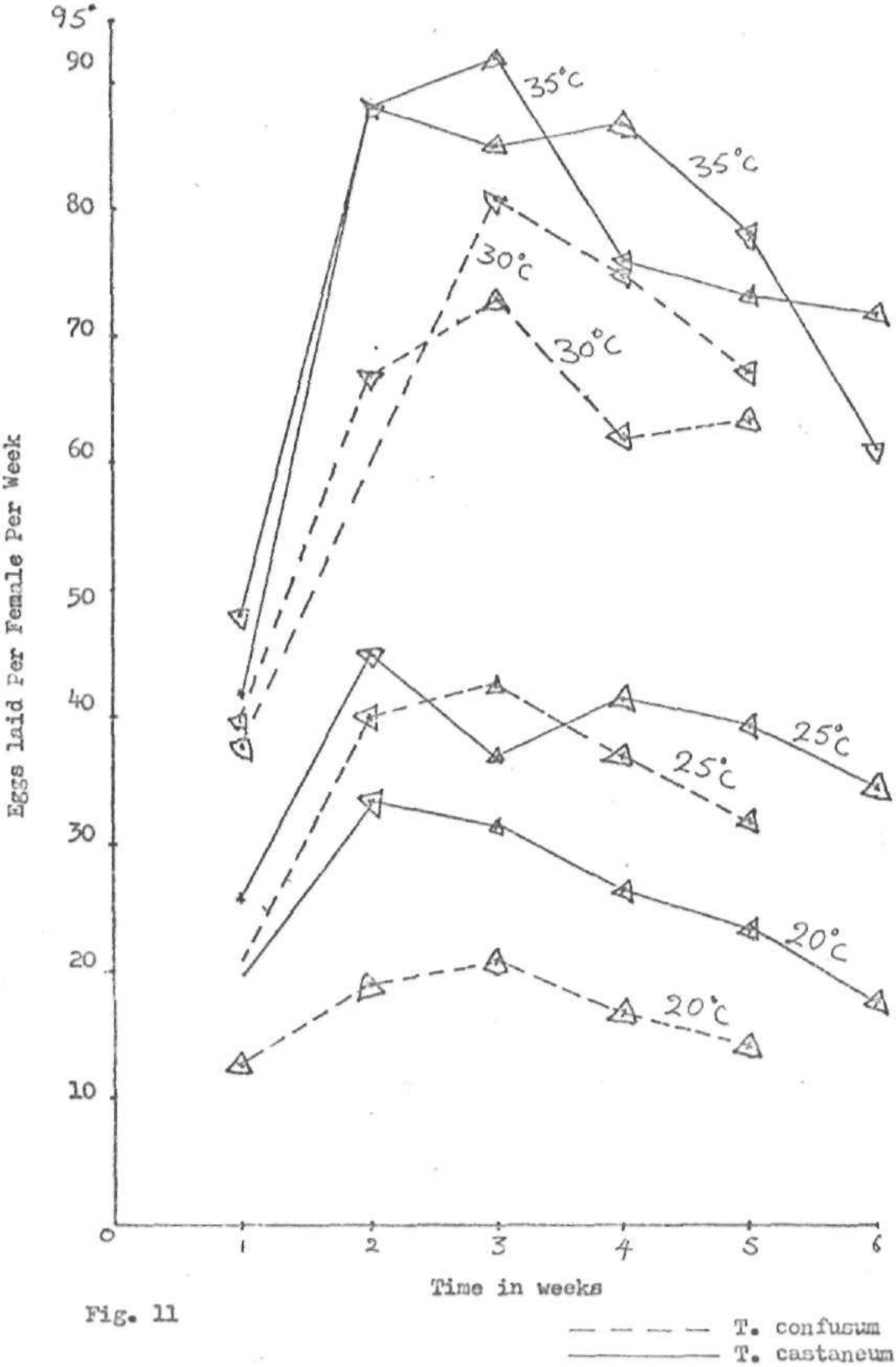

Fig. 11

MEAN RATE OF OVIPOSITION OF T. CONFUSUM AND T. CASTANEUM COMBINED FOR 5 WEEKS OF OBSERVATION AT TEMPERATURES OF 20°, 25°, 30° AND $35^{\circ}C$

