EFFECT OF TRICALCIUM PHOSPHATE ON *TYROPHAGUS PUTRESCENTIAE* (Schr.) (Acari: Acaridae)

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Many insect pests of stored food products are known to be sensitive to tricalcium phosphate contained in their diet. *Sitophilus oryzae* L., *Stegobium paniceum* (L.) and *Trogoderma granarium* Ev. reared on food supplemented with 3% $Ca_3(PO_4)_2$ produced adults, but the second generation was less numerous and produced smaller larvae and adults which weighed less than untreated insects. Inhibition of the development of *Tribolium castaneum* Herst., *Sitophilus oryzae* L., *Cadra cautella* W., *Callosobruchus chinensis* (L.), *Laemophloeus minutus* (Ol.), and *Oryzaephilus surinamensis* (L.) was observed when they were fed on foods with 2-3% $Ca_3(PO_4)_2$ (Majumder 1974, Highland 1975, Lawson 1972, Press et al. 1972). In some species an increase in mortality was noted and in others the reproduction potential was reduced with a decrease in numbers of F_1 offspring. Increased numbers of moultings and deformations of external and internal organs of treated insects were often also observed (Majumder 1974).

Shaver (1974) found that tricalcium phosphate caused an irreversible dehydration of the insects' body. He found rapid mortality of all active stages of various insect species that were in contact with the compound.

Until now the effects of this salt have not been studied on stored product mites.

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MATERIALS AND METHODS: The fecundity and longevity of mites were determined for 25 pairs. Young, virgin mites were paired and placed separately in rearing cages with ground wheat germ. The reaction coefficient Wr upon fecundity was calculated with the formula:

$$Wr = \frac{Np \cdot 100}{Nk}$$

where Np = average number of eggs in the test and Nk = the average number of eggs in the check. The longevity of virgin females and males was determined in each case for 100 adults kept in 40 cages (5 virgin females or males in one cage) with ground wheat germ mixed thoroughly in agate mortar with various concentrations of the salt. The time of development of one generation and mortality during development were compared starting with 50 eggs in each cage (5 cages each with 10 eggs).

The contact action of $Ca_3(PO_4)_2$ was tested on 25 mites of consecutive stages kept in cages with a 0.5 -1.0 mm layer of

the salt on wheat germ. LT_{50} and LT_{95} were defined. Cultures were usually kept at 85% r.h. and 25°C.

RESULTS AND DISCUSSION: The effect of $Ca_3(PO_4)_2$ mixed with food upon fecundity, longevity and time of development is presented in Table I. It was found that the addition of the salt affected the fecundity but at a 6% concentration was lower than the check only by 23.2%. The inhibitory effect increased both in P and F_1 generations with the duration of feeding of females with salt-containing diets. Generation time was then extended by 2.2 - 3.9 days with very low mortality during development. Mites of the F_1 generation, usually more sensitive to the addition of salts to their diet, also reacted only slightly to the addition of $Ca_3(PO_4)_2$. The effect of higher concentrations of tricalcium phosphate on fecundity and on egg viability and mortality during development, is shown in Figure 1. A 50% reduction in fecundity compared with the check was found at 18.0 - 21.0% concentrations. When salt was applied in higher concentrations, it affected the adult mite longevity. At a 1.5% concentration, egg laying females lived 15.8 days longer while at 6% concentration the longevity was decreased by 22.2 days when compared to check. Males on diets with a concentration greater than 1.5% also lived for shorter periods of time.

This salt also affected the longevity of virgin mites. At all concentrations, the longevity of males was shorter and females longer than the checks. Males of the F_1 generation lived 16.3 - 40.7 days longer than those in the check, while the females' longevity compared favourably with females living on untreated wheat germ.

Only at 30.0 to 31.5% concentrations was lower egg viability observed. At concentrations of 18.0 to 21.5%, the fecundity was 50% lower and at 31.5% concentration, it was 83.9% lower than the check (Figure 1).

Even at very high concentrations 9.0 to 31.5%, this salt did not appreciably affect mite mortality during development (i.e. 14.0%).

