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Tadeusz PRUS, Paweł BIJOK, Mirosława PRUS

Department of Ecological Bioenergetics, Institute of Ecology, Polish Academy of Sciences, Dziekanów Leśny (near Warsaw), 05-092 Łomianki, Poland

AUTECOLOGICAL FEATURES OF STRAINS: *TRIBOLIUM CASTANEUM* HBST CI AND *T. CONFUSUM* DUVAL BIV

ABSTRACT: Autecological features i.e. fecundity, mean weight of eggs and hatchability were investigated during 100 days of culturing individual pairs of 6- and 7-instar groups within *T. castaneum* cI and *T. confusum* bIV strains. The groups in both species differ one from another by shorter (6-instar) and longer (7-instar) developments. The 6-instar groups showed higher fecundity, similar mean egg weight and similar hatchability than 7-instar groups. Differences between species were higher than those between 6- and 7-instar groups. *T. castaneum* cI strain showed higher fecundity, lower individual egg weight and higher hatchability than *T. confusum* bIV strain.

KEY WORDS: Fecundity, hatchability, life strategy, intrapopulation differentiation.

1. INTRODUCTION

In the course of bioenergetic studies on *Tribolium castaneum* differentiation within strain has been observed in duration of developmental cycle, the maximum weight attained by larvae, time of reaching it and in weight of adult beetles (P r u s 1976). Similar differences were found in *T. confusum* bIV strain (B i j o k 1986). These observations enhanced us to examine such features as fecundity, mean individual egg weight and hatchability within the discerned groups in both species. Information on these autecological features is thought to be useful for further interpretation of the populational phenomena in terms of life strategy theory.

Phenotypic differentiation for *T. castaneum* cI strain was described in details in an earlier study (T. P r u s and M. P r u s 1987). Significant differences were found in development duration, maximum larval weight, fecundity and hatchability of the two substrains (6- and 7-instar groups).

The period of more then three months of censusing of individual pairs of beetles was considered to be long enough to grasp time changes in these characteristics studied.

Similar period of censusing of *Tribolium* populations for primary characteristics has been adopted by Park (P a r k et al. 1961).

The present paper aims at detecting significance of differences in these features mentioned between the substrains. Differences observed between species will be useful for evaluation of position of these two strains on $r \rightarrow K$ continuum in S t e a r n s (1980) sense.

2. MATERIAL AND METHODS

All experiments were carried out in standard conditions of 29°C, 75% relative humidity, in medium consisting of 95% of wheat flour and 5% of baker's yeast.

Material used for experiments consisted of 6- and 7-instar substrains. They were separated on the basis of differences in attaining pupal stage, similarly as in earlier study (T. P r u s and M. P r u s 1987). The design of experiment consisted of four series (2 species × 2 substrains) with 10 replications in each, except for 7-instar *T. confusum*, where were only 4 replications due to the shortage of material.

Fecundity of individual pairs kept in 8 g of standard medium was measured as number of eggs laid in 3-day interval. At each census the culture medium was renewed. Fecundity was expressed as number of eggs laid by female during 24 h, or during 72 h.

The collected batch of eggs from each pair was weighed on Cahn model G electrobalance in order to assess mean fresh weight of eggs. Thus collected eggs were left over in incubator to hatch. Number of hatched eggs was counted after six days elapsed from the moment of their deposition. This duration exceeds much the time needed for all eggs to hatch under the experimental conditions.

The results were presented for 3-day intervals in the substrains examined (6- and 7-instar groups). However, in order to make the interpretation of interspecies differences more lucid the results were grouped in 9-day intervals (3 censuses together).

The significances of difference between substrains were tested using $t-$test method for combined presentation of results. Probability of $P = 0.005$ was accepted as the significance level.

3. RESULTS

In *Tribolium castaneum* cI strain females of 6-instar group lay more eggs than these of 7-instar group (Fig. 1). Maximum fecundity occurs during the first month of adult life. In this period the differences between substrains are statistically significant (Table 1). Later on, at diminishing fecundity these differences became obscured. In *T. confusum* bIV strain the differences of fecundity between substrains are rather significant throughout the whole experiment and the decreasing tendency of fecundity with time is less conspicuous (Fig. 2, Table 1).

Table 1. Fecundity of 6- and 7-instar females of *Tribolium castaneum* cI and *T. confusum* bIV (numbers of eggs per female per day)

Days	*T. castaneum* cI							*T. confusum* bIV						
	6-instar group			significance	7-instar group			6-instar group			significance	7-instar group		
	mean	*SD*	*n*		mean	*SD*	*n*	mean	*SD*	*n*		mean	*SD*	*n*
1–9	19.60	2.54	30	S	16.24	3.31	30	11.61	1.66	29	S	9.74	1.18	9
10–18	18.33	5.18	30	S	15.2	3.65	30	11.31	1.48	30	NS	10.07	1.79	9
19–27	18.56	2.80	30	S	16.41	2.00	27	10.92	1.25	30	NS	10.00	1.72	9
28–36	17.32	2.82	30	NS	16.21	1.67	27	10.29	1.26	30	S	9.19	1.34	9
37–45	14.83	4.89	29	NS	15.28	2.17	27	9.87	2.06	30	NS	8.63	1.97	9
46–54	15.46	4.63	26	NS	13.97	2.86	26	9.14	1.30	30	S	7.48	1.56	9
55–63	14.36	4.51	24	NS	12.36	3.79	24	8.54	1.75	27	S	6.70	0.92	9
64–72	11.60	4.58	24	NS	12.43	4.92	23	8.11	1.22	27	S	6.07	1.32	9
73–81	10.72	4.61	24	NS	11.37	5.07	21	8.16	1.05	27	S	5.81	1.59	9
82–90	10.33	3.96	19	NS	10.17	5.13	21	6.96	1.15	27	S	5.89	1.05	6
91–99	10.65	4.09	18	NS	9.79	5.77	14	6.62	1.21	27	S	5.92	0.42	4