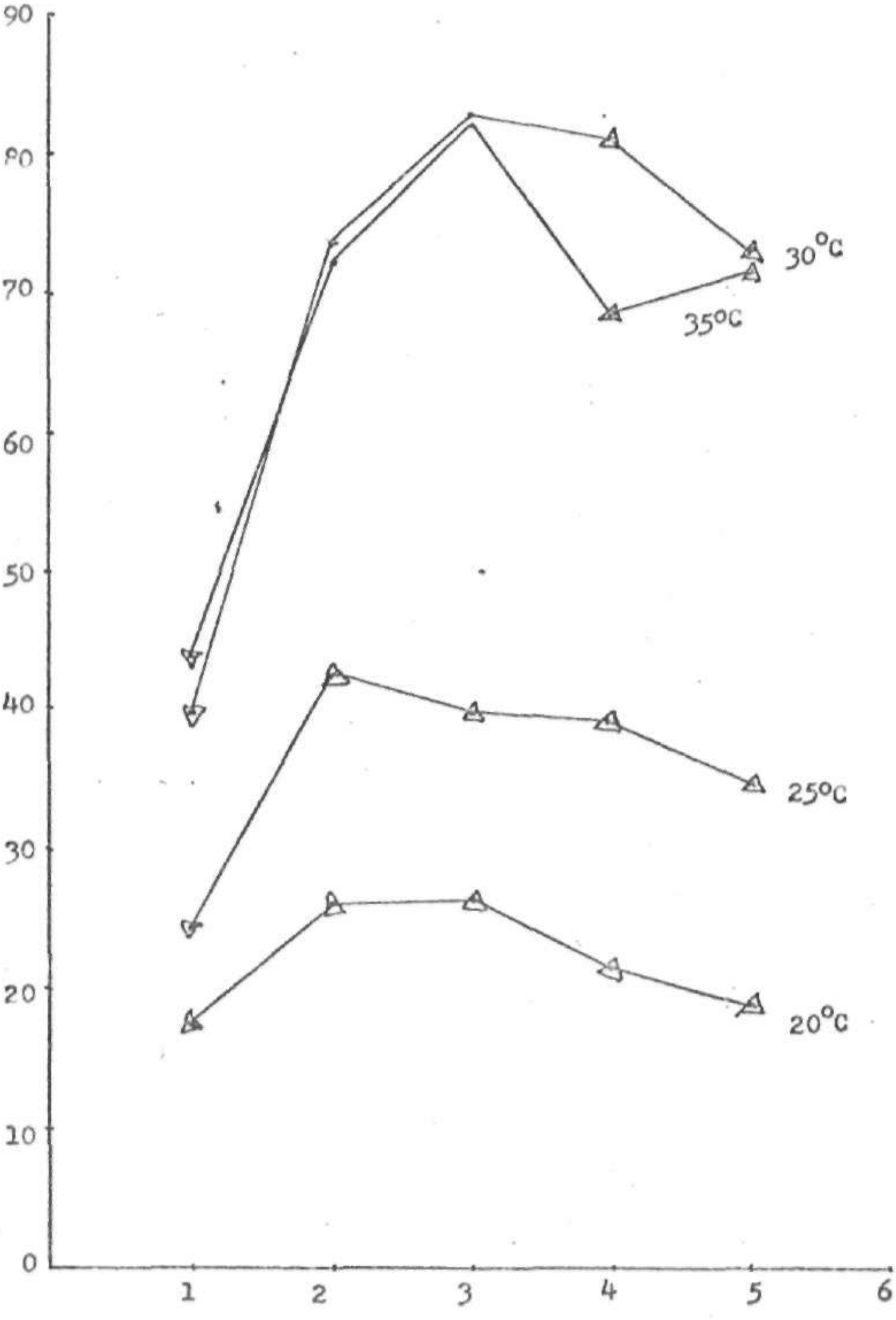

Figure 12

A P P E N D I C E S

TABLE XV

Eggs laid per week by T. castaneum at 20°C

	1	2	3	4	5	6	TOTAL	MEAN
1	36	42	52	39	28	24	221	35.1
2	17	47	25	23	18	11	141	23.5
3	20	17	29	38	21	25	160	26.66
4	33	35	37	30	26	29	190	31.66
5	29	37	34	33	29	30	192	32
6	36	42	40	28	24	30	200	33.33
7	5	13	14	19	20	9	80	13.33
8	30	49	37	30	17	14	177	29.3
9	29	37	43	34	43	17	203	33.8
10	29	10	13	17	16	9	94	15.66
11	22	32	14	12	11	13	104	17.3
12	30	51	53	46	41	18	239	39.8
13	12	28	36	25	20	13	134	22.3
14	13	25	38	24	39	20	159	26.5
15	24	49	38	18	13	27	169	28.1
16	13	27	24	17	20	7	108	18
17	11	19	14	20	18	9	91	15.16

TABLE XVI

Eggs laid per week by T. castaneum at 25°C

	1	2	3	4	5	6	TOTAL	MEAN
1	29	42	38	40	31	33	213	35.5
2	26	44	32	45	40	38	225	37.5
3	52	46	50	51	44	51	294	49
4	14	46	36	29	17	20	162	27
5	16	61	34	58	44	51	264	44
6	12	33	42	35	32	36	190	31.66
7	8	45	28	70	56	43	250	41.66
8	45	48	36	25	24	26	204	34
9	32	40	44	38	34	35	223	37.2
10	45	44	25	28	18	10	170	28.33
11	12	30	35	38	43	24	182	30.33
12	21	63	43	64	68	53	312	52
13	51	43	46	51	57	39	287	47.83
14	43	58	40	41	40	60	272	45.33
15	34	47	41	28	13	11	174	29
16	9	35	20	26	34	27	151	25.16

