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THE INFLUENCE OF SOME ECOLOGICAL FACTORS
ON THE SUSCEPTIBILITY OF *TRIBOLIUM CASTANEUM*
(HERBST) (*COL.*, *TENEBRIONIDAE*) TO PYBUTHRIN

Investigations were made in this study of the influence of temperature, relative atmospheric humidity, age, sex and stages of development of *Tribolium castaneum* (Herbst) on the susceptibility of these beetles to Pybuthrin. It was found that all these factors modify the susceptibility of the insects.

Preparations belonging to the Pyrethrins group have been used increasingly frequently of recent years for the control of food store pests. The preparations in this group deserve attention on account of their harmlessness to humans and higher animals with their simultaneously high degree of toxicity to insects. Many authors have examined the suitability and degree of toxicity of these preparations in relation to different insects. There is, however, no elaboration in literature of susceptibility to Pyrethrins depending on the development conditions of the pest population. It has been known for a considerable time that susceptibility to the action of pesticides is variable in character and depends on the development conditions of the insect and also on its age and sex. The aim of the study, the results of which are presented here, was to ascertain the effect exerted by some of the abiotic and biotic conditions of development of *Tribolium castaneum* (Herbst) on its susceptibility to Pybuthrin 6/60.

The following method was used. The beetles were cultured in bakelite boxes, each of which contained 50 g of nutrient medium composed of 95 parts of wheat flour to 5 parts of dried yeast. Thirty individuals of *T. castaneum* were introduced into each of these portions. The boxes were placed in thermostats in which three variants of temperature and relative atmospheric humidity were maintained (variant I: 25°C and 75% relative atmospheric humidity, variant II: 30°C and 75%, variant III: 30°C and 55%). The beetles were kept under these conditions for 5–7 generations. The method introduced by Sandner (1960) was used for these cultures. After 25 days the individuals of the initial generation were removed, and the individuals of the next generation were transferred to new media. The imagines of the final generation (the fifth, or seventh) were exposed to the action of the preparation.

The beetles were treated with water suspensions of Pybuthrin of the following concentrations: 0.002; 0.005; 0.01; 0.02; 0.05. The preparation was transferred on to filter paper placed in a Petri dish 10 cm in diameter, in amounts of 1 ml per dish. 50 beetles varying in age from 1–5 days were introduced into each dish. 5 repeats were made of each experiment. Beetles placed on filter paper with 1 ml of water were used as a control. The beetles remained in contact with the preparation (or water) for 72 hours, after which the dead individuals were counted and removed.

In order to ascertain the effect of the food insects were cultured under optimum temperature and humidity conditions (30°C and 75% humidity) in the following media: wheat flour, ground rice, ground barley, ground rye and crushed

peeled barley. 5 parts of dried yeast to 95 parts of medium were added to all the media. The final generation was treated with the preparation in the same way as in the experiments on the effect of temperature and humidity. The influence of the beetles' sex was investigated by separating the males from females at the pupa stage, and treating the adult forms with the preparation. The influence of age was examined by treating beetles aged 1–5 days, 15 days, 30 days and 40 days with the preparation.