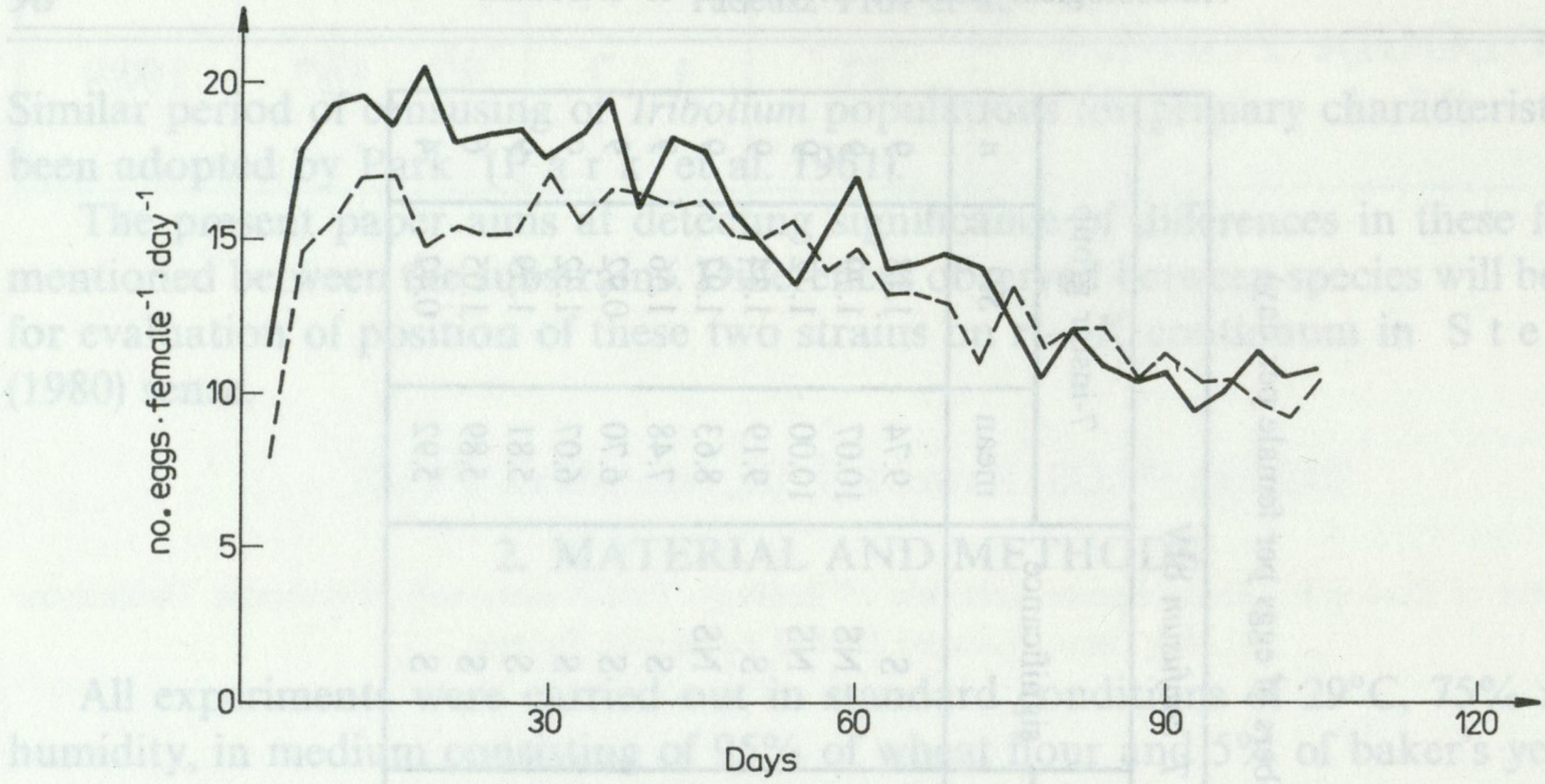

Fig. 1. Fecundity of 6- (solid line) and 7-instar (broken line) females of *Tribolium castaneum* cI in subsequent censuses