The contact action of tricalcium phosphate on various stages of *T. putrescentiae* is presented in Table II and Figure 2. Within 10-15 minutes after the mites were placed into the rearing cages with the salt, they were excited and tried to escape from the cage. They did not feed at all. After 0.5 to 1.0 hours of contact with the compound, the bodies of the mites were covered with particles of the salt and many mites were already dead. Dead mites had stretched bodies and legs. The inert stages--eggs, larvae and nymphs--were resistant to the salt, and progressed to the next developmental stages. As shown in the data, the younger developmental stages--larvae and protonymphs--were more sensitive to the contact action of the salt. Females were the most resistant.

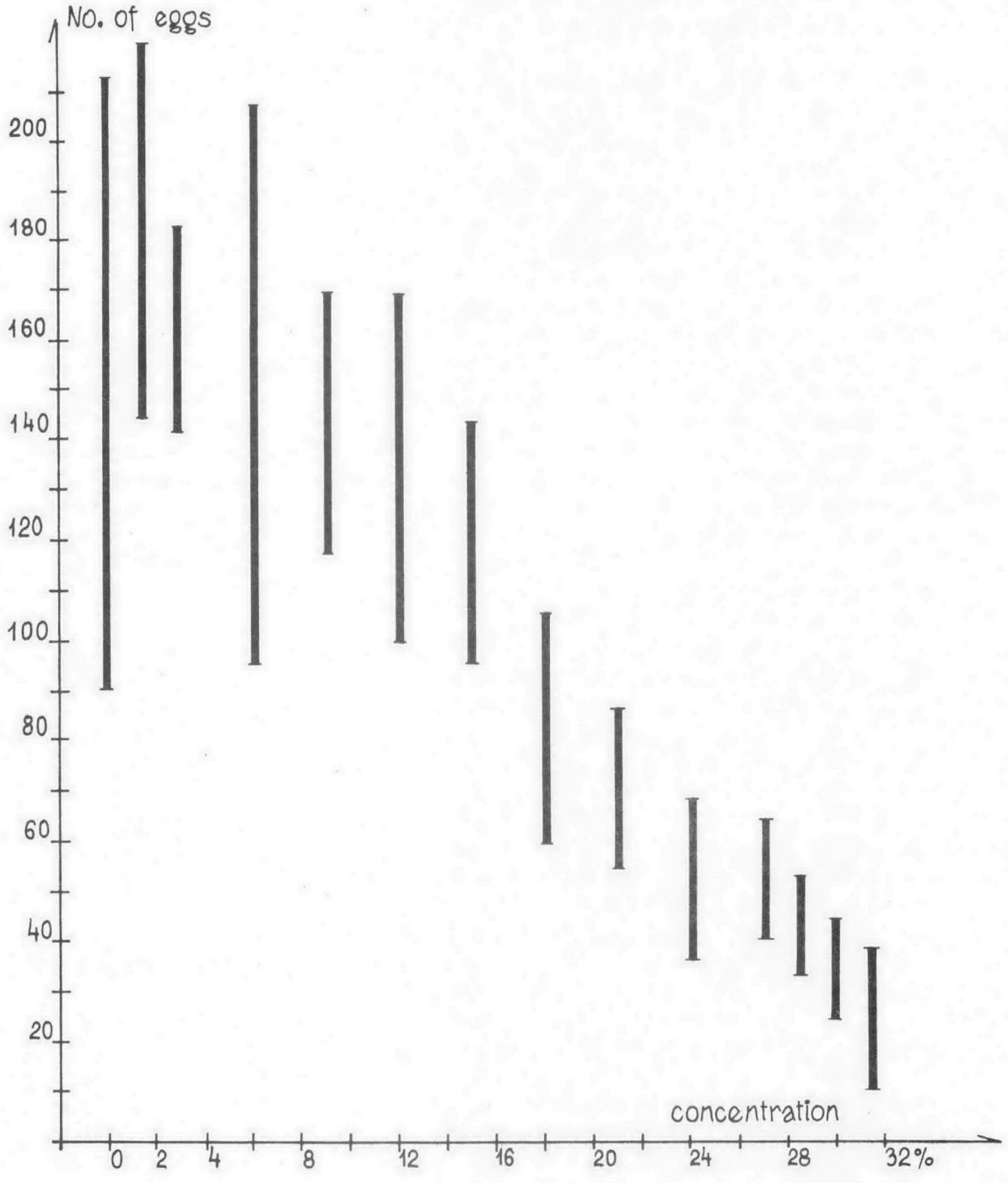

Figure 1. Effect of $Ca_3(PO_4)_2$ at doses 1.5 - 31.5% on fecundity of *T. putrescentiae* (from-to, averages)