The results of the expe-

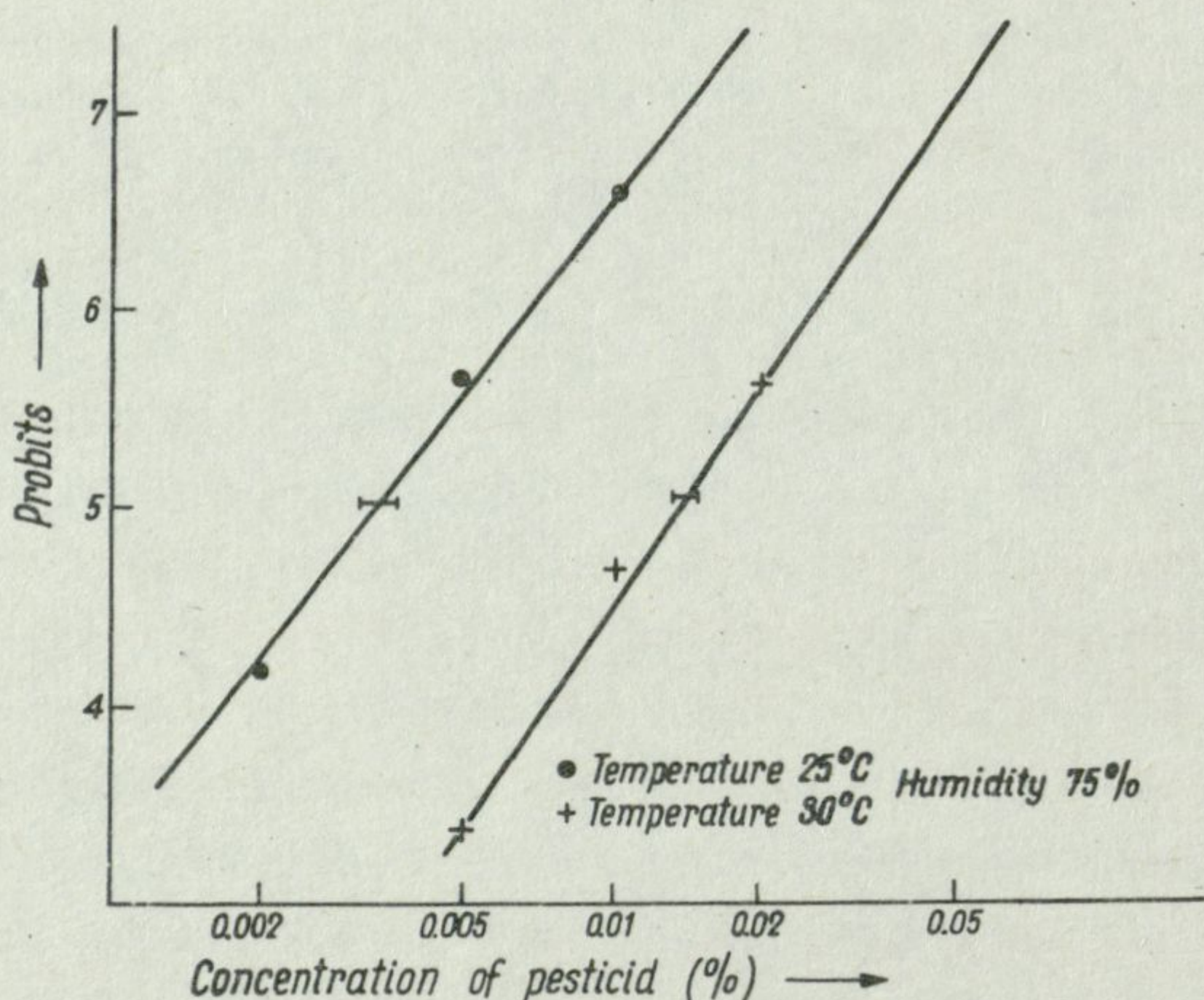


Fig. 1. Influence of temperature on susceptibility of imagines of *T. castaneum* to Pybuthrin 6/60

riments are given in successive diagrams. It will be seen from the graph (Fig. 1), illustrating the effect of temperature with constant humidity, that at a temperature of 30°C (close to optimum temperature) the susceptibility of the beetles is markedly lower than at a temperature of 25°C. LC_{50} at a temperature of 25°C is 0.0035, and at 30°C—0.0140.