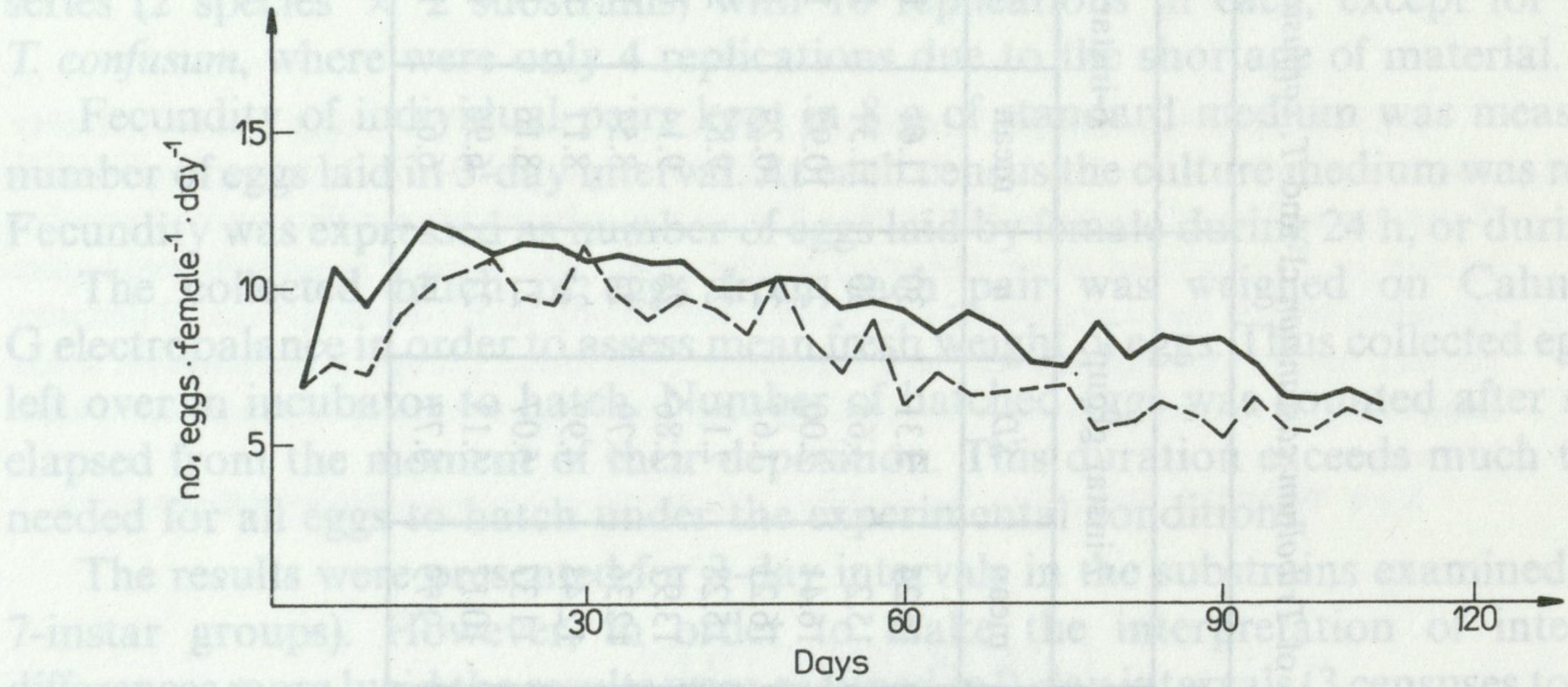

Fig. 2. Fecundity of 6- (solid line) and 7-instar females (broken line) of *T. confusum* bIV in subsequent censuses

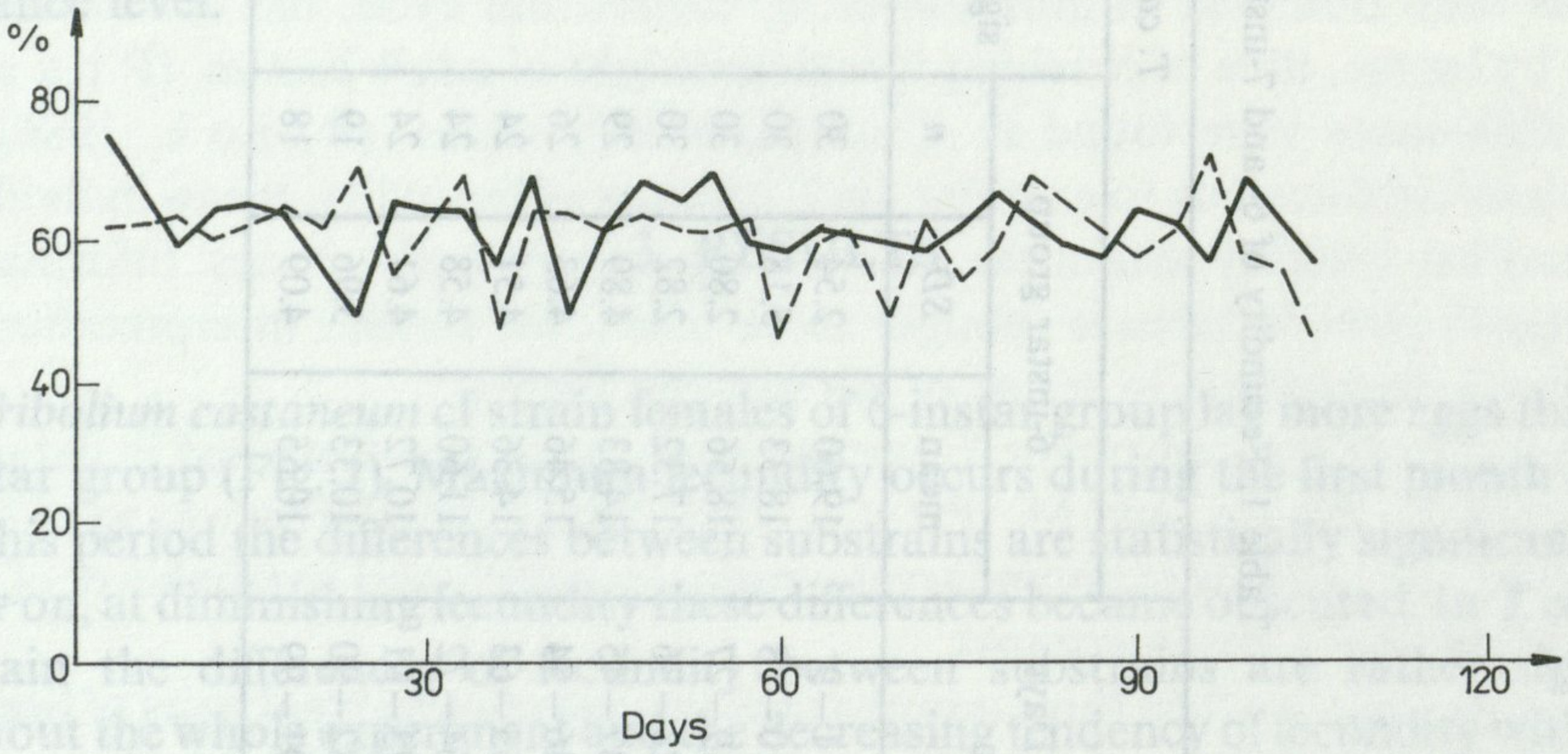

Fig. 3. Hatchability of eggs laid by 6- (solid line) and 7-instar females (broken line) of *T. castaneum* cI in subsequent censuses