TABLE XVII

Eggs laid per week by T. castaneum at 30°C

	1	2	3	4	5	6	TOTAL	MEAN
1	39	58	69	87	73	70	396	66
2	51	103	87	90	85	59	475	79.16
3	38	96	85	96	94	65	474	79
4	44	102	89	65	72	69	441	73.5
5	16	94	92	88	88	64	442	73.66
6	32	76	60	94	65	59	386	64.33
7	66	101	93	82	86	56	484	80.66
8	36	87	92	85	76	65	441	73.5
9	63	91	77	88	99	69	487	81.16
10	28	88	86	79	87	72	440	73.33
11	60	93	91	98	61	59	462	77.00
12	49	102	87	70	94	40	442	73.66
13	63	104	101	98	66	45	477	79.5
14	33	49	95	92	66	41	376	52.66
15	51	87	89	94	77	59	457	76.16
16	32	102	89	87	77	55	442	73.66
17	24	84	86	89	66	46	395	65.83
18	34	69	63	86	84	56	392	65.33

TABLE XVIII

Eggs laid per week by T. castaneum at 35°C

	1	2	3	4	5	6	TOTAL	MEAN
1	48	83	86	64	85	79	445	74.166
2	46	91	99	65	90	84	475	79.166
3	47	82	98	80	86	80	473	78.83
4	53	89	89	80	86	9	476	79.33
5	48	90	95	76	84	82	475	79.166
6	47	86	95	79	75	80	463	77.166
7	52	88	87	69	77	70	443	73.83
8	53	80	91	65	70	60	428	71.33
9	45	94	85	78	90	55	447	74.5
10	41	89	99	76	80	78	463	77.166
11	40	87	84	75	74	72	441	73.5
12	53	88	83	65	76	69	434	72.33
13	46	93	88	87	84	78	476	79.33
14	48	89	102	80	78	68	465	77.5
15	46	78	99	81	75	65	444	74
16	58	83	83	78	69	60	431	71.83
17	44	90	97	80	83	75	468	78

TABLE X IX

Eggs laid per week by T. confusum at 20°C

	1	2	3	4	5		WEEKLY MEAN
1	16	27	24	20	20	107	21.4
2	9	16	15	10	13	63	12.6
3	8	10	20	13	12	63	12.6
4	20	22	22	20	16	100	20
5	14	16	13	10	13	66	13.2
6	11	13	17	21	17	79	15.8
7	12	18	25	19	13	87	17.4
8	12	13	16	10	14	65	13
9	19	30	25	21	13	108	21.6
10	14	19	28	22	18	101	20.2
11	14	17	28	23	15	97	19.4
12	17	19	31	24	12	103	20.6
13	18	28	24	12	13	95	19
14	9	11	20	11	14	65	13
15	4	21	13	10	12	60	12
16	12	27	27	18	16	100	20
17	14	18	18	19	15	84	16.8
18	6	18	15	17	16	72	14.4

TABLE XX

Eggs laid per week by T. confusum at 20°C

	1	2	3	4	5	TOTAL	MEAN
1	18	30	35	30	28	141	28.2
2	24	37	42	38	31	172	34.4
3	11	46	46	34	30	167	33.4
4	21	47	42	46	37	193	38.6
5	24	40	49	45	32	190	38
6	11	31	40	39	29	150	30
7	29	45	42	38	34	188	37.6
8	20	49	46	37	36	188	37.6
9	24	49	45	43	34	195	39
10	31	40	46	35	39	191	38.2
11	11	38	40	43	36	168	33.6
12	21	48	48	35	31	183	36.6
13	27	38	40	41	30	176	35.2
14	14	26	39	28	28	125	25
15	24	39	40	27	29	159	31.8
16	28	43	44	34	34	183	36.6
17	22	34	40	39	33	168	33.6

TABLE XXI

Eggs laid per week by T. confusum at 30°C

	1	2	3	4	5	TOTAL	MEAN
1	35	72	80	90	81	358	71.6
2	48	69	98	66	70	351	70.2
3	23	65	80	52	68	288	55.6
4	40	68	87	70	65	330	66.6
5	44	44	84	64	70	306	61.2
6	37	69	86	89	50	331	66.2
7	33	74	89	81	72	349	69.8
8	32	64	75	70	78	319	63.8
9	39	42	59	49	60	249	49.8
10	55	82	83	96	74	390	78
11	18	38	69	99	62	286	57.2
12	31	46	74	93	80	324	64.8
13	45	64	93	89	75	366	73.2
14	35	34	79	45	50	243	48.6
15	37	41	89	50	52	269	53.8
16	40	73	60	88	73	334	66.8
17	48	69	89	87	69	362	72.4