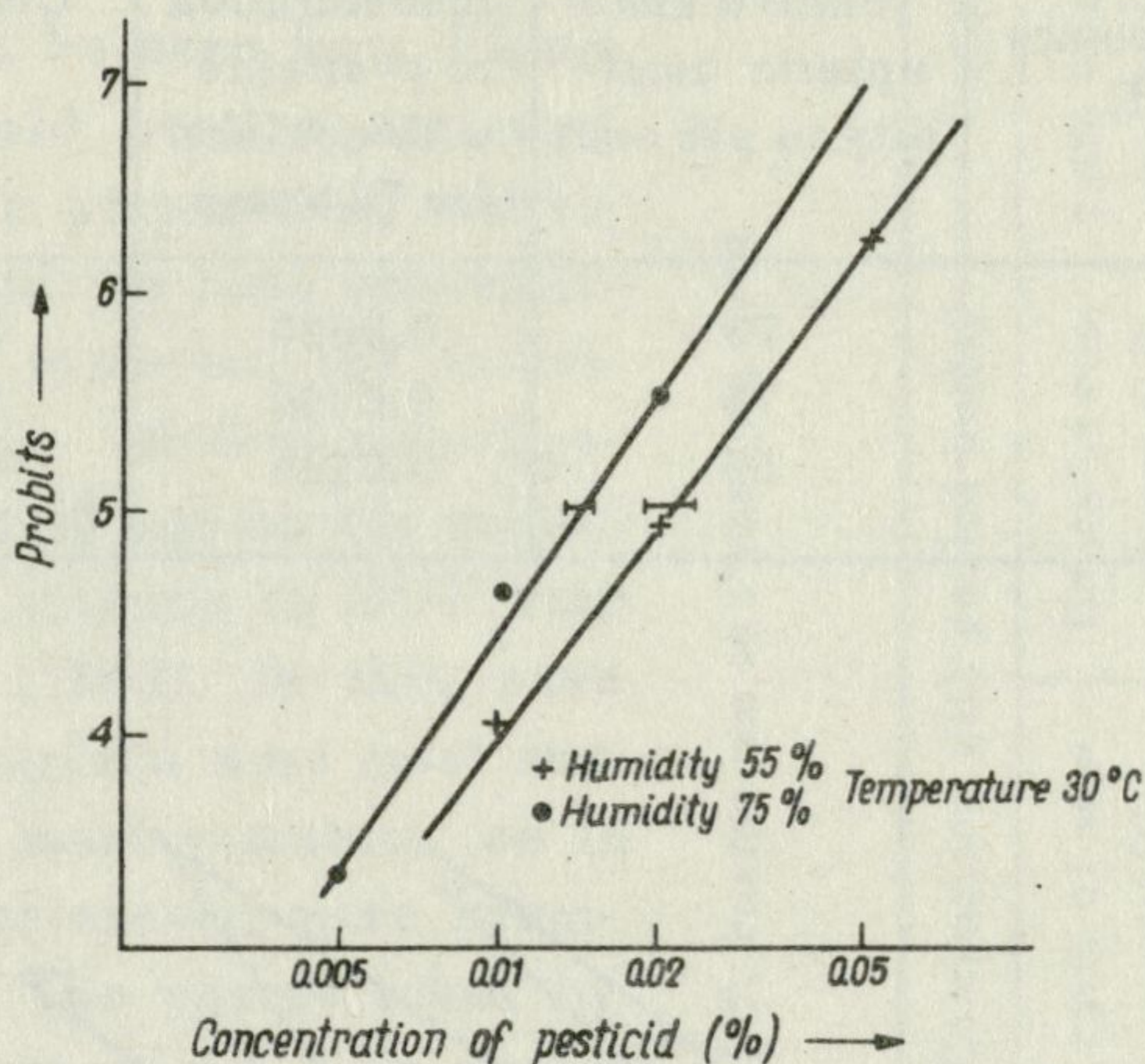


Fig. 2. Influence of humidity on susceptibility of imagines of *T. castaneum* to Pybuthrin 6/60

Figure 2 illustrates the effect of humidity at a constant temperature. With higher relative atmospheric humidity (75%) the susceptibility of the beetles to the preparation examined was greater than at a lower humidity (55%) (Tab. I).

The influence of food is illustrated by the diagram in Figure 3. The method used by Litchfield and Wilcoxon (1949) was chosen from among the different methods of statistical interpretation of results of studies on the susceptibility of insects to pesticides (Bojanowska 1961). The statistical calculations made by this method show that not all the straight lines shown on Figure 3 are comparable. It was found that straight lines illustrating the susceptibility of beetles cultured on peeled barley can be compared (with probability of 0.95) with the straight lines illustrating the susceptibility of beetles cultured on rye, barley and rice. In all comparisons it was found that the differences are significant, and each of the media undoubtedly acts in a different way. It is impossible to compare the susceptibility of beetles cultured on peeled barley with that of beetles cultured on flour, as the straight lines illustrating the susceptibility are not parallel. Analogically comparison was made of the straight line illustrating beetles cultured on rye with the straight lines illustrating insects cultured on barley, rice and flour. It was found that foods such as rice and flour exert a significantly different influence in comparison with rye. It is not, how-

The effect of temperature and relative atmospheric humidity on the susceptibility of imagines of *T. castaneum* to Pybuthrin 6/60