Table 2. Mean individual weight of eggs laid by 6- and 7-instar females of *T. castaneum* cI and *T. confusum* bIV (μg fresh wt)

Days	*T. castaneum* cI							*T. confusum* bIV						
	6-instar group			significance	7-instar group			6-instar group			significance	7-instar group		
	mean	*SD*	*n*		mean	*SD*	*n*	mean	*SD*	*n*		mean	*SD*	*n*
1–9	42.82	3.91	30	S	39.71	5.79	28	54.93	8.29	29	NS	54.56	7.28	9
10–18	43.36	10.93	30	NS	43.01	11.33	29	58.17	10.59	30	NS	57.39	9.94	9
19–27	40.31	4.47	30	S	36.7	4.26	27	50.92	4.71	30	S	47.60	3.00	9
28–36	39.72	5.68	30	NS	38.94	3.36	27	50.83	4.45	30	NS	49.99	3.24	9
37–45	38.88	5.31	28	NS	39.04	3.88	26	51.31	5.48	30	NS	48.23	7.71	9
46–54	41.49	4.88	24	S	37.66	4.16	26	51.26	5.16	29	NS	52.37	3.07	9
55–63	38.94	5.37	23	NS	39.12	3.76	24	54.14	6.02	27	NS	52.50	4.29	9
64–72	46.80	10.48	23	NS	43.64	5.56	21	64.27	11.18	27	NS	65.54	14.63	9
73–81	43.73	7.27	24	NS	44.22	2.91	21	60.13	3.76	27	NS	57.68	4.55	9
82–91	45.39	6.65	19	NS	47.69	5.80	21	65.11	5.48	27	NS	66.83	3.60	6
92–99	46.06	9.02	18	NS	49.45	8.93	14	66.08	4.25	27	NS	68.69	3.14	4

Table 3. Hatchability of eggs laid by 6- and 7-instar females of *T. castaneum* cI and *T. confusum* bIV (%)

Days	*T. castaneum* cI						*T. confusum* bIV					
	6-instar group			7-instar group			6-instar group			7-instar group		
	mean	*SD*	*n*	mean	*SD*	*n*	mean	*SD*	*n*	mean	*SD*	*n*
1–9	64.51	8.37	30	63.00	10.77	29	47.99	18.61	29	52.63	22.03	9
10–18	55.95	15.64	30	62.98	15.40	30	56.22	16.08	30	53.90	18.45	9
19–27	61.58	11.20	30	59.65	12.48	27	51.97	13.38	28	54.16	17.58	9
28–36	60.32	12.00	30	62.86	9.84	27	51.62	13.29	29	50.47	15.22	9
37–45	67.34	15.45	29	62.12	7.43	27	45.03	15.46	30	51.56	19.55	9
46–54	59.69	15.38	25	55.95	13.96	26	42.6	18.16	30	50.29	18.55	8
55–63	59.56	11.86	23	57.40	12.56	24	45.76	14.31	26	47.26	12.95	9
64–72	63.23	12.47	24	60.07	14.15	23	42.47	16.4	27	37.48	20.70	9
73–81	60.87	11.53	23	61.33	15.01	21	36.02	16.24	27	37.44	24.29	9
82–90	62.71	13.75	19	63.00	15.85	21	37.38	14.80	27	40.19	20.03	6
91–99	55.59	16.91	18	50.13	16.91	13	34.19	17.40	24	37.86	17.19	4