TABLE II. Effect of tricalcium phosphate on consecutive stages of *Tyrophagus putrescentiae* and *Acarus siro*/contact action/hours

Species and stage	LT_{50}	LT_{95}
T. putrescentiae		
Larva	0.75	1.00
Protonymph	0.95	2.05
Tritonymph	1.15	3.70
Male	1.15	3.40
Female	1.25	4.00
A. siro		
Larva	0.75	2.10
Protonymph	0.80	1.70
Tritonymph	1.10	2.25
Male	1.20	3.25
Female	1.20	3.75

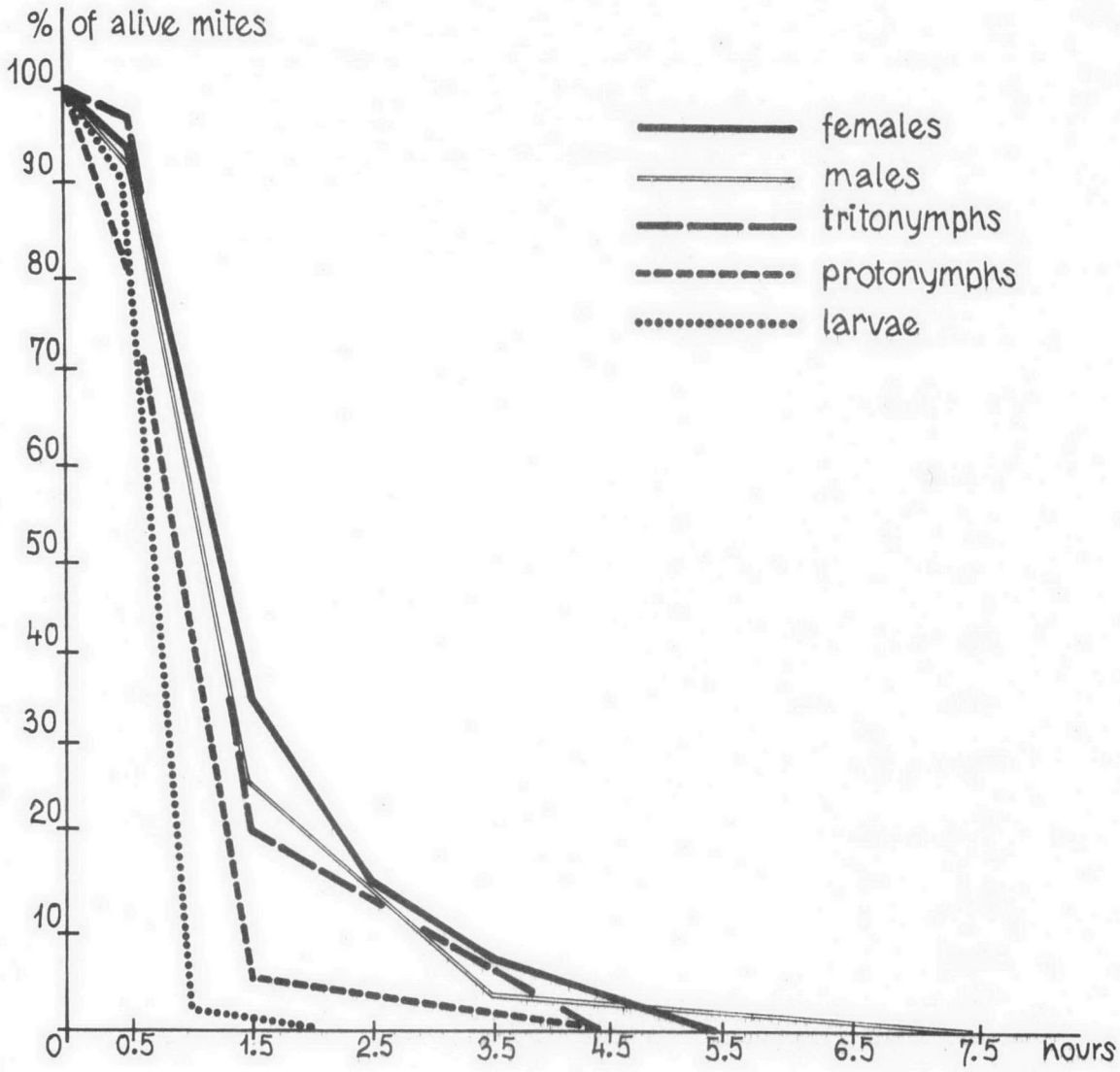

Figure 2. Contact action of $Ca_3(PO_4)_2$:
mortality of various stages of *T. putrescentiae*

TABLE I. Effect of tricalcium phosphate upon the fecundity, longevity, and time of development of *Tyrophagus putrescentiae*/Schr./

Characters studied	Check	Salt concentration (%) in diet		
		1.5	3.0	6.0
Fecundity, no. of eggs				
Wr (P generation)	472.4± 68.4	431.6± 54.6	383.4± 88.8	362.9± 85.1
		-5.6	-18.8	-23.2
Longevity of reproducing females (days)	56.5± 27.1	72.3± 35.4	52.0± 21.1	34.3± 7.8
Longevity of reproducing males (days)	85.5± 34.6	113.2± 30.3	94.0± 37.3	75.1± 19.6
Longevity of virgin females (days)	152.0± 43.4	160.9± 56.2	136.4± 53.2	166.7± 45.5
Longevity of virgin males (days)	122.0± 31.7	113.6± 20.1	102.4± 22.9	99.3± 39.6
Time of development of generation (days)	14.1	13.5	17.9	16.2
Mortality during development	5.2	4.7	5.1	4.9
Fecundity of F_1 generation	430.5± 29.7	377.2±106.7	365.5± 93.3	405.8±151.7
Wr (F_1 generation)		-20.2	-22.6	-14.1
Longevity of F_1 females		58.8± 19.5	52.0± 15.0	53.8± 19.6
Longevity of F_1 males		101.8± 35.0	125.0± 18.7	126.2± 32.0