Tab. I

Variant	Conditions		LC ₅₀ per cent of concentration of pesticide with contact for 72 hours	Limits of confidence for $P = 0.05\%$
	temperature in °C	relative atmo- spheric humi- dity in per cent		
I	25	75	0.0035	0.0038–0.0032
II	30	75	0.0140	0.0147–0.0133
III	30	55	0.0210	0.0231–0.0189

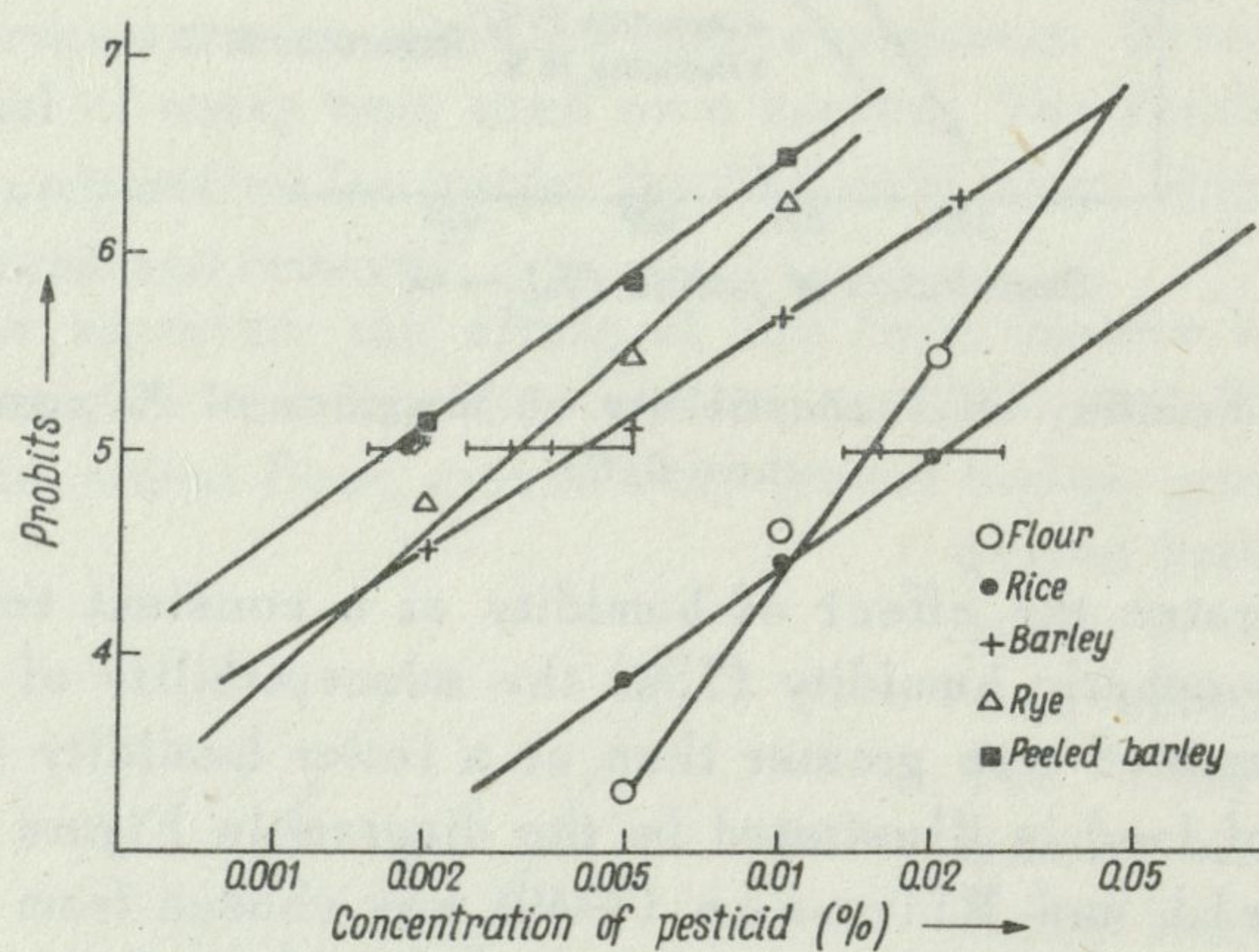


Fig. 3. Influence of food on susceptibility of imagines of *T. castaneum* to Pybuthrin 6/60

ever, possible to compare straight lines illustrating the susceptibility of beetles cultured on rye with the susceptibility of imagines cultured on barley, since these straight lines are not parallel. There are also differences between the susceptibility of insects cultured on barley, and that of insects cultured on rice. LC₅₀ values and comparative data for beetles cultured on different media are given in Table II.