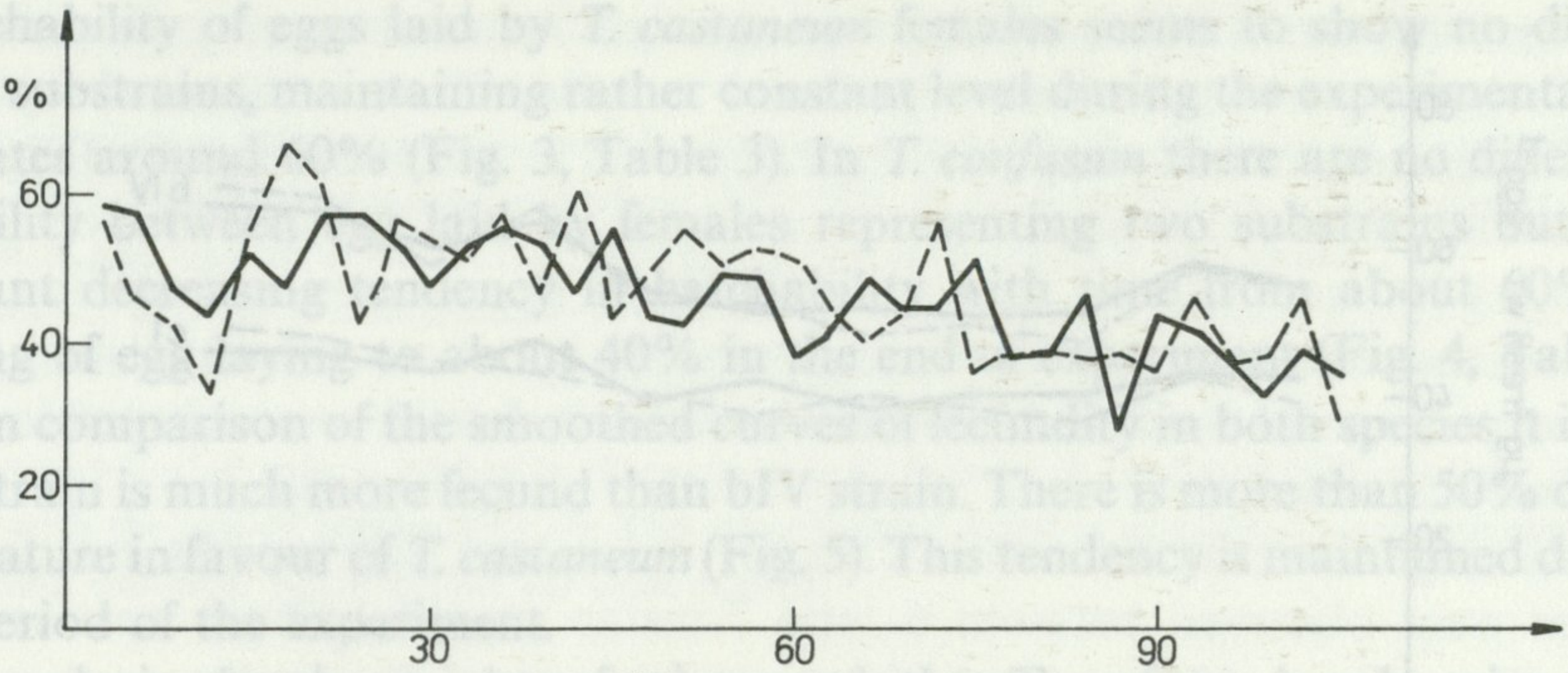

Fig. 4. Hatchability of eggs laid by 6- and 7-instar females of *T. confusum* bIV in subsequent censuses
Solid line — 6-instar females, broken line — 7-instar females

Table 4. Changes in fecundity of 6- and 7-instar females of *T. castaneum* cI and *T. confusum* bIV in subsequent experiments (No. eggs · female^{-1} · 72 h^{-1})

Species	Date	6-instar	7-instar	Reference
T. castaneum cI	June 1982	50.8	57.5	T. Prus and M. Prus 1987
	December 1982—January 1983	55.9	57.9	
	March—June 1986	56.5	48.0	present paper
T. confusum bIV	January—February 1983	38.7	36.3	Bijok 1985
	March—June 1986	35.1	33.3	present paper

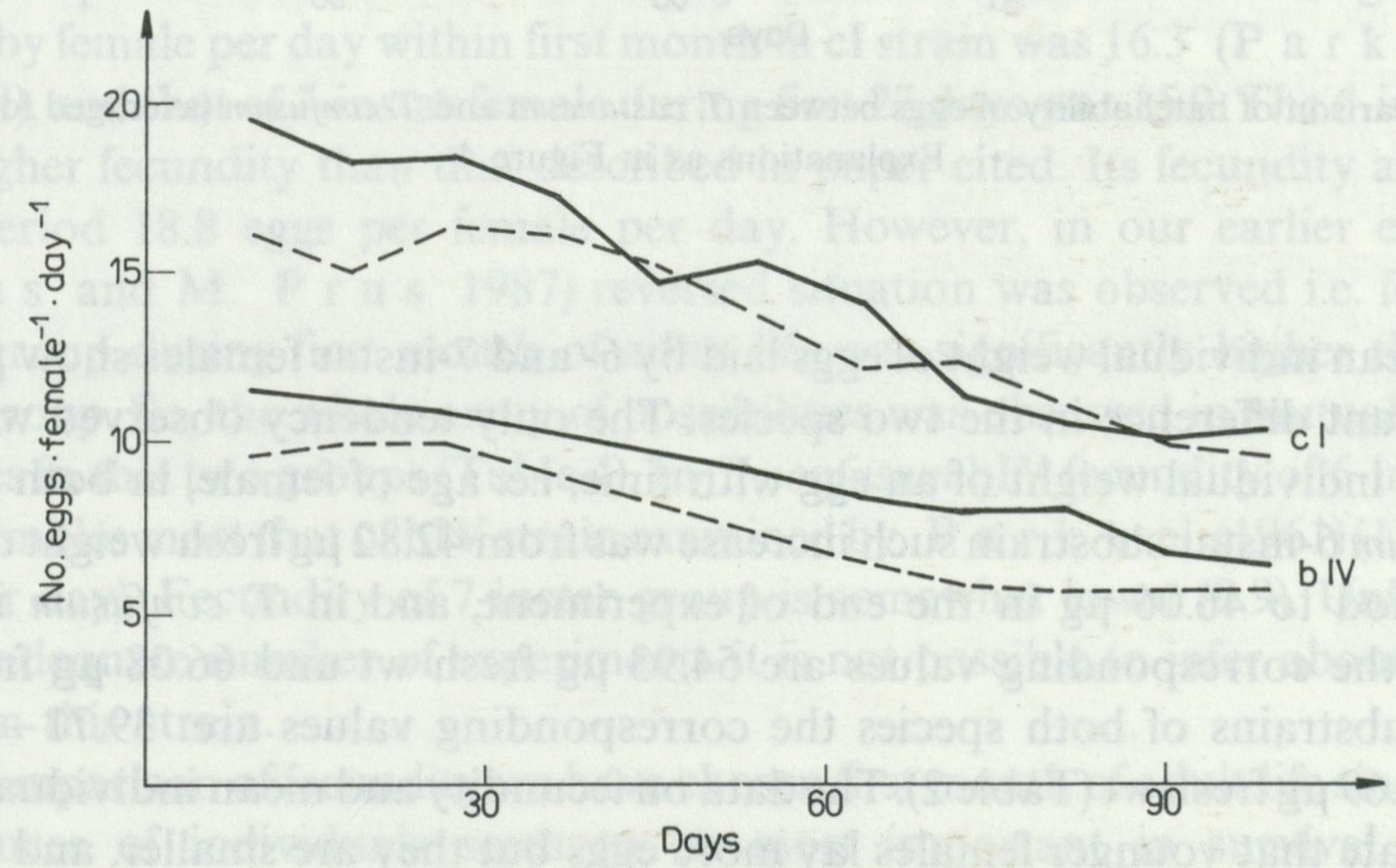

Fig. 5. Comparison of fecundity between *T. castaneum* and *T. confusum* (averaged for 3 censuses)
Explanations as in Figure 4