However, the differences between consecutive developmental stages were not very great. The LT_{50} ranged from 0.75 to 1.25 hours and the LT_{95} from 1.0 hour for larvae to 4.0 hours for females. Screening tests made for 7 other species of related acarid mites (Table III) showed that *T. putrescentiae* was the most resistant. The LT_{50} and LT_{95} were usually lower for females and males of other species of mites. No significant differences were found in the sensitivity of adult mites as related to age and temperature (10-28°C).

CONCLUSIONS: In contrast to insects, the effect of tricalcium phosphate added to the diet of copra mites in concentrations of 1.0-6.0% was only slight in both P and F_1 generations. The fecundity, longevity, and mortality of the mites were only slightly, if at all, affected. Reduction of the fecundity by one-half was reached at a salt concentration as high as 18.0% in the diet. Mortality during development and egg viability were practically not affected until the concentration of the salt reached 31.5%.

Tricalcium phosphate showed very strong contact action on *T. putrescentiae* causing 100% mortality of all active stages of the mites after 3-5 hours. Inert stages were resistant. Its action was of a physical nature, causing scratching and wax absorbtion of cuticle.

Related species of acarid mites living in stored food products were still more sensitive to the contact action of the salt than *T. putrescentiae*.

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TABLE III. Contact action of tricalcium phosphate on females and males of acarid mites/hours/

Species	Females		Males	
	LT_{50}	LT_{95}	LT_{50}	LT_{95}
T. putrescentiae	1.25	4.00	1.15	3.40
T. casei	0.80	1.40	0.75	1.10
T. similis	1.10	1.80	0.75	1.30
T. palmarum	0.75	2.60	0.75	2.10
T. longior	0.55	3.75	0.65	5.10
T. neiswanderi	0.95	1.45	0.75	1.45
A. siro	0.80	1.70	0.75	2.10
T. entomophagus	0.75	1.60	0.70	1.20