Figure 4 illustrates the effect of sex of *T. castaneum* on susceptibility to the preparation. Females proved to be more susceptible than males. These results are confirmed by the studies made by Loschiavo (1955) and Tielecke (1960), who obtained similar results with *Calandra granaria*. On the other hand Byrdy and Górecki (1961), in their studies on the susceptibility

to DDT of male and female of house flies, obtained opposite results. Females proved to be more resistant than males.

In addition to the above mentioned factors, the age of the individuals of *T. castaneum* also affects their susceptibility. It will be seen from Figure 5 that 30 days old beetles are most susceptible to the preparation, individuals 1-5 days old are less susceptible, but the most resistant are individuals 15 days old. Similar investigations of the effect of age on the resistance of *Calandra granaria* to DDT were made by Goos (1961). In this case the 5 days old imagines were most susceptible, and the most resistant, as in the case of *T. castaneum*, were imagines 15 days old. The course taken by variations in values of LC_{50} is shown in Table III.

The stage of development of the insect in which contact with the preparation takes place is also important. Investigation was made of imagines, pupae and larvae aged 1-5 days and 10 days. The results of this series of experiments are shown in Figure 6. The most susceptible proved to be 1-5 day old larvae, then imagines. Pupae and 10 days old larvae proved to be most resistant.

The results presented above permit of reaching the following conclusions:

1. The susceptibility of imagines of *T. castaneum* is lower at a temperature of 30°C than at 25°C.

2. Imagines cultured at a relative atmospheric humidity of 75% exhibited greater susceptibility than beetles cultured at a humidity of 55%.

Influence of food on the susceptibility of *T. castaneum* to Pybuthrin 6/60

Tab. II

Kind of food	Slope of straight line of regression S	LC_{50} per cent of concentration of pesticide with contact for 72 hours	Limits of confidence LC_{50} for $P = 0.05\%$	Comparison with peeled barley		Comparison with rye	
				ratio of susceptibility PR	limits of confidence PR for $P = 0.05\%$	ratio of susceptibility PR	limits of confidence PR for $P = 0.05\%$
Peeled barley	2.76	0.0017	0.0018-0.0015	-	-	-	-
Rye	2.59	0.0029	0.0035-0.0024	1.70	1.97-1.39	-	-
Barley	4.03	0.0038	0.0050-0.0029	2.12	2.86-1.57	uncomparable straight lines	9.50-4.90
Rice	3.20	0.0200	0.0270-0.0150	11.70	16.00-8.50	6.89	8.30-4.40
Flour	1.80	0.0140	0.0147-0.0133	uncomparable straight lines	uncomparable straight lines	4.82	8.30-4.40

