SOME ASPECTS ON THE BIOLOGY

OF

DEROCERAS PANORMITANUM and DEROCERAS RETICULATUM

WITH

SPECIAL EMPHASIS ON EFFECTS CAUSED

BY

SOME COMMON AGRICULTURAL CHEMICALS

A Thesis presented in partial fulfilment of the requirements for the degree of Masterate of Science in Zoology at

MASSEY UNIVERSITY

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Year........1980..................

PLATE I DEROCERAS RETICULATUM (MULLER,1774.)

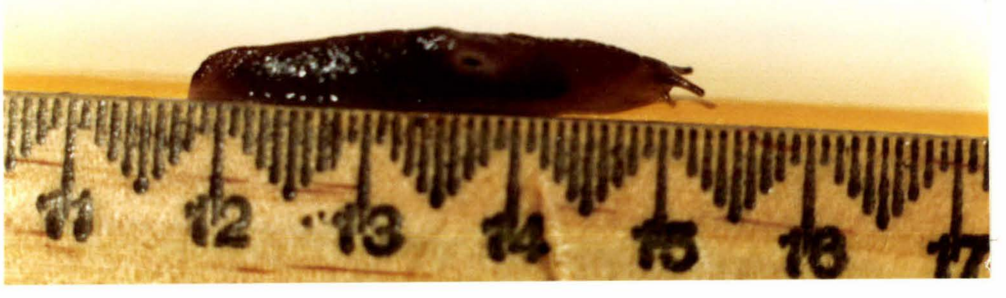

PLATE II DEROCERAS PANORMITANUM (LESSONA & POLLONERA,1882.)

- ABSTRACT -

Two species of slugs Deroceras panormitanum (Lessona & Pollonera, 1882), and Deroceras reticulatum (Muller, 1774), were chosen as a subject for investigation. In part 'A' the fecundity and longevity of D. panormitanum was observed at four different locations, three at constant temperatures, and the fourth in Shade-house, which was the control site. A seasonal effect was evident in Shade-house, more eggs being oviposited in Spring and Autumn than in Winter. No such effect was observed with the constant temperatures.

The number of eggs per cluster was 22.5 in Shade-house, 23.2 at 16 °C, 22.9 at 24 °C, and 18.5 at 5 °C. The average number of clusters oviposited per slug was 1.3 in Shade-house, 1.4 at 16 °C, 1.1 at 24 °C and 0.4 at 5 °C. The average number of eggs laid by each slug in this part of the experiment was 28.7 in Shade-house, 31.8 at 16 °C, 25.2 at 24 °C, and 7.7 at 5 °C. The optimal condition for slugs to oviposit was at 16 °C.

Thirteen D.panormitanum and fifteen D. reticulatum that hatched on the same day were kept in the laboratory till natural death ensued. The average number of eggs per cluster for D. panormitanum was 15.6, and for D. reticulatum 15.4 . The number of clusters per slug was 3.8 for D. panormitanum and 3.5 for D. reticulatum, and the average number of eggs oviposited per slug was 59.8 for D. panormitanum, and 53.4 for D. reticulatum.

The effects of Temperature, Humidity, and Evaporation-rate, was correlated with oviposition rate. An increase in temperature and evaporation-rate showed a positive correlation, with an increase in oviposition rate. Humidity has a negative correlation with oviposition rate.

Significantly more eggs hatched from D. panormitanum 59.9 %, than of D. reticulatum 53.0 %, under laboratory conditions.

The time taken for eggs to hatch is temperature dependent, taking for D. panormitanum an average of 33.7 days for Shade-house, 20.9 days at 16 °C, 16.5 days at 24 °C, and 103.4 days at 5 °C. The average number of eggs hatched for D. panormitanum in Shade-house was 38.3 %, at 16 °C 37.0 %, at 24 °C 32.1 %, and at 5 °C 25.4 %.

In the laboratory D. panormitanum's average life-span was 171 days, and D. reticulatum 151 days. At the four temperatures D. panormitanum survived for an average of 32.7 days in Shade-house, 23.2 days at 16°C, 16.8 days at 24 °C, and at 5°C for 63.1 days.

In part 'B' eightythree biocides were tested against the slug species D. panormitanum and D. reticulatum. These included 16 fungicides, 16 insecticides, 26 herbicides, and 2 molluscicides, at the maximum rates as specified by the manufacturer. Five fungicides, two insecticides, five herbicides, one molluscicide, and seven of the combinations showed high ovicidal activity. Five insecticides, one molluscicide, and ten of the combinations showed high toxicity when ingested, and two insecticides, one molluscicide, and six of the combinations were highly effective when used as a surface spray. Metaldehyde and methiocarb were effective in all three treatments, and phorate was a good bait and contact molluscicide. Dazomet caused a reluctance by slugs to cross the treated area to obtain food, and as a result died of starvation in the refuge area.

The effects of all two possible combinations of three herbicides and three insecticides could not be determined from a knowledge of their individual properties. Each reacted in an undetermined manner according to their combined properties.

ACKNOWLEDGEMENTS.

I would like to thank Professor B.P. Springett for the supervision of this Thesis, and Dr. J.A. Springett for the co-supervision, and valuable advice given during the preparation of the Thesis. Thanks is also due to Ivon Watkins Dow for the supply of industrial grade phorate.

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INTRODUCTION

Aims of study.

Two species of slugs, *Deroceras panormitanum* (Lessona & Pollonerà,1882), and *Deroceras reticulatum* (Muller,1774), were chosen as a subject for research because of a lack of information available for both species as applied to New Zealand conditions. Overseas literature deals primarily with *D.reticulatum* and *Arion* species.

The aims of this study are;

(a) To observe and test if *D.reticulatum* acts similarly in this country.

(b) To determine if *D.panormitanum* acts in a manner similar to *D.reticulatum*.

(c) To observe and record the fecundity of *D.panormitanum* taken from the field, and under laboratory conditions.

(d) To determine if temperature effects cause changes in egg-laying, hatching rate, and survival of slugs.

(e) To test commonly used biocides on the two species of slugs (eggs, juveniles, adults), for molluscicidal properties.

SLUG BIOLOGY

Slugs are known common pests of agriculture and horticulture, and may be found in large numbers in damp places. This makes cover crops such as pastures and potatoes especially vulnerable to attack. High losses, both at the seed and early seedling stage, and later by spoiling ripening fruit and vegetables can be attributed to these pests.

Slugs have been classed as major economic pests during the establishment of cereals in temperate climates (Runham and Hunter, 1970; Newell, 1966; Duthiot, 1961.). They are also garden pests feeding on potatoes, lettuce, carrots, chrysanthemums, brassicas, legumes, and young seedlings.

H.J.Gould (1962) in field experiments found D. reticulatum associated with hollowed grain and shoots which had been severely grazed below the soil surface.Control measures are usually taken after braiding when slug damage to the young seedlings become obvious. Therefore much loss of seed may have already occurred below ground.

Slug populations can increase dramatically at the soil surface with overhead irrigation, and Howitt (1961) found that slugs could destroy a field of Ladino white clover in a single season.

In England damage by slugs is evident in late Autumn and early Spring. D. reticulatum is an important pest on farms, and is well adapted to life at low temperatures (Mallanby, 1961). Reasons why damage occurs at this time is that (1) alternative food sources are scarce, and crop plants such as germinating wheat are sometimes the only food available. (2)Slugs are active at temperatures which would put most poikilothermic animals into a chill-coma. (3) Some slug species are naturally most numerous in winter (Barnes, 1948).

Slugs emerge from a hole or refuge, crawl on the surface, feed, copulate if they find a mate, crawl, feed again, and finally, before daybreak, return to the refuge from which they emerged (Newell, 1966). The time spent on each of these nocturnal activities varies within wide limits. This type of behaviour suggests that the majority of slugs remain in a relatively small area, and that pest-control measures aimed at slugs need only be applied to areas of a garden, or crops, covering their home range (Newell, 1966).

Weather has an influence on slugs, but it is difficult to ascertain which aspect has the most influence. Crawford-Sidebotham (1972) found that the activity of slugs is both a function of temperature and the vapour pressure deficit. Slugs have a permeable cuticle and therefore lose body-water continuously in a dry atmosphere. Activity tends to increase with increasing temperature, and decrease with increasing vapour pressure deficit.

Water relations is the most single important factor affecting the activity, reproduction and survival of slugs (Stephenson, 1968). A large daily water loss is usual for slugs, and they can survive for short periods in dry conditions, and remain active enough to move to a more favourable habitat.

In temperature trials on feeding Hunter (1968) found (a) D. reticulatum has a greater tendency to feed on green vegetation than the underground dwelling Arion hortensis Ferussac, 1819, and Milax budapestensis (Hazay, 1881). (b) Feeding activity of all three species increased as the temperature rose to 20°C, but slowed at 25°C. (c) At a low temperature of 5°C, D. reticulatum was found to be the most active of all the three species.

D. reticulatum has two generations per year in the Northern hemisphere, a Spring generation hatching in May, and an Autumn generation hatching in late September. The latter taking seven months per generation, and the former five months (Hunter, 1968).