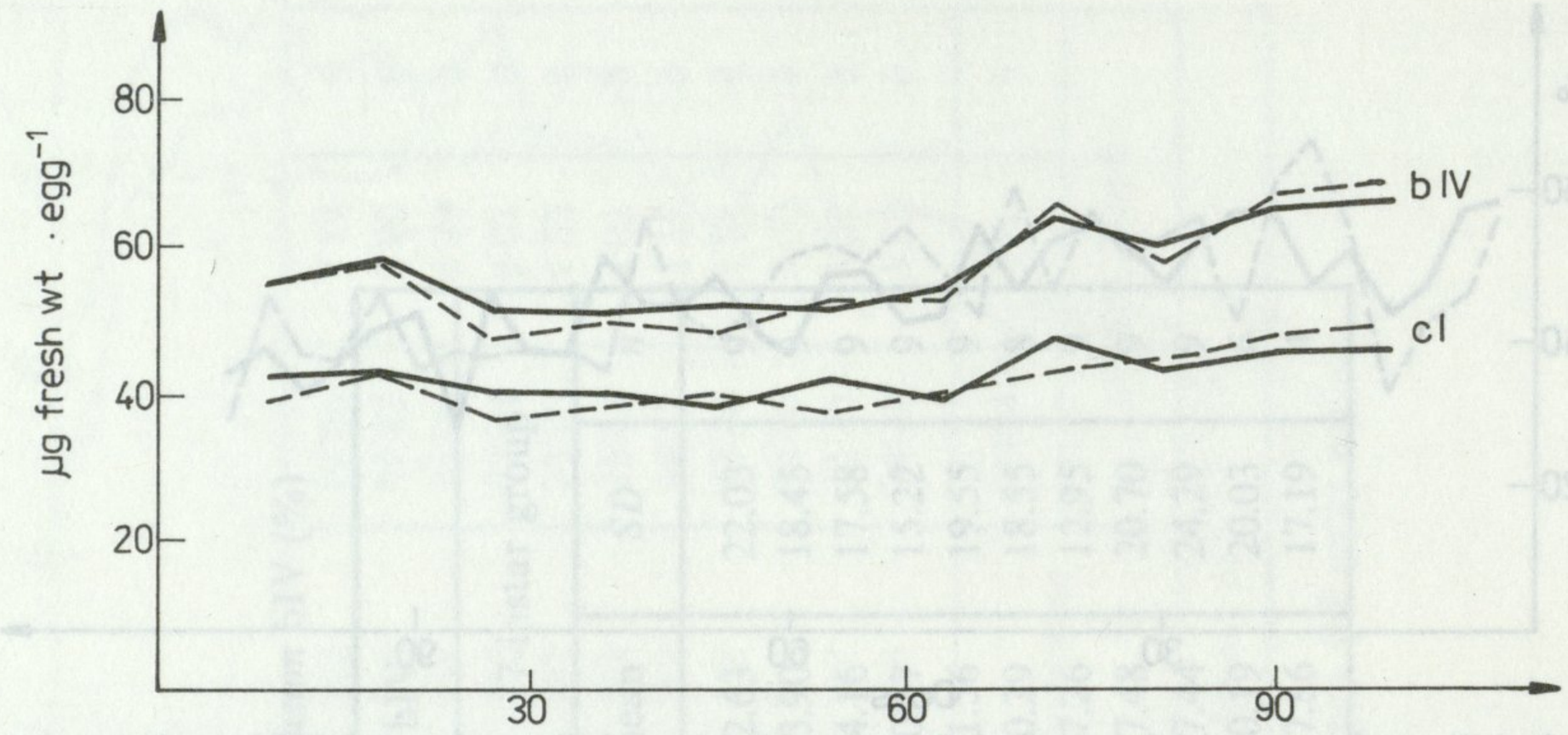

Fig. 6. Comparison of mean egg weight between *T. castaneum* and *T. confusum* (averaged for 3 censuses)
Explanations as in Figure 4

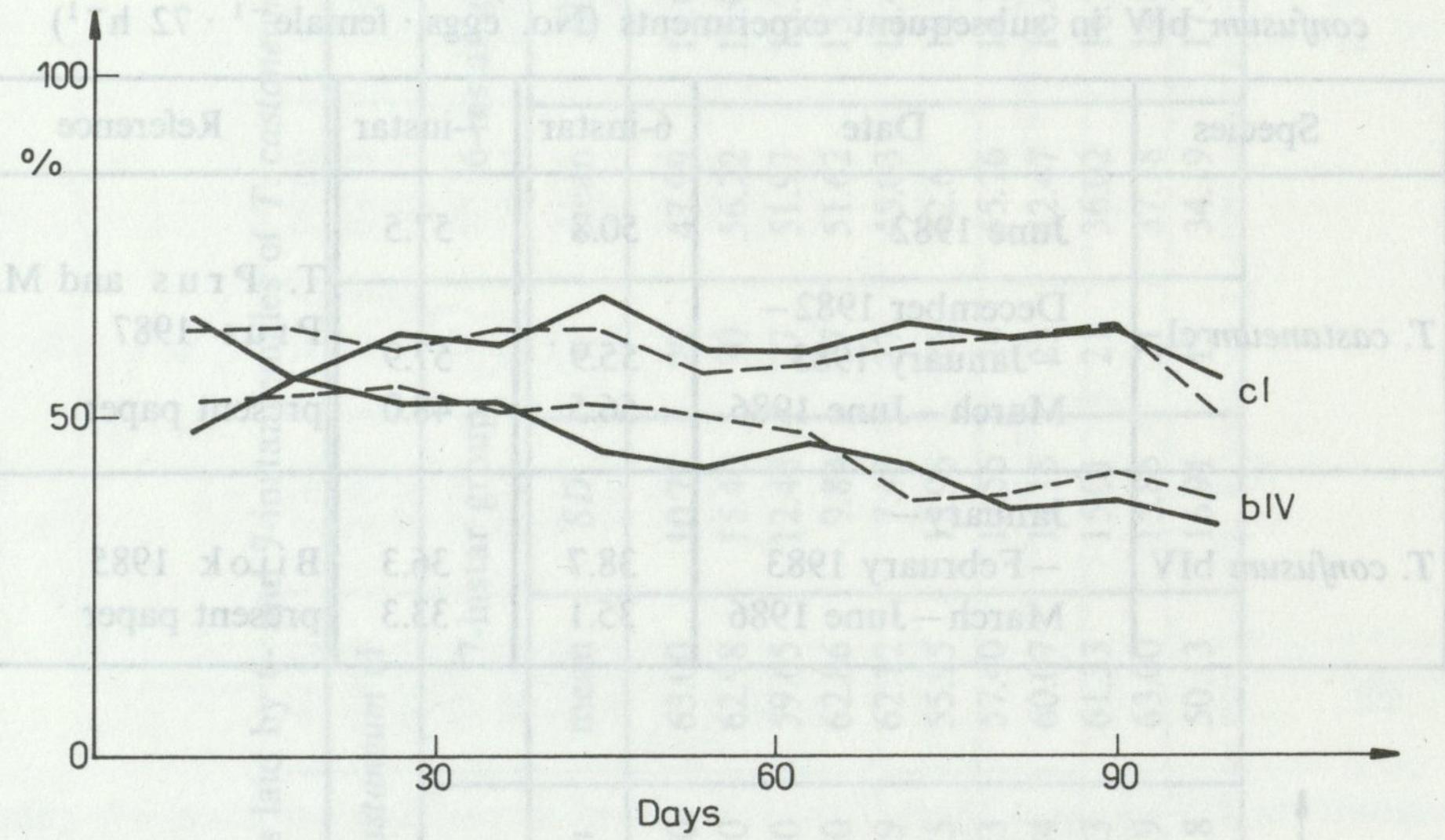

Fig. 7. Comparison of hatchability of eggs between *T. castaneum* and *T. confusum* (averaged for 3 censuses)
Explanations as in Figure 4

The mean individual weight of eggs laid by 6- and 7-instar females show practically no significant difference in the two species. The only tendency observed was slightly increasing individual weight of an egg with time, i.e. age of female, in both species. In *T. castaneum* 6-instar substrain such increase was from 42.82 µg fresh weight during first 9-day period to 46.06 µg in the end of experiment, and in *T. confusum* in 6-instar substrain the corresponding values are 54.93 µg fresh wt and 66.08 µg fresh wt. In 7-instar substrains of both species the corresponding values are: 39.71 – 49.45 and 54.56 – 68.69 µg fresh wt (Table 2). The data on fecundity and mean individual weight of eggs indicate that younger females lay more eggs but they are smaller, and older ones lay less eggs but with higher individual weight.

Hatchability of eggs laid by *T. castaneum* females seems to show no differences between substrains, maintaining rather constant level during the experimental period. It oscillates around 60% (Fig. 3, Table 3). In *T. confusum* there are no differences in hatchability between egg laid by females representing two substrains but there is a constant decreasing tendency in hatchability with time from about 60% in the beginning of egg laying to about 40% in the end of experiment (Fig. 4, Table 4).

From comparison of the smoothed curves of fecundity in both species it is evident that cI strain is much more fecund than bIV strain. There is more than 50% difference in this feature in favour of *T. castaneum* (Fig. 5). This tendency is maintained during the whole period of the experiment.

The analysis of mean weights of eggs reveals that *T. confusum* lays heavier eggs than those of *T. castaneum*. There is about 20% difference in favour of the former species. However, there is a similar tendency in both species which depends on increased individual weight of eggs with time i.e. age of females (Fig. 6).

Higher hatchability was observed in *T. castaneum* cI strain than in *T. confusum* bIV strain. Due to decreasing tendency of hatchability in bIV strain with time, the almost equal values of percentage of eggs hatched at the beginning of the experiment in both species become more and more different in the course of the experiment (Fig. 7).

4. DISCUSSION

Strains used in the experiment were derived from University of Chicago where they have been created and cultured for many years in laboratory run by Prof. Thomas Park. Primary characteristics of these strains are given in paper by P a r k et al. (1961). If we compare fecundity of cI strain in that time with fecundity of the two substrains of this strain obtained in our laboratory we can state that fecundity of 7-instar group resambles most the fecundity of initial cI strain. The average number of eggs laid by female per day within first month in cI strain was 16.3 (P a r k et al. 1961, recounted), and that of 7-instar female during first 27 days was 15.9. The 6-instar group shows higher fecundity than that described in paper cited. Its fecundity amounts for 27-day period 18.8 eggs per female per day. However, in our earlier experiments (T. P r u s and M. P r u s 1987) reversed situation was observed i.e. fecundity of 6-instar group during first month of adult life was significantly higher than that of 7-instar group. So, the whole array of possibilities was observed in mutual relation of fecundities in this two groups (Table 4). In *T. confusum* bIV fecundity of 6-instar group (11.3) resembles most that of bIV strain examined by P a r k et al. (1961) (11.7 eggs per female per day). Fecundity of 7-instar group is somewhat lower (9.9). Unfortunately, due to inadequate number of experiments it is not possible to infer about long term changes in this strain.

For comparison of fecundity we have chosen first month of adult life since the early performances of individuals seem to be most important in survival success of a population. In later period the situation is different in the two compared strains, since

in *T. castaneum* cI strain differences became nonsignificant, whereas in *T. confusum* bIV strain differences were statistically significant in spite of low number of replicates.

The diminishing of fecundity with time observed in the present paper (Fig. 5) finds its corroboration in earlier studies by P a r k et al. (1961) for both species and by T a k a h a s h i and Y a m a m o t o (1972) in *T. confusum* wild strain.

It seems that fecundity of examined substrains is not a well established trait yet. Both the experimental work and selection procedure should be continued in order to achieve univocal results.

Considering the characteristic of mean individual egg weight no significant differences were observed between 6- and 7-instar groups in both species (Fig. 6). However, *T. confusum* bIV strain laid heavier eggs than *T. castaneum* cI strain, the difference being about 20%. So *T. castaneum* cI strain lays more smaller eggs than *T. confusum* bIV (Figs. 5, 6). A tendency of larger eggs laid with age of female is well known in poultry studies (H u t t 1949). It was observed here, too.

Hatchability of eggs in both species shows much higher variation than other traits examined in this paper (cf. standard deviation in Table 3). Hatchability of eggs when referred to its first assessment (P a r k et al. 1961) for cI and bIV strains showed substantial differences. The observed percentages of eggs that hatch in both strains were much lower than these listed by P a r k et al. (1961) and the interspecies difference became evidently smaller.

In the light of what was said above, this trait is not good for determining the rank of *Tribolium* strains mortality pattern. First, it depicts the combined effect of natural egg mortality and failure of fertilization. Therefore it cannot be taken here as a good measure of life history character.

When characterising both strains in terms of life strategy performance it can be said that *T. castaneum* cI strain is characterised by shorter developmental cycle, earlier maturity, lower individual weight of eggs and higher hatchability. All these traits but last predispose this strain to be *r*-regulated strategist as compared to *T. confusum* bIV strain. Our earlier studies (P r u s 1976, B i j o k 1986, T. P r u s and M. P r u s 1987) showed differentiation of the examined strains into 6- and 7-instar groups. When these substrains were tested for autecological traits considered to be substantial for life history strategy it turned out that 6-instar strains in both species have strategy more of *r* type as compared with 7-instar substrains.

The constant existence of phenotypic groups in populations can have important significance for their survival. In colonizing new habitats 6-instar groups seen to be more important whereas 7-instar groups are necessary for further maintaince of these populations in already occupied habitats.

5. SUMMARY

In 6- and 7-instar groups discerned in strains of *Tribolium castaneum* cI and *T. confusum* bIV the following features were examined: fecundity, average weight of eggs and hatchability of eggs. Fecundity of females belonging to 6-instar groups was higher in both the species (Figs. 1, 2, Table 1). The 6- and 7-instar

groups showed no significant differences in average egg weight, whereas some increase of egg weight was observed with the age of females (Table 2).

When comparing the two strains examined, it was found that *T. castaneum* cI is more fecund than *T. confusum* bIV with difference reaching about 50% (Fig. 5). In *T. castaneum*, a much higher decrease of fecundity with age was observed, but in *T. confusum* bIV such decrease was smaller.

There was no difference in hatchability of eggs laid by females of 6- and 7-instar groups (Figs. 3, 4). At the lack of significant differences in average weight of eggs in 6- and 7-instar groups it was observed that *T. confusum* bIV laid heavier eggs than *T. castaneum* (Fig. 6).

The hatchability of eggs is higher in *T. castaneum* cI than in *T. confusum* bIV, and the difference is deepening with the age of beetles (Fig. 7). The autecological features examined were compared with the literature data obtained much earlier for these strains.

6. POLISH SUMMARY

U wyróżnionych w szczepach 6- i 7-stadialnych grup gatunków *Tribolium castaneum* cI i *T. confusum* bIV zbadano płodność, średni ciężar jaj i zdolność wylęgową jaj. U obu gatunków zaobserwowano wyższą płodność samic należących do grup 6-stadialnych (rys. 1, 2, tab. 1). Grupy 6- i 7-stadialne nie wykazują istotnych różnic w średnim ciężarze jaj, natomiast zaobserwowano pewien wzrost średniego ciężaru jaja z wiekiem samicy (tab. 2).

Porównując oba badane szczepy stwierdzono, że szczep cI jest bardziej płodny niż szczep bIV, przy czym różnica sięga 50% wartości (rys. 5). U *T. castaneum* stwierdzono znaczny spadek płodności wraz z wiekiem samic, natomiast u *T. confusum* bIV spadek ten jest mniejszy.

Podobnie nie stwierdzono istotnych różnic w zdolności wylęgowej jaj składanych przez samice z grup 6- i 7-stadialnych (rys. 3, 4). Przy badaniu istotnych różnic w średnim ciężarze jaj u grup 6- i 7-stadialnych zaobserwowano, iż *T. confusum* składa cięższe jaja niż *T. castaneum* (rys. 6). Zdolność wylęgowa jaj u *T. castaneum* jest wyższa niż u *T. confusum*. Różnica ta pogłębia się z wiekiem zwierząt (rys. 7). Badane cechy autekologiczne porównano z wcześniejszymi danymi literaturowymi dla tych szczepów.

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