(The former case corresponds to $z=1$.) This log activity is plotted as a function of t for $z=0{\cdot}805$ and $x=0{\cdot}18$ (Fig. 2, curve B).

Curve B corresponds at high values of t to the experimental points. A better fit at low values of t can be obtained by assuming that, after modification of one active site in the oligomer, the GTP response of the remaining sites is intermediate between that of the unmodified and the more fully modified. Let the fraction y $(z>y>x)$ be the activity of the monomodified oligomer in the presence of GTP, then the activity is

$$\text{Activity}_{\text{GTP}} = 6E_0\,[e^{-6kt}(x-5y+4z)+e^{-5kt}(5y-5z)+ze^{-kt}]\theta$$

Log activity is plotted for $k=1{\cdot}31\times10^{-2}$ min^{-1}, $x=0{\cdot}18$, $z=0{\cdot}805$ and $y=0{\cdot}4$ (curve D, Fig. 2) and $y=0{\cdot}5$ (curve C, Fig. 2). The line E in Fig. 2 is the activity in the presence of GTP if the GTP response is unchanged on modification ($x=0{\cdot}18$, $y=0{\cdot}18$, $z=0{\cdot}18$).

Curves C and D are reasonably good fits to the experimental points. At other GTP concentrations, where x has different values, the curves have similar features.

In conclusion, each subunit in the unmodified enzyme is equally inhibited by GTP. Substitution in one subunit by ISA decreases the inhibition produced by GTP in the remaining subunits in the oligomer. Substitution in two or more subunits by ISA further decreases the GTP inhibition of the remaining subunits. This falls within the general sequential model for allosteric systems proposed by Koshland[8,9], and is consistent with our earlier kinetic studies on the biphasic nature of the allosteric changes in GDH[10].

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Use of a Juvenile Hormone Analogue as Insecticide for Pests of Stored Grain

INFESTATION by insect pests of stored grains is one of the principal causes of food losses in developing countries[1]. Fumigation and treatment with conventional organic insecticides are handicapped by the problems of residual toxicity and the development of resistant strains of insects. Williams[2,3] has pointed out that juvenile hormone or its chemical analogues could be used as insecticides free from such disadvantages. We have explored the possibility of using a chemical analogue of juvenile hormone—methyl 3,7,11 - trimethyl - 7,11 - dichloro - 2 - dodecenoate[4] (MTDD)—in controlling the multiplication of stored grain pests and the preliminary results are reported in this communication.

MTDD was synthesized and purified according to the method of Romanuk *et al.*[4]. *Tribolium castaneum* (Herbst), *Stegobium paniceum* (L), *Bruchus chinensis* L—pests of wheat flour, spices and pulses respectively—were used as the test insects. Known amounts of MTDD were dissolved in ether and mixed thoroughly with the foodstuffs. The food commodities in the control experiments were also treated with an equivalent amount of ether. For testing the effect on *T. castaneum*, twenty adults—ten males and ten females—of known age were liberated on wheat flour containing various amounts of MTDD maintained at 70 per cent relative humidity and 30° C. At least three replicates were carried out for each experiment. Observations were made once a week for egg laying and the course of larval development was followed for a period of 90 days.

The results (Table 1) indicate that at all the concentrations of MTDD tested, viable eggs were produced and the percentage of first instar larvae reaching fifth instar was a function of the concentration of the chemical. Similar results were obtained when third instar larvae were liberated into the treated media. When the experiments were repeated with fifth instar larvae, however, a large number of them pupated and became adults, indicating that there is a critical stage—probably the late fourth instar or the early fifth instar—beyond which MTDD is not effective. The most salient feature of the experiments is the observation that none of the first instar or third instar larvae could either pupate or become adult even at the lowest concentration of the chemical tested.

Table 1. EFFECT OF METHYL 3,7,11-TRIMETHYL-7,11-DICHLORO-2-DODECENOATE ON *Tribolium castaneum* (HERBST)

Stages of development	Percentage development on p.p.m. of MTDD in wheat flour 100	250	500	1,000	Control ‡
First to fifth instar*	50·0 ± 2·0	26·6 ± 3·7	27·5 ± 1·9	7·1 ± 2·3	79·7 ± 4·7
Third to fifth instar†	45·6 ± 3·4	30·6 ± 2·7	23·0 ± 2·2	10·0 ± 1·0	86·1 ± 2·9
Fifth instar larva to adults ‡	51·5 ± 1·6	39·2 ± 1·0	28·1 ± 1·4	21·0 ± 2·1	82·0 ± 3·1

* Adult insects were allowed to lay eggs on wheat flour treated with MTDD and percentage development is based on number of first instar larvae formed from eggs.
† Third and fifth instar larvae were selected from standard culture.
‡ No adults were formed in any of the experiments using first or third instar larvae. In the control 82·9 per cent become adult.

Other economically important pests were tested with only two concentrations of MTDD. *Stegobium paniceum* grown on *Cuminum cyminum* showed an average increase of 23 per cent of adult population at 500 p.p.m. and 19 per cent at 1,000 p.p.m. of MTDD, whereas in the control the increase in adult population was 260 per cent. *Bruchus chinensis* grown on *Cicer arietinum* treated with 500 p.p.m. of MTDD laid viable eggs, but the larvae were not able to complete their development. In the control, a 488 per cent increase in the adult population was noticed. These results indicate that MTDD may be successfully used in preventing development of a second generation of insect pests of stored grains. The concentration of the chemical required seems to vary with the nature of the stored food and/or the type of insect.

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