The oviposition places for slugs are not selected at random. Soil of approximately 75% moisture was found to be the most suitable for the oviposition of eggs by D. reticulatum (Arias and Crowell, 1963). Carrick (1942) came to a similar conclusion, and stated further that in soils below 10% saturation, or close to 100 % saturation will not allow normal slug development. Some decomposing plant matter in the soil is also essential, as this forms part of young slug's food (Carrick, 1942).

In an experiment on the effect of temperature on egg production, Stephenson (1966) found that the slug Milax budapestensis when kept at fluctuating temperatures of 10 °C to 20 °C laid more eggs than at a constant temperature of 20°C.

Differences in egg production by the slug D. reticulatum was noticed by Hunter (1968) from slugs collected from the field shortly before the breeding season. These slugs laid an average of 24 eggs per individual and died soon afterwards. Slugs kept in cultures from their young stages, laid an average of 32.5 eggs per individual.

The total number of eggs laid differ from species to species, and more eggs are laid in laboratory cultures than in the field (Carrick, 1938). Egg numbers laid by laboratory slugs were ; Limax maximus Linnäeus, 1758, 676-874 eggs per slug; Limax marginata (Muller, 1774), 105-132 eggs per slug; Arion hortensis, 150 to 203 eggs per slug, and for D. reticulatum up to 300 eggs per slug (Stephenson, 1968). Hunter (1968) found eggs of D. reticulatum in soil samples at all times of the year, and numbers fluctuated widely - fewer in Summer, and peaks in Autumn and Spring. Most species of slugs do not lay all their eggs at one time, and Stephenson (1968) found that 2-3 clusters were oviposited containing from 4-400 eggs depending on the species. However the usual variation per cluster is from 10-15 eggs to 40-50 eggs per cluster (Stephenson, 1968).

Temperature affects the time taken for eggs to hatch, and there are also some species differences. Hunter (1968) in temperature experiments on eggs of Arion hortensis found that the time taken for eggs to hatch at 20 $^{\circ}$C was two weeks, at 15 $^{\circ}$C three weeks, at 10 $^{\circ}$C four to five weeks, and at 5 $^{\circ}$C fourteen weeks. The incubation period for D. reticulatum eggs has been reported to range from 15-65 days (Taylor, et. al., 1907). Arias and Crowell (1963) found that at 20 $^{\circ}$C the period of incubation for D. reticulatum eggs was between 11 to 21 days with a mean of 15.5 days, and at 5 $^{\circ}$C eggs took 105 days to hatch.

Most workers have to depend on field collected slugs for their test animals, which are usually abundant only in the Spring and Autumn (Arias and Crowell, 1963). In slug cultures, many of the slugs brought in from the field die as a result of diseases contracted while in the field. At least fortysix species of invertebrates are known to be associated with twentyfive species and subspecies of slugs (Stephenson and Knutson, 1966). Ten species of invertebrates are known to kill 14 species of slugs, and the frequency with which infested and damaged slugs are found in nature, suggests that biological control may be possible. The protozoans, brachylaemid flatworms, lungworms, lampyrid beetles, and some sciomyzid larvae seem to be the most important natural slug enemies (Stephenson, 1968). Carabids are known to prey on slugs, and when Judge and Kuhr (1972) caged two of these animals with seven to fourteen-day old D. reticulatum in the laboratory, one hundred slugs were consumed in three days.

CHEMICAL COTROL OF SLUGS

Early attempts to kill slugs included nocturnal dressings of fields with copper-sulphate (Anderson and Taylor, 1926), and the use of paris-green and bran baits (Miles et.al.,1931). Meta (metaldehyde) was first mentioned as a slug bait by Haddon (1936), who recommended its use mixed with bran. Further references followed quickly in scientific and horticultural literature. Metaldehyde in bran baits (Gimingham and Newton, 1937), gave a better kill and remained the standard treatment for many years. Metaldehyde is most effective when dry conditions follow its application, because many slugs who ingest a sublethal dose are killed by dehydration.

To be effective baits must be attractive and toxic, and must be able to withstand variable climatic conditions. They must also be adaptable to convential methods of application, and be economical. To reach their site(s) of action, molluscicides must be inhaled, ingested, or absorbed over the body surface (Judge and Kuhr, 1972). A constant flow of slime which is a characteristic of slugs, poses a special problem as it is possible that lipid-soluble insecticides will not readily pass through this water-based barrier (Judge and Kuhr,1972). Systemic insecticides are water-soluble and would therefore be more likely to penetrate the slime. Webley (1962) found that different species of slugs react in varying ways to certain molluscicides.

Trials with various molluscicides have been carried out before and since the discovery of metaldehyde. Some chemicals are claimed to have better molluscicidal properties, and others claim better toxicity when additives are combined with metaldehyde. The following is an incomplete list of Authors and their findings.

Gould (1962) experimented with six chemical sprays, two chemical powders, and two slug baits, on a wheat plot. None of the chemicals gave better results than the standard metaldehyde bran baits. Metaldehyde and D.N.O.C. gave some promise as a spray, and copper-sulphate as a powder. The other chemicals tested were; (1) as sprays, pentachlorophenol, sodium arsenate, and copper-sulphate. (2) as a powder, calcium cyanamide, and as a bait, paris-green with bran.

A.J. Howitt, (1961) in his experiments on slugs found metaldehyde applied at a rate of 1-2 lb a.i./acre, as a suspension into the irrigation system was sufficient to reduce the slug population, and increase Ladino white clover production.

B.D. Barry (1969) found that phorate (E.C.) at a rate of 1-1.5 lb a.i./acre, was the only economical chemical tested that produced appreciable reductions in slug populations. Metaldehyde meal applied at a rate of 2 lb a.i./acre was also effective in reducing slug populations, but he found this rate to be non-economic.

I.F. Henderson (1969) administered biocides to slugs by forced ingestion. This method did not measure the attraction or repellent effects of the materials tested on the slug D. reticulatum. The median lethal doses for the three biocides were;

(1) Sodium pentachlorphenate	22.9 ± 2.5 ug / slug	= most toxic.
(2) Metaldehyde	85.2 ± 4.0 ug / slug	
(3) Copper-sulphate	129.0 ± 5.9 ug / slug	

Judge and Kuhr (1972) tested 29 chemicals for molluscicidal properties. Of these eight showed some potential. Two were the molluscicides metaldehyde and carbaryl, and the other six were the insecticides; phorate, zinophos, methomyl, aldecarb, du-Pont 1410, and du-Pont 1764. Metaldehyde was found to be the most toxic. The carbamates and phosphates were also highly toxic, and their mode of action on animals is by inhibiting cholinesterase, which causes a disruption of nervous activity, and eventual death (O'Brien, 1967). Presumably their action is similar on slugs.

Musick (1972) applied phorate at a rate of 1 lb a.i./ acre as a broadcast spray to the soil surface against the slug D. reticulatum. With one application there was a significant reduction in the slug population, but with a properly timed second application maximum population reduction was achieved.

Symonds (1975) stated that metaldehyde was a more effective treatment against slugs than methiocarb when field conditions were favourable to its action. Methiocarb however gave more consistant results under a wide range of field conditions.

Charlton (1978) showed that legume seed coated with methiocarb had a higher survival rate at six weeks after sowing than untreated seeds, in box experiments. A field trial showed little benefit from commercial seed coating, with and without methiocarb.

H.H. Crowell (1977) tested the effects of seventy chemicals on slugs. As a result of these tests a series of dinitro-alkyl-phenols were shown to be as toxic by contact as metaldehyde against D. reticulatum. Also several of the dinitro-phenol compounds were found to be ovicidal at low concentrations.

Godan (1966) found some differences in susceptibility to molluscicides between juveniles and mature slugs. He also found species differences to molluscicides, some showing higher mortality and others a lower mortality.

SLUGS IN NEW ZEALAND

In New Zealand the four most widely distributed pest species of slugs are; Arion hortensis, D.panormitanum, D.reticulatum, and Milax gagates (Draparnaud,1801), (Barker,1978).

In this study the two most common species found in pastures and orchard were D.panormitanum and D.reticulatum, and these were used in this investigation (Appendix I). These slugs were plentiful for most of the year, but showed a decline in numbers when the weather became warm and dry.

MATERIALS and METHODS

Experimental Conditions

Biological studies were carried out on slugs using three temperature controlled cabinets (at constant temperatures of 24°C, 16°C, and 5°C), a Shade-house, and in the laboratory (Plates III — VII).

The temperature fluctuated less in the laboratory than in Shade-house. Two thermohydrographs were calibrated together at ambient temperature and percent relative humidity. The average temperature difference between the laboratory and Shade-house was 1.5°C for the maximum temperature, and 2.5°C for the minimum temperature. The maximum temperature in the laboratory being lower than Shade-house, and the minimum temperature being higher in the laboratory (Table 1).

The difference in percent relative humidity (% R.H.) was 9 % for the maximum % R.H. , and 3% for the minimum % R.H. The % R.H. being lower in the laboratory than in Shade-house. Fig 1 shows the average temperature and % R.H. (at the time of egg collection) vs season.

The fluctuations with temperature and % R.H. in the constant temperature cabinates were;

At 24°C temperature fluctuations were between 23.5 - 24.5 °C .
" " % R.H. fluctuated between 68 - 70 %.

At 16°C temperature fluctuations were between 15.0 - 17.0 °C.
" " % R.H. fluctuated between 40 - 80 %.

At 5°C temperature fluctuations were between 3.5 - 6.5 °C.
" " % R.H. fluctuated between 58 - 74 %.

PLATE III 24°C CONSTANT TEMPERATURE CABINET

PLATE IV 16°C CONSTANT TEMPERATURE CABINET

PLATE V $5^{\circ}C$ CONSTANT TEMPERATURE CABINET

PLATE VI SHADE-HOUSE (CONTROL)

PLATE VII LABORATORY WORK AREA

PLATE VIII CLUSTERS OF EGGS OVIPOSITED IN SOIL BETWEEN TUB-SOIL INTERFACE

Table 1

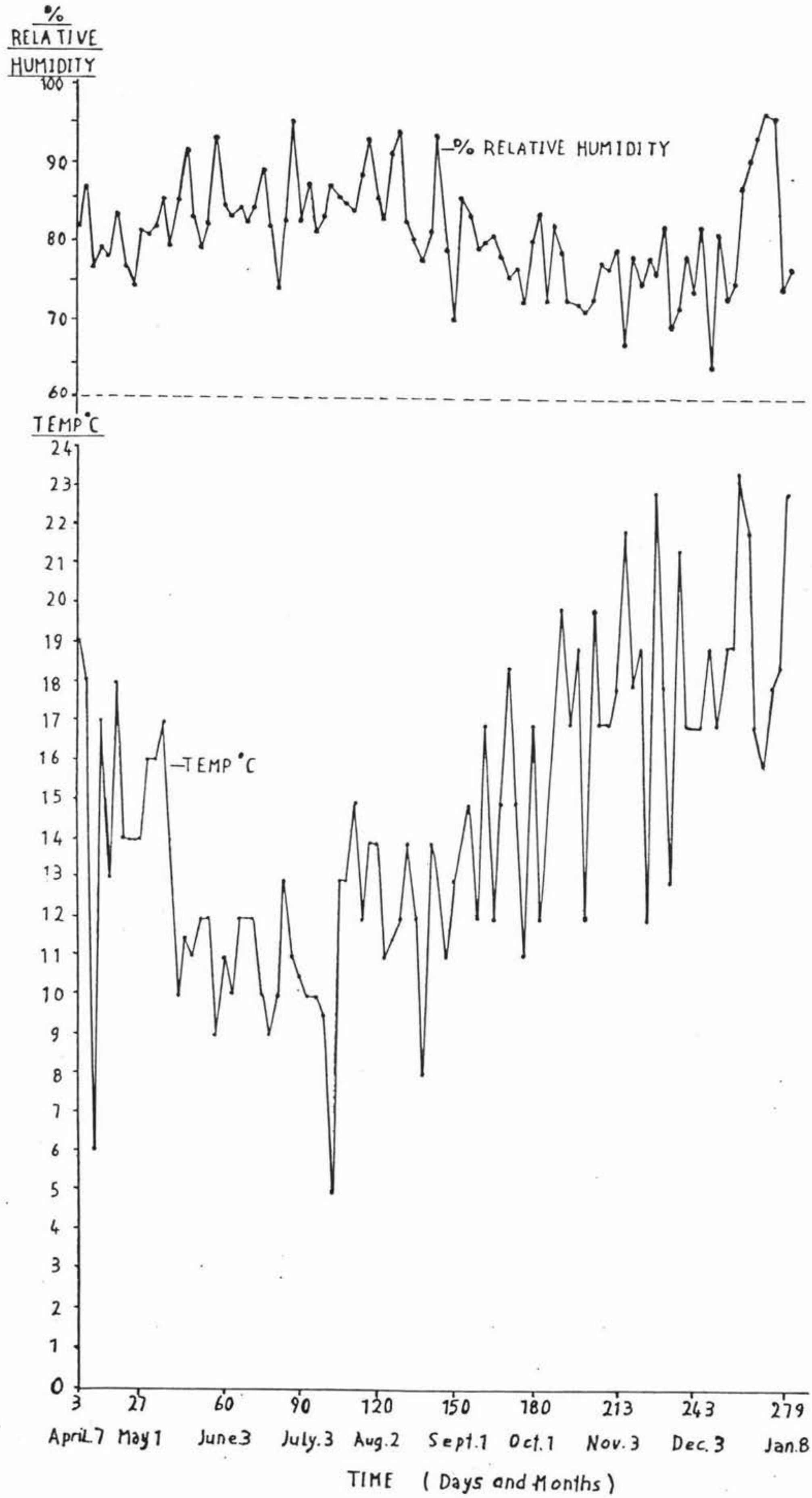
The temperature and percent relative humidity in the laboratory and Shade-house, and the differences between them.

TEMPERATURE

Date	Temperature °C Laboratory.		Temperature °C Shade-house.		Temperature differences °C between laboratory and Shade-house.	
	Max.	Min.	Max.	Min.	Max.	Min.
19/1/80	21.00	-	22.50	-	1.50	-
20/1/80	22.0	18.50	23.00	17.50	1.00	1.00
21/1/80	22.00	17.00	23.00	15.00	1.00	2.00
22/1/80	23.00	18.00	22.00	16.00	1.00	2.00
23/1/80	20.50	18.50	19.75	16.00	0.75	2.50
24/1/80	22.50	16.00	22.50	14.00	0.00	2.00

% RELATIVE HUMIDITY.

Date	% R.H. Laboratory.		% R.H. Shade-house.		% R.H. difference between laboratory and Shade-house.	
	Max.	Min.	Max.	Min.	Max.	Min.
19/1/80	-	61.5	-	62.0	-	0.5
20/1/80	67.5	63.0	75.0	65.5	7.5	2.5
21/1/80	65.0	61.5	73.0	62.0	8.0	0.5
22/1/80	66.0	64.0	74.0	66.5	8.0	2.5
23/1/80	66.5	62.5	75.0	65.5	8.5	3.0
24/1/80	66.0	63.0	75.0	66.0	9.0	3.0
25/1/80	67.5	-	75.0	-	7.5	-



<u>Fig. 1</u> Temperature and Percent Relative Humidity <u>vs</u> Season.

CONSTRUCTION OF EXPERIMENTAL AND HOLDING BOXES

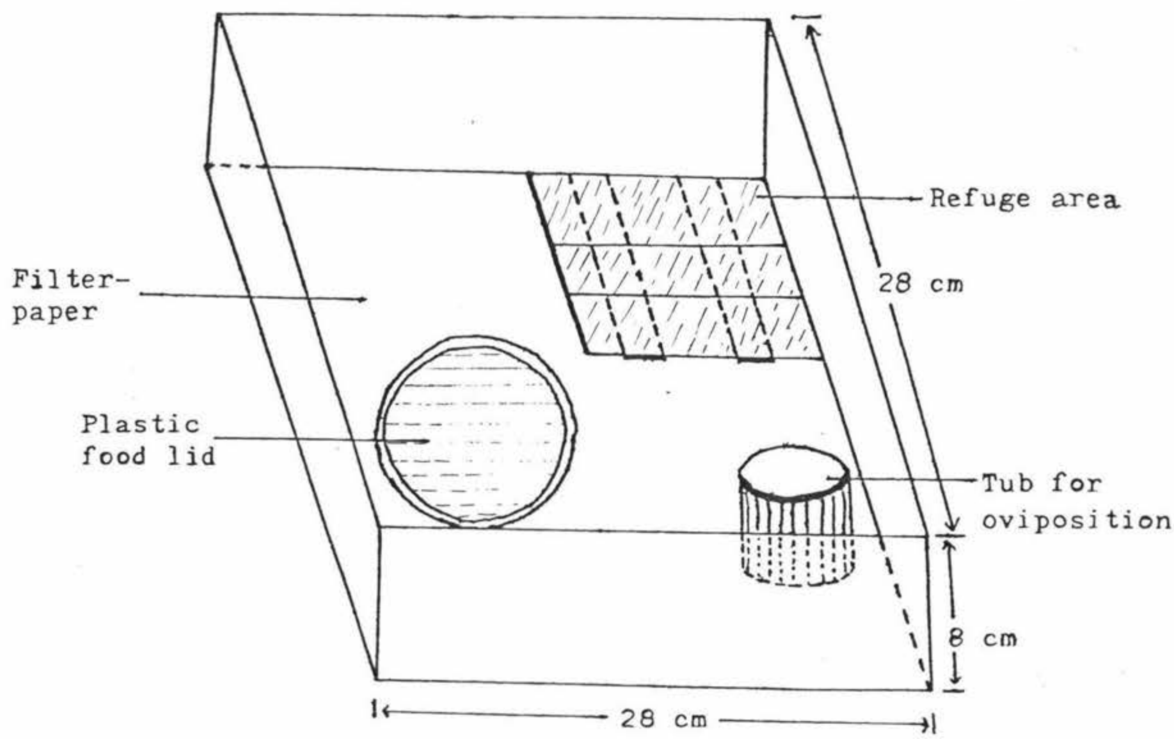
Boxes were constructed from 1 cm thick sheets of polystyrene. Box size was 28 cm x 28 cm and 8 cm deep. The lid of the box was close-fitting, and consisted of an outer wooden frame to which muslin cloth was attached (fig. 2). This gave free movement of air while at the same time retaining some of the moisture within the box. A triple layer of moist filter-paper lined the base of the box and a refuge area was added. This consisted of pieces of wood giving an area of 12 cm x 10 cm. The wood was kept from touching the the filter-paper by two wooden rails 13 x 2 x $\frac{1}{2}$ cm. Distilled water was sprayed with a fine mist-sprayer onto the filter-paper and refuge area every three days, to prevent desiccation of the slugs.

Food was supplied to the slugs on a 10 cm diameter plastic lid inside the box. Bran was the only food source for both slug species , and this was readily eaten. The food was replaced when eaten, or when contaminated with mould. The boxes were cleaned, and filter-paper replaced when these became contaminated with faeces.

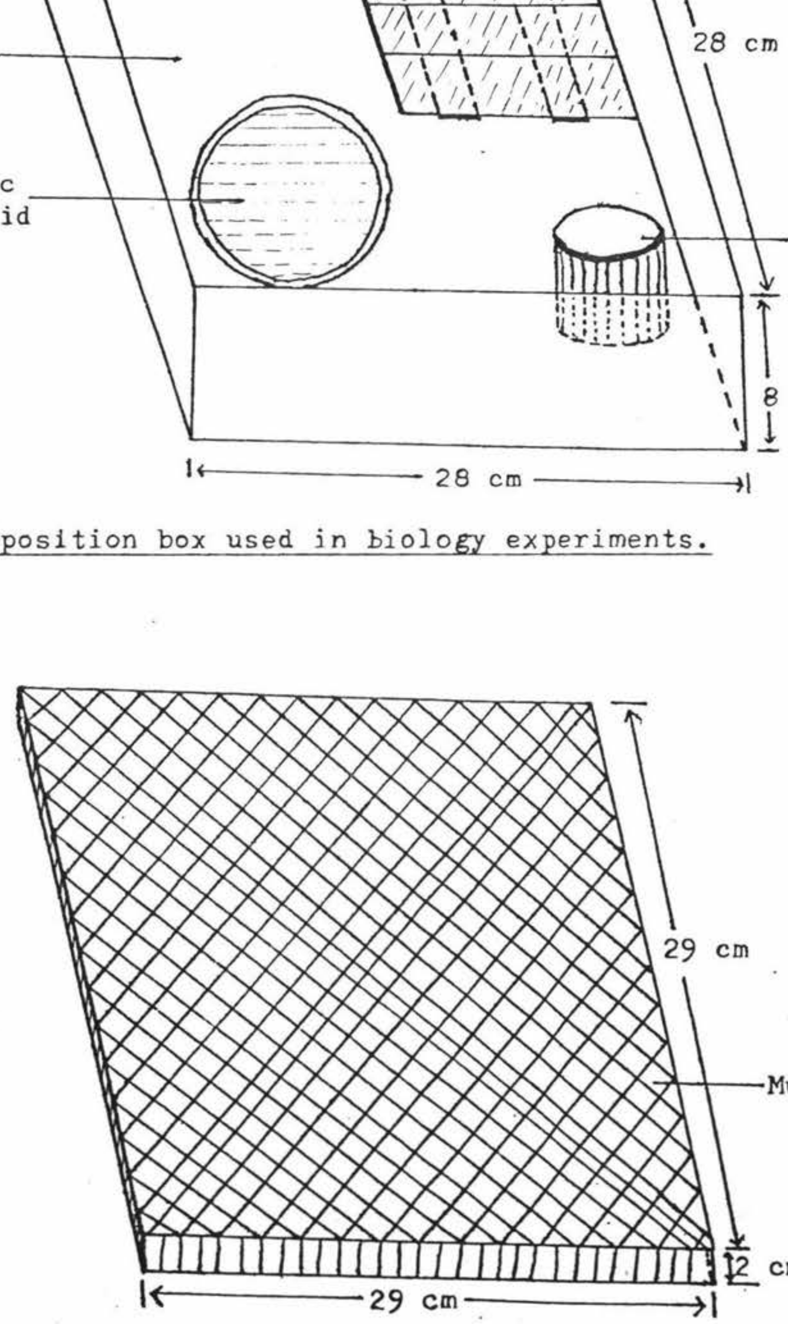
COLLECTION OF SLUGS

Slugs used in the experiments were collected from the orchard, and farms surrounding Massey University, where they were found mainly under pieces of wood and stones. Ratios of the two species found are shown on Table II. When brought into the laboratory, slugs were sorted into adults, and juveniles of each species. Individuals were classed as adults or juveniles according to their extended length, D.panormitanum adults over 2.5 cm, juveniles up to 1 cm ; D.reticulatum adults over 3.0 cm, and juveniles up to 1.5 cm. These were then placed in separate holding boxes, and kept up to 1 week prior to being used in the experiments.

FIG. 2 Box used in slug biology experiments. Scale = ¼



Holding and Oviposition box used in biology experiments.



Close-fitting muslin lid.

TABLE II Number of slugs collected from pasture and orchard

AREA	DATE	D. panormitanum	D. reticulatum	RATIO
Adults Pasture	2/6/79	50	52	0.96
"	5/6/79	88	36	2.44
"	11/6/79	61	48	1.27
"	14/6/79	140	137	1.02
TOTAL		339	273	1.24
Adults Orchard	14/6/79	60	5	12.00
Juveniles Pasture	2/6/79	84	60	1.40
"	5/6/79	66	32	2.06
"	11/6/79	84	36	2.33
"	14/6/79	167	50	3.34
TOTAL		401	178	2.25
Juveniles Orchard	14/6/79	31	3	10.30

BIOLOGICAL STUDIES

For the fecundity experiments adult D. panormitanum were held in the Shade-house, and at constant temperatures of $24^{o}C$, $16^{o}C$, and $5^{o}C$. The boxes were checked, eggs collected, dead slugs removed and replaced, and recordings taken every third-day (collection day) for the duration of the experiment.

Eggs were oviposited by D.panormitanum in black plastic tubs, 6.5 cm in diameter and 5.0 cm deep, containing moist potting mixture. Some eggs were oviposited in the refuge area, but this did not amount to more than one or two clusters for each collection date.Eggs were oviposited 1-2 cm deep with the majority of clusters being oviposited between the soil and tub interface. When the tub was inverted the compacted soil would retain the tub's shape, and eggs would adhere to the soil, and could be counted in complete clusters (Plate VIII) The number of eggs contained in each cluster, and the number of clusters oviposited by the 30 slugs for each box was recorded. In the Appendix results are shown for the five box totals at each of the four experimental temperatures for each third day of experimentation.

INCUBATION OF EGGS AT DIFFERENT TEMPERATURES

Eggs collected from D. panormitanum were incubated at the same temperature from which they were collected. One hundred eggs were placed in 9 cm diameter petridishes containing two layers of filter-paper, and kept moist. Samples were incubated at the beginning,and middle of each month, for the duration of the experiment. The parameters measured for each batch of eggs were;

(a) Number of eggs.

(b) Time taken for the first egg to hatch.

(c) Hatching range (from first to last egg hatched).

(d) Number of eggs hatched.

(e) Number of eggs with partial development and failing to hatch.

(f) Number of eggs showing no development.

THE FECUNDITY AND LIFE-SPAN

Thirteen one-day old D. panormitanum, and fifteen one-day old D. reticulatum were obtained from hatching-rate experiments on 20/7/79 and transferred to two separate experimental boxes. The boxes were kept moist, and the only food presented was All-bran. All eggs laid by these slugs were collected and incubated in the laboratory in separate 9 cm diameter petridishes containing moist filter-paper. The parameters measured for each batch of eggs were the same as for 'Incubation of eggs at different temperatures'. The times when natural deaths occured for each individual of the two slug species was recorded.

CHEMICAL CONTROL

PREPARATION OF SLUGS

The required number of slugs were kept in holding boxes without food for 48 hours, prior to the start of the experiment, to ensure that there was no food left in their guts.

Eggs were obtained from fresh stock held at 5°C. These stocks were made up of eggs from fecundity experiments, and from D. reticulatum kept in holding boxes.

TEST CONTAINER SIZES

Adult ingestion and spray boxes were of similar size, and made of 1.5 cm thick white polystyrene. The outer measurements of the box was 47 x 33 cm and 8 cm deep. The top of the box was closed by a tight fitting wooden framed muslin lid (fig. 3). The base of the box was covered with a 2 cm thick layer of moist sieved soil. The box was divided into two areas. A test area of 28 x 28 cm, and a covered refuge area of 28 x 16 cm supported on two wooden rails 16 x 2 x $\frac{1}{2}$ cm.

JUVENILE TEST CONTAINERS

Standard 15 cm diameter petridishes were used containing 5 mm of moist sieved soil. Half of the dish area was used as a test area, and the other half as a refuge, covered with 1 mm thick white opaque plastic, supported by two 6 x $\frac{1}{2}$ x $\frac{1}{4}$ cm wooden rails (Fig 3).

EGG TESTING CONTAINERS

Standard 9 cm diameter petridishes were used. Two circles of 9 cm filter-paper were placed inside the dish, and covered by the lid.

BIOCIDES USED.

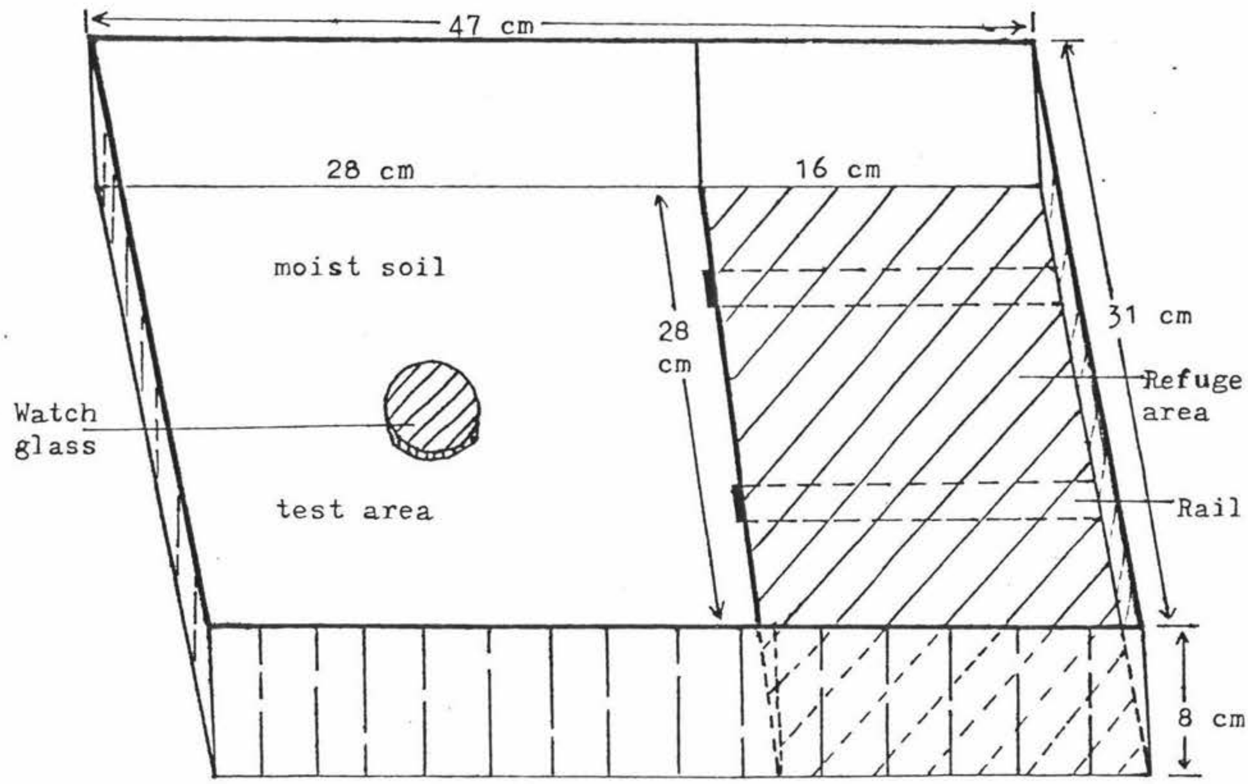
The common names of all 68 biocides used are shown on Appendix II. The percent active ingredient (a.i.) of manufacturers formulation is also shown on this table, as is the % a.i. used in baits, and sprays, and the grams equivalent of a.i./ha used in the ovicide experiments.

PRESENTATION OF BIOCIDES.

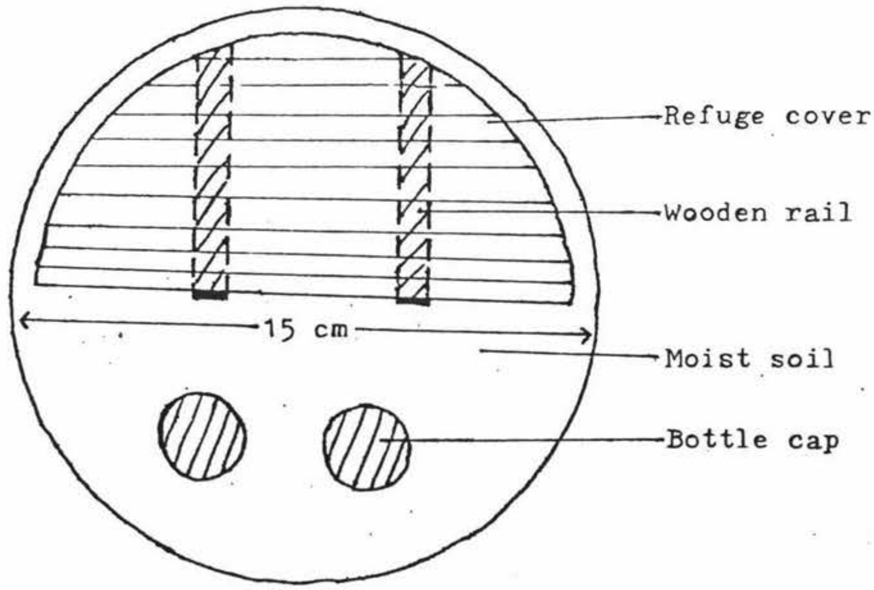
ADULT INGESTION

Chemicals were mixed with All-bran to attract the slugs. The concentration of the test chemical was the same throughout the experiment, and made up as follows; to 1.92 g of bran, 0.08 g of the test chemical was added and thoroughly mixed. This gave a 4 % concentration of chemical, and the % a.i. was that as specified by the manufacturer. Metaldehyde was used at 3 % active ingredient.

FIG. 3 Adult test box. Scale = $\frac{1}{4}$



Adult chemical test-box. Lid not shown - but same type as on Fig.2



Juvenile 15 cm diam. test-dish. Scale = $\frac{1}{2}$

The bait was placed in a 5 cm watchglass, and placed in the centre of the test area in the box. Ten slugs of the same species were then introduced into the refuge area of the test box. The biocidal effects on the slugs was recorded daily for the ten days of experimentation. Bran was used for the controls.

JUVENILE INGESTION

The chemical was mixed with bran as for adult ingestion, and placed in two shallow 2.5 cm plastic bottle caps. These were then placed in the test area. Fifteen juvenile slugs were then introduced to the refuge area, and biocidal effects recorded for the ten days of the experiment. Bran was used for the controls.

ADULT CONTACT-SPRAY

Chemicals were applied to the experimental area of the test-box by the use of a hand-held mist-sprayer. The concentration of the spray was that as specified by the manufacturer at maximum rates of application per hectare (Appendix II). The volume of spray used was equal to 1000 l/ha . After the biocide was applied, a 5 cm watch-glass containing 2 g of bran was placed in the centre of the test area. Ten slugs of the same species were then introduced to the refuge area. The slugs were hungry and to get to the bran had to cross the treated soil. The effects on the slugs after contact with the biocide was recorded daily for 10 days. Fresh soil was used for every experiment. Unsprayed soil was used for controls.

OVICIDAL ACTION

All biocides used were diluted with water to 20 parts per million (p.p.m.) of manufacturers formulation. Combinations were 20 + 20 p.p.m. Four ml of each diluent was added to the filter-paper of each test-dish with a bulb-pipette. One hundred fresh slug eggs were then added to each dish,and covered with a single circle of 7 cm diameter filter-paper. The lid was replaced and labelled. After 10 days 1 ml of the appropriate diluent was added to each dish, and repeated on the 20th day. Distilled water was used for controls.

A duplicate set of test-dishes was done for each biocide, and this was repeated for biocides showing molluscicidal activity.

Results were recorded as; Number of eggs hatched.

Number of eggs that failed to hatch.

With 20 p.p.m. a rate of 188.63 g/ha is obtained.

RESULTS

BIOLOGICAL STUDIES

THE FECUNDITY AND SURVIVAL OF SLUGS IN THE LABORATORY

NUMBER OF EGGS PER CLUSTER

A cluster is a collection of two or more eggs laid by a slug at anyone time in one place.

Tables III , and IV show the cluster size, the number of slugs, and the number of eggs oviposited by these slugs at the dates shown.

Fig 4 shows the cluster size and eggs per cluster, for the two species. There was a variation in the number of eggs per cluster, these being from 4-57 for D.reticulatum. The average for this species was 15.40 $\pm$ 9.63 eggs per cluster. The range in cluster size for D.panormitanum was 4-34 eggs with an average of 15.56 $\pm$ 7.34 eggs.
Analysis showed that there was no statistical difference between the number of eggs oviposited per cluster for either species. A t-test showing $t = 0.094$ was not significant at the 1% level.

NUMBER OF CLUSTERS PER SLUG

During the egg-laying period (October 1979 to January 1980), the slugs of each species were kept together in separate boxes. The average number of clusters for each slug was calculated by dividing the total clusters by the total number of slugs. The cluster distribution is shown on fig. 4, and the expected average number of clusters per slug is three or four. A t-test showed that there was no significant difference between species at the 1% level of significance, $t = 0.094$.

TABLE III

THE NUMBER OF SLUGS, THE OVIPOSITION DATES, CLUSTER SIZE and NUMBER, and THE TOTAL NUMBER OF EGGS LAID.

DEROCERAS RETICULATUM

DATE	Days since hatching.	Slug number alive.	Number of clusters laid and eggs per cluster.	Total eggs oviposited.
18/10/79	90	15	14,15.	29
21/10/79	93	15	12,10.	22
25/10/79	97	15	19	19
30/10/79	102	15	10,13, 5, 4, 5, 5.	42
10/11/79	113	15	13, 8,14, 6,18,16,41.	116
15/11/79	117	14	21,13,57,11,11,22.	135
28/11/79	131	12	24,33,18,16,12,10.	113
4/12/79	137	12	16, 9,10,36.	91
12/12/79	145	9	16,13, 7,10,10,13,27.	105
17/12/79	150	3	11,15.	26
20/12/79	153	3	14.	14
24/12/79	157	3	14, 9.	23
3/ 1/80	167	3	23.	23
11/ 1/80	175	2	22, 6.	28
13/ 1/80	177	2	15	15
21/ 1/80	185	0	0	0
TOTALS			52.00 clusters	801.0 eggs
AVERAGES			3.47 clusters	53.4 eggs

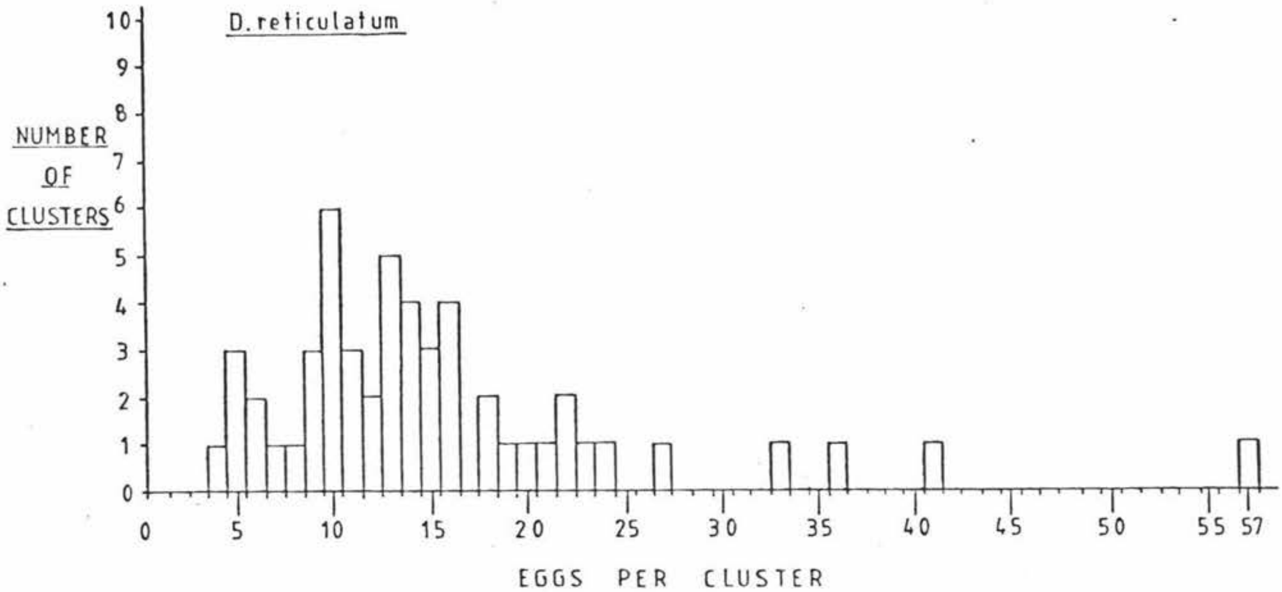
TABLE IV

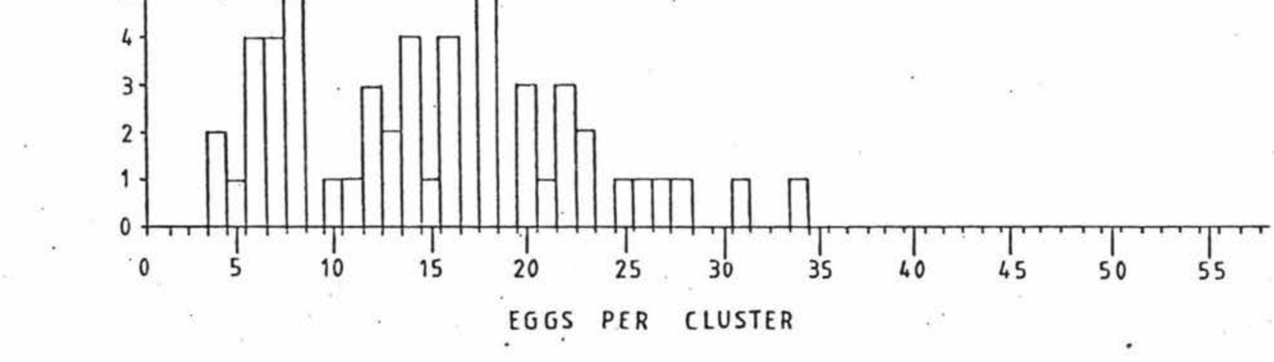
THE NUMBER OF SLUGS, THE OVIPOSITION DATES, CLUSTER SIZE and NUMBER, and THE TOTAL NUMBER OF EGGS LAID.

DEROCERAS PANORMITANUM

Date	Days since hatching.	Slug number alive.	Number of clusters laid and eggs per cluster.	Total eggs oviposited.
30/10/79	102	13	4.	4
3/11/79	106	13	12.	12
10/11/79	113	13	23.	23
15/11/79	118	13	18, 7,22.	47
22/11/79	125	13	25,26,27.	78
28/11/79	131	13	15, 8,23,22, 6,20.	106
4/11/79	137	13	16,14,18,14,10.	72
12/12/79	145	11	13,34,22,18,28.	115
17/11/79	150	9	20, 4,18,18,31.	91
20/12/79	153	9	7, 5.	12
24/12/79	157	9	16, 8,12,14,20.	70
3/ 1/80	167	9	16,13,18,21,18,16.	102
11/ 1/80	175	4	11, 7, 8.	26
13/ 1/80	177	3	6.	6
21/ 1/80	185	2	6, 8.	14
8/ 2/80	213	0	0	0
TOTALS			50.00 clusters	778.00eggs
AVERAGES			3.84 clusters	59.85eggs

Fig. 4 The number of eggs per cluster, and the number of clusters oviposited by D.reticulatum and D.panormitanum of the Spring generation July 20, 1979 to January 25, 1980.





NUMBER OF EGGS OVIPOSITED PER SLUG

The total number of eggs oviposited by the fifteen slugs of the species D.reticulatum of the Spring generation was 801. Thirteen D.panormitanum laid a total of 774 eggs over the same period. The average numbers of eggs was calculated from tables III and IV and are as follows;

D. reticulatum = 53.40 eggs per slug.

D. panormitanum = 59.85 eggs per slug.

A t-test showed that there was no significant difference at the 1% level for oviposition rates between species t = 0.099 .

OVIPOSITION RATE OF SLUGS KEPT SINGLY AND IN GROUPS

Table V shows that of the fiftyseven slugs used in this experiment only eight (14 %) oviposited. The number of clusters per ovipositing slug varied from 1 - 3 , and eggs per cluster from 4 - 48. In this part of the experiment the average number of eggs for each slug was 3.7 . At the same temperature, box experiments (where the slugs were in groups) showed an average of 25.1 eggs per slug (Table XI), and this is a significant difference at the 1% level, t = 20.46 . This led to the supposition that most slugs when kept singly will fail to oviposit, or only oviposit in low numbers.

Table VI shows the number of eggs and clusters oviposited when the experiment was repeated with slugs kept singly, or in a group. Mature slugs were selected at random for this part of the experiment. Results show that there was a 5.5 fold increase in cluster numbers where slugs were kept in a group.A t-test showed that there was a significant difference at the 1% level t = 3.80 .

OVIPOSITION SITES

To test whether oviposition sites were of importance to D.panormitanum eggs were collected from one box of 30 slugs every third day, and from

Table V.

THE CLUSTER AND EGG DISTRIBUTION PER PETRI-DISH FOR SLUGS KEPT SINGLY.

Slug Species = D.panormitanum.

Petri-dish number.	Number of slugs used per dish.	Number of slugs ovipositing.	Clusters per slug	Eggs per cluster	Totals
1	9	1	1	18	18
2	14	2	1	23	55
			2	21,11	
3	14	1	2	26,14	40
4	10	3	1	4	51
			3	16,12,5	
			2	12,2	
5	10	1	3	31,7,10	48
Totals	57	8	15	15	212
Average eggs per cluster				14.14 ± 8.41	
Average eggs per slug				3.70 ± 7.60	

TABLE VI

THE DIFFERENCE IN CLUSTERS WHEN SLUGS WERE KEPT SEPARATELY IN 9-cm PETRI-DISHES, AND WHEN SLUGS WERE IN A GROUP. SLUG SPECIES = D. panormitanum.

(1) Petri-dishes numbered from 1-25 containing 1 slug each were kept for 10 days.

Date started 8/1/80 , concluded on 18/1/80.

Date	Petri-dish number	Number of clusters.	Number of eggs.
8/1/80	-	-	-
11/1/80	-	-	-
14/1/80	14	1	9
18/1/80	1,6	1+1	5,21
Totals	3	3	35

(2) Ten of the above petri-dishes containing one slug each were kept as a control, these were dish numbers, 2,6,7,9,11,13,14,15,17,18. Ten slugs from petri-dishes ,1,4,5,10,12,16,19, 21, 23, 25, were put together in a box, and the number of clusters and eggs recorded.

Date commenced 18/1/80, concluded on 28/1/80.

(2) 10 slugs together in a box.		
Date..	Number of clusters.	Total number of eggs.
18/1/80		
21/1/80	12,25,30, 20.	87
24/1/80	7,16,17,26.	66
28/1/80	13,22,6.	41
Total =	11	194

(2a) 10 slugs kept separately in dishes		
Date..	P-dish number with 1 cluster.	Number of eggs.
18/1/80		
21/1/80	6	7
" "	13	34
24/1/80	-	-
28/1/80	-	-
Total =	2	41

another box of 30 slugs every two weeks. The slug number was kept at 30 slugs from laboratory stocks. The boxes were held at a constant temperature of 16 °C. The results are shown on table VII. There was no reduction in oviposition-rate as sites became less plentiful. A t-test showed that there was no significant difference at the 1% level between boxes. t = 0.008 .

HATCHING SUCCESS UNDER LABORATORY CONDITIONS FOR TWO SLUG SPECIES

Table VIII shows the totals of eggs oviposited, fate of the eggs, and the averages for the two species. Figures 5a, and 5b, show the cumulative totals of the fate of the eggs for D.panormitanum and D.reticulatum . A t-test showed that there were no significant differences at the 5% level in egg numbers oviposited by the two species. t = 0.094

A t-test showed that at the 5% level of significance, more young hatched from D.panormitanum eggs, than from D.reticulatum eggs. t = 2.06 .

THE LIFE-SPAN OF D.RETICULATUM and D.PANORMITANUM in the LABORATORY

Table IX shows the hatching date of the slugs in the experiment, and the dates when the first and last slugs died. The average life-span for D.reticulatum was calculated at 151 ± 19 days, and for D.panormitanum 171 ± 19 days . A t-test showed that there was a significant difference at the 1% level between species. t = 2.68 . Deroceras panormitanum lives an average of 20.64 days longer than D.reticulatum under identical laboratory conditions.

TABLE VII

THE NUMBER OF CLUSTERS, AND OF EGGS OVIPOSITED BY 2 x 30 SLUGS OF THE SPECIES D. panormitanum, AND KEPT IN TWO SEPARATE BOXES, UNDER IDENTICAL CONDITIONS AT 16 °C CONSTANT TEMPERATURE. THIS EXPERIMENT WAS INITIATED ON 31/10/79 AND CONCLUDED ON 14/1/80.

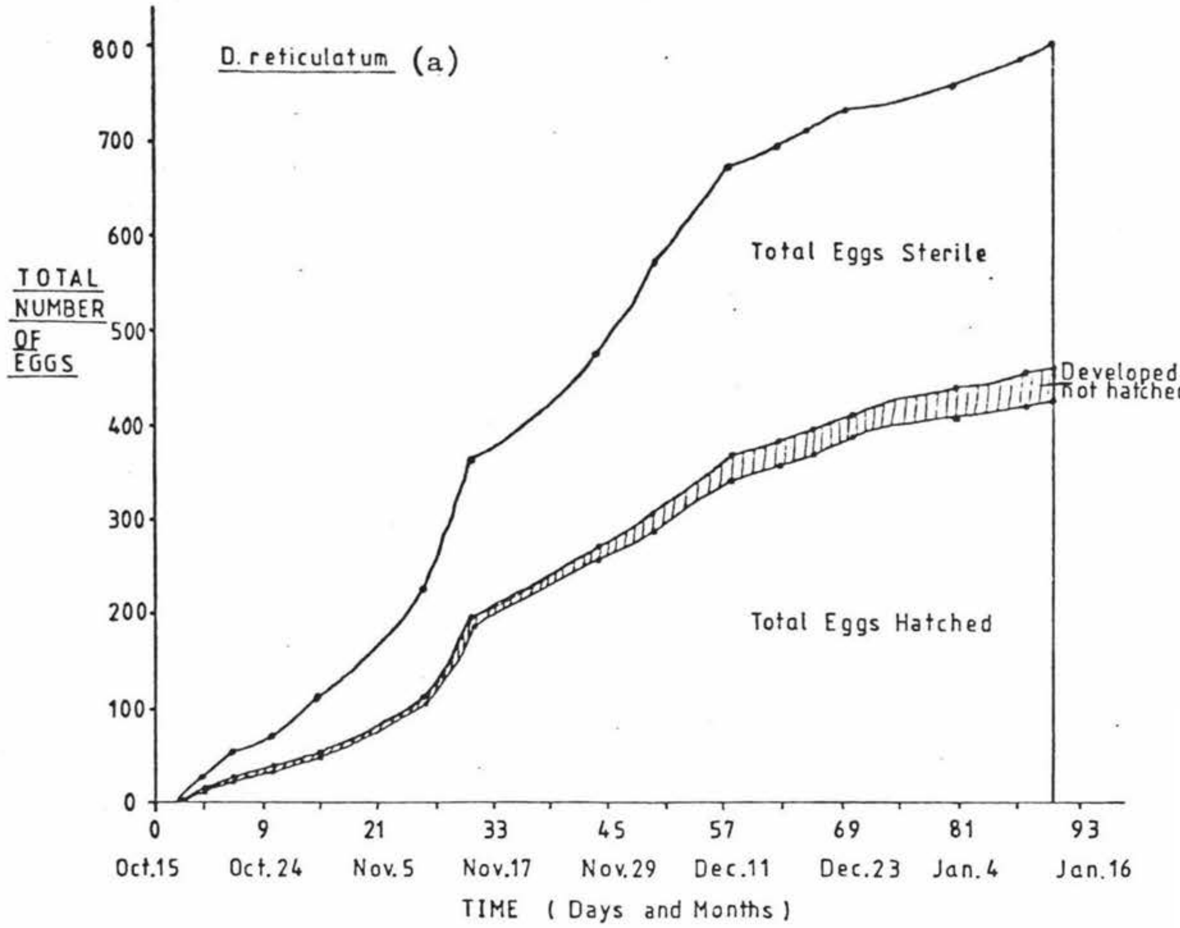
(1) Eggs collected every 3-days.			(2) Eggs collected twice monthly.		
Date.	Number of Clusters.	Total number of eggs.	Date.	Number of Clusters.	Total number of eggs.
3/11/79	8	203			
6/11/79	8	175			
9/11/79	9	221			
12/11/79	5	152			
15/11/79	8	213			
18/11/79	5	121	18/11/79	31	958
21/11/79	9	217			
24/11/79	10	226			
27/11/79	6	147			
30/11/79	5	124	30/11/79	32	838
Total =	73	1799	Total =	63	1796
3/12/79	7	195			
6/12/79	3	79			
9/12/79	9	214			
12/12/79	5	113			
15/12/79	6	116	15/12/79	32	880
18/12/79	8	203			
21/12/79	9	177			
24/12/79	6	122			
27/12/79	7	166			
30/12/79	5	93			
2/1/80	7	133		39	723
Total =	72	1611	Total =	71	1603
5/1/80	4	57			
8/1/80	7	138			
11/1/80	7	133			
14/1/80	5	93	14/1/80	25	416
Total =	22	421	Total =	25	416

Table VIII

HATCHING SUCCESS AND FATE OF EGGS OF TWO SLUG SPECIES UNDER LABORATORY CONDITIONS.

	Total eggs oviposited	Total eggs hatched	Eggs partially developed	Eggs undeveloped
D. reticulatum				
Totals	801.0	425.0	32.0	344.0
Averages per slug	53.4	28.3 **	2.1	22.9
Percentages		53.0	4.0	43.0
D. panormitanum				
Totals	778.0	559.0	16.0	203.0
Averages per slug	59.9	43.0 **	1.2	15.6
Percentages		72.0	2.0	26.0

** = Significant difference at the 5% level. t = 2.06 .



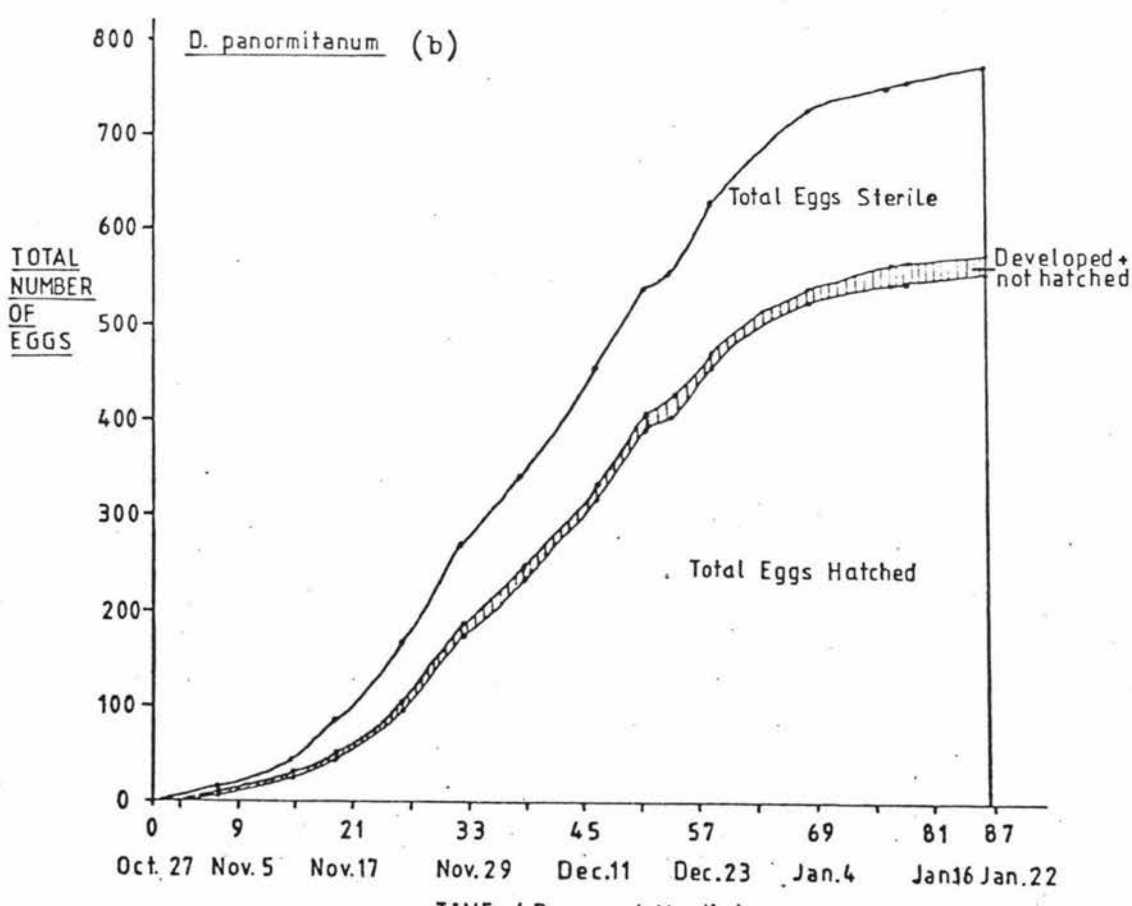


Fig. 5a, 5b, The fate of (a) eggs of D.reticulatum
(b) eggs of D.panormitanum
The results are cumulative.

Table IX

THE LIFE-SPAN OF D.RETICULATUM and D.PANORMITANUM. THE DATE WHEN THE FIRST and LAST SLUG DIED ARE SHOWN.

	D.reticulatum		D.panormitanum	
	Date	Days from hatching.	Date	Days from hatching
Date hatched	20/ 7/79	0	20/ 7/79	0
Date first egg oviposited	18/10/79	90	30/10/79	102
Date last egg oviposited	13/ 1/80	187	21/ 1/80	185
Date of first death	15/11/79	118	12/12/79	145
Date of last death	28/ 1/80	192	8/ 2/80	203
Mean life-span (days)	151.1 ± 19.7 = 21.6 weeks.		171.7 ± 19.5 = 24.6 weeks.	

EGG LAYING AT DIFFERENT TEMPERATURES BY DEROCERAS PANORMITANUM

NUMBER OF EGGS PER CLUSTER

Fig. 6 shows the distribution of cluster size, and the most frequent number of eggs oviposited for each cluster at the four temperatures. The four graphs are skewed to the left showing that there were fewer clusters with high numbers of eggs. The majority of the egg clusters were of 10 - 30 eggs for Shade-house, 24 °C, and 16 °C. The 5 °C graph shows fewer eggs per cluster, from 6 - 25.
A One-way analysis of varience test showed that there was no significant difference at the 1% level between the five boxes held at each temperature, values being;

Shade-house	$F_{4,2009}$	=	2.410
16 °C	$F_{4,2878}$	=	0.541
24 °C	$F_{4,3051}$	=	1.266
5 °C	$F_{4,395}$	=	1.429

There is some seasonal difference in average cluster size as can be seen from Fig. 7 . Three-point-running-means were plotted to show a clearer seasonal distribution. The overall pattern shows a larger cluster size for the Winter months of June to November, and a smaller cluster size for the warmer months of the year. The average number of eggs per cluster for Shade-house was 22.5 ± 11.4 , at 16 °C 23.2 ± 10.4, at 24 °C 22.9 ± 10.4 , and at 5 °C 18.5 ± 9.4 . Appendix III shows the average cluster size for each collection date.

A t-test was carried out to test for differences between the Shade-house and the other three temperatures, for the average number of eggs per cluster. Results obtained were;
Shade-house with 16°C $t_{\infty} =$ 2.22

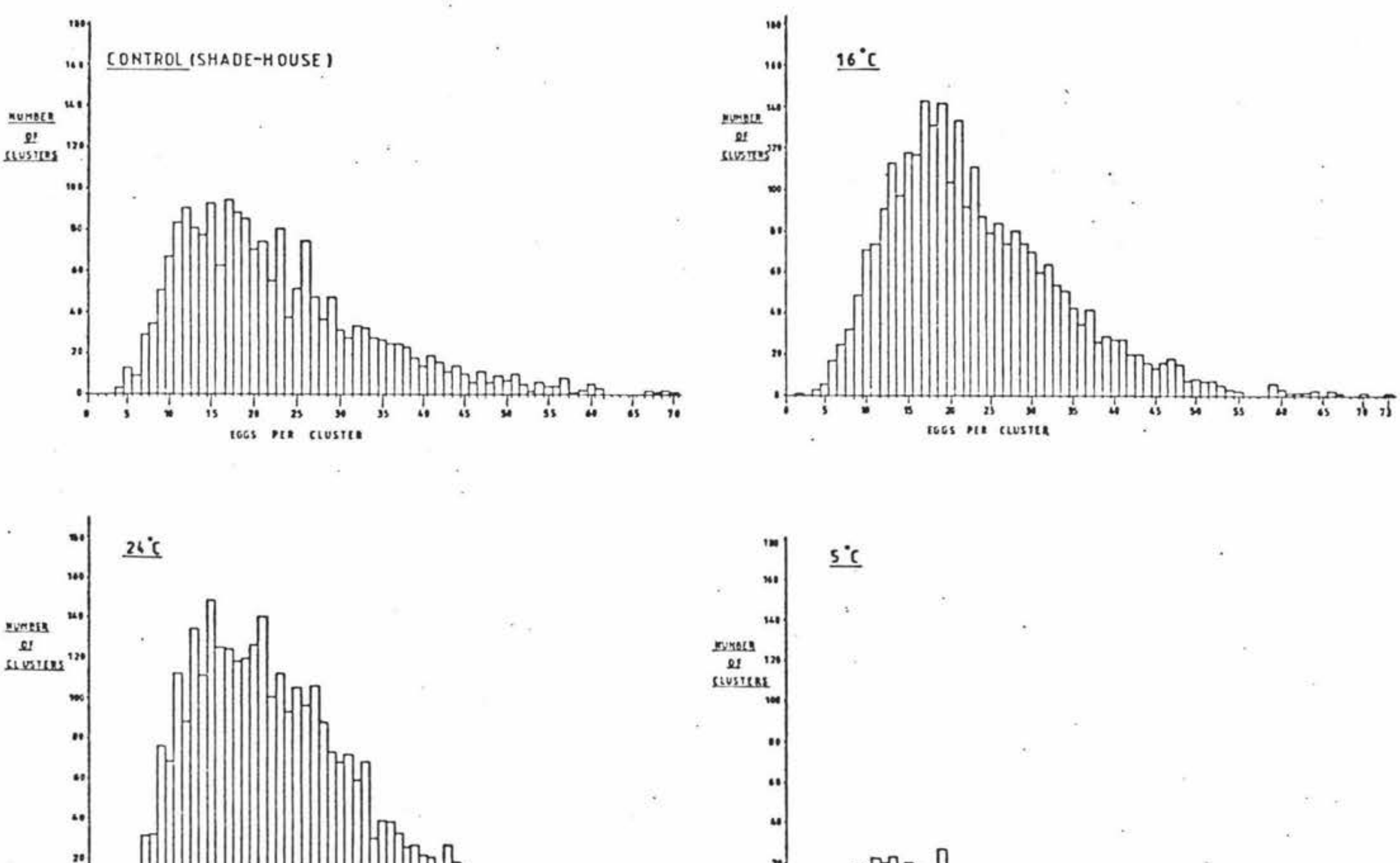


Fig. 6 TOTAL NUMBERS OF CLUSTERS OVIPOSITED, SHOWING THE NUMBER OF EGGS PER CLUSTER AND CLUSTER DISTRIBUTION.