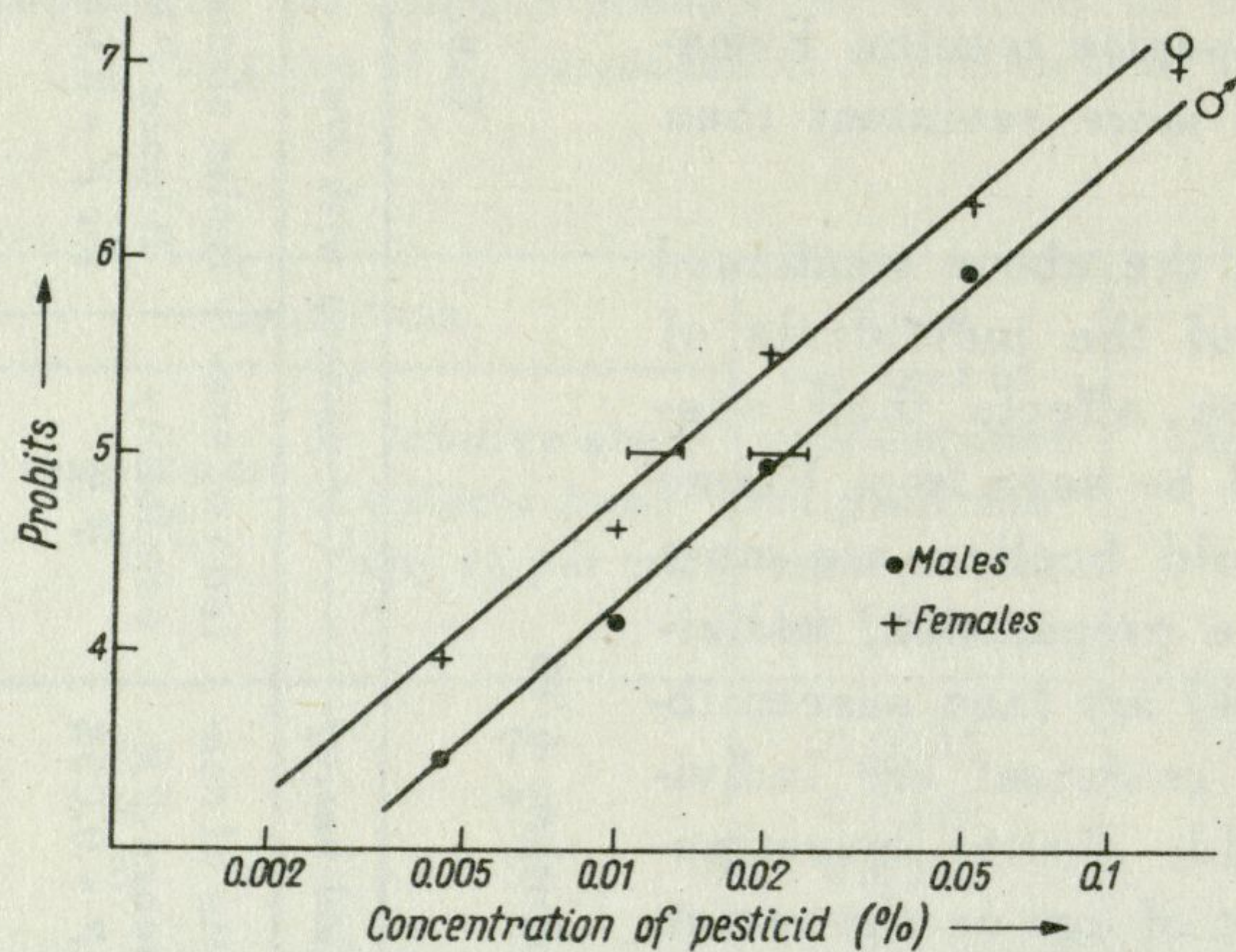


Fig. 4. Mortality $\varphi\delta$ of *T. castaneum* of 8th generation treated with Pybuthrin 6/60

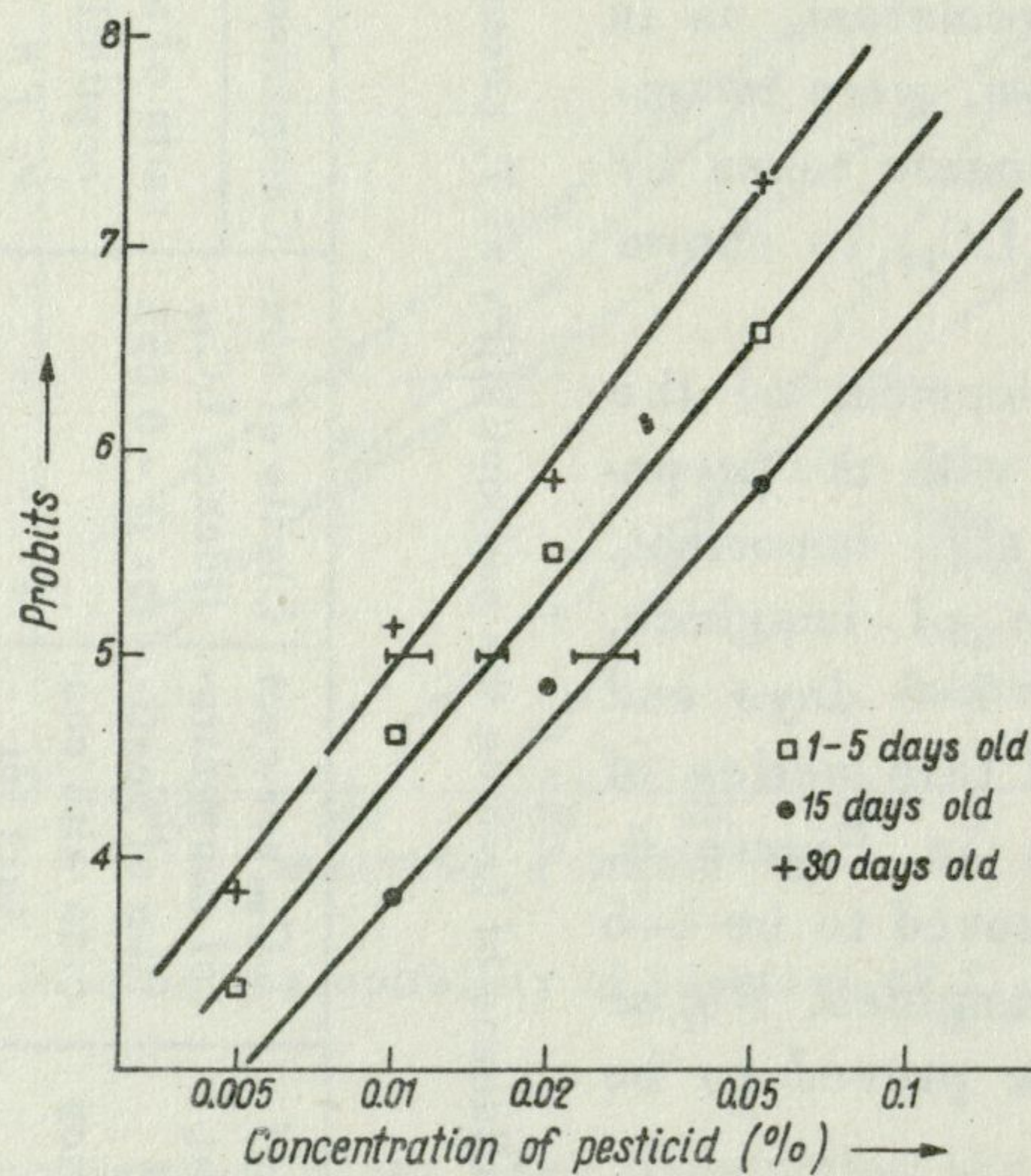


Fig. 5. Influence of the age of imagines of *T. castaneum* on their susceptibility to Pybuthrin 6/60

3. The kind of food influences the formation of the beetles' susceptibility. The most susceptible proved to be beetles cultured on peeled barley, and the most resistant beetles cultured on rice.

4. Susceptibility differs depending on age, sex and stage of development of the individual examined. Beetles 15 days old and pupae were the least susceptible, and beetles 30 days old and larvae at the age of 1-5 days were most susceptible.

Course of variations in LC_{50} of different stages of development of *T. castaneum* to Pybuthrin 6/60

Tab. III

Stage of development	LC_{50} per cent concentration of pesticide with contact for 72 hours	Limits of confidence for $P = 0.05\%$
larvae 1-5 days old	0.0063	0.0073-0.0054
larvae 10 days old	0.0500	0.0580-0.0431
pupae	0.0900	0.1026-0.0789
imagines 1-5 days old	0.0150	0.0165-0.0146
imagines 15 days old	0.0260	0.0299-0.0226
imagines 30 days old	0.0110	0.0120-0.0100
imagines 40 days old	0.0112	0.0152-0.0110

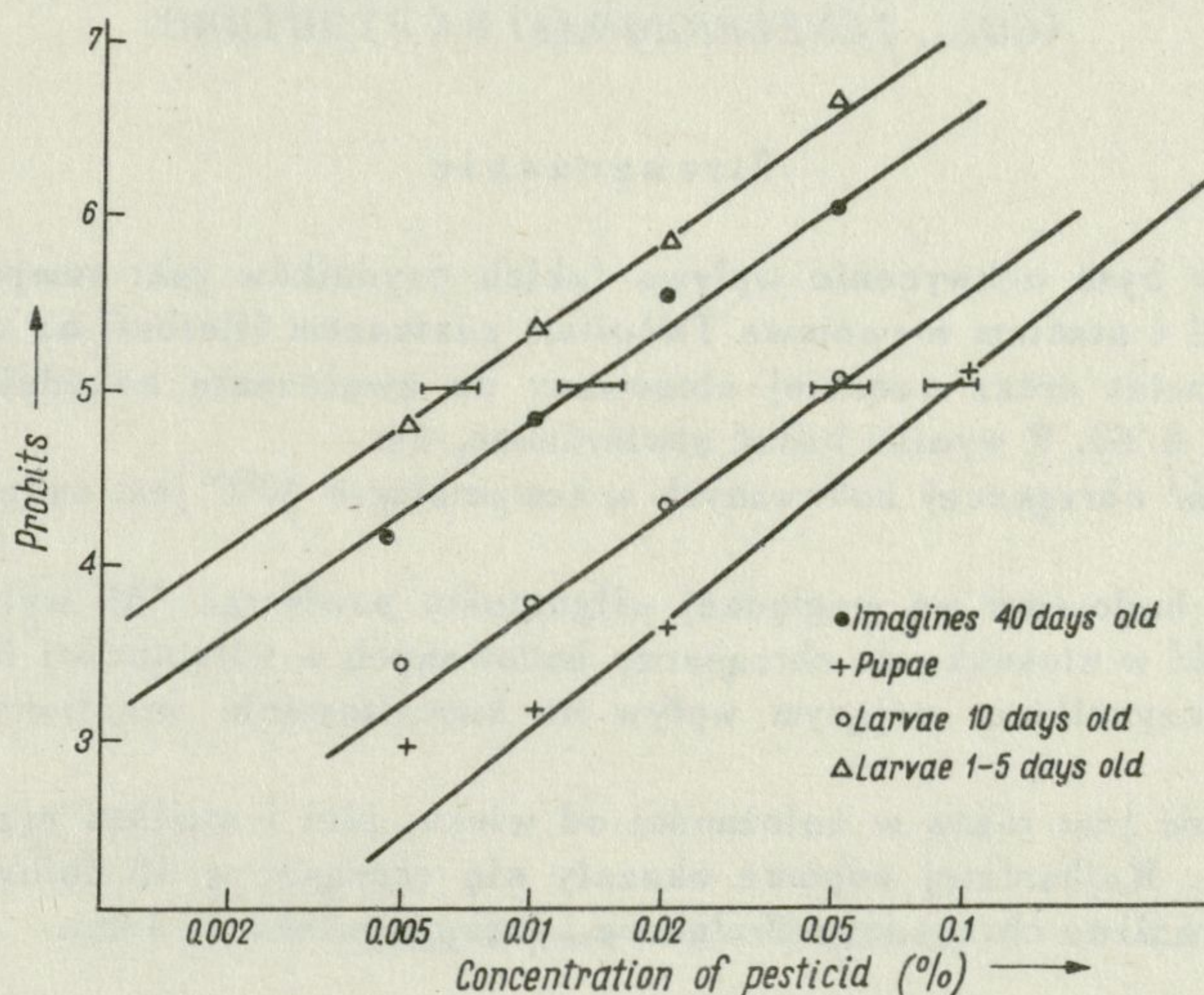


Fig. 6. Susceptibility of development stages of *T. castaneum* to Pybuthrin 6/60

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WPLYW NIEKTÓRYCH CZYNNIKÓW EKOLOGICZNYCH
NA WRAŻLIWOŚĆ *TRIBOLIUM CASTANEUM* (HERBST)
(COL., TENEBRIONIDAE) NA PYBUTHRIN

Streszczenie

Celem pracy było uchwycenie wpływu takich czynników jak: temperatura, wilgotność, wiek, płeć i stadium rozwojowe *Tribolium castaneum* (Herbst) na wrażliwość tego gatunku na preparat coraz częściej stosowany do zwalczania szkodników magazynowych, Pybuthrin 6/60. W wyniku badań stwierdzono, że:

1. Wrażliwość chrząszczy hodowanych w temperaturze 30°C jest mniejsza niż w temperaturze 25°C.
2. Imagines hodowane we względnej wilgotności powietrza 75% wykazywały zwiększoną wrażliwość w stosunku do chrząszczy hodowanych w wilgotności 55%.
3. Ważnym czynnikiem mającym wpływ na kształtowanie wrażliwości jest rodzaj pokarmu.
4. Wrażliwość jest różna w zależności od wieku, płci i stadium rozwojowego badanych osobników. Najbardziej odporne okazały się chrząszcze 15 dniowe i poczwarki, a najbardziej wrażliwe chrząszcze 30 dniowe i larwy w wieku 1–5 dni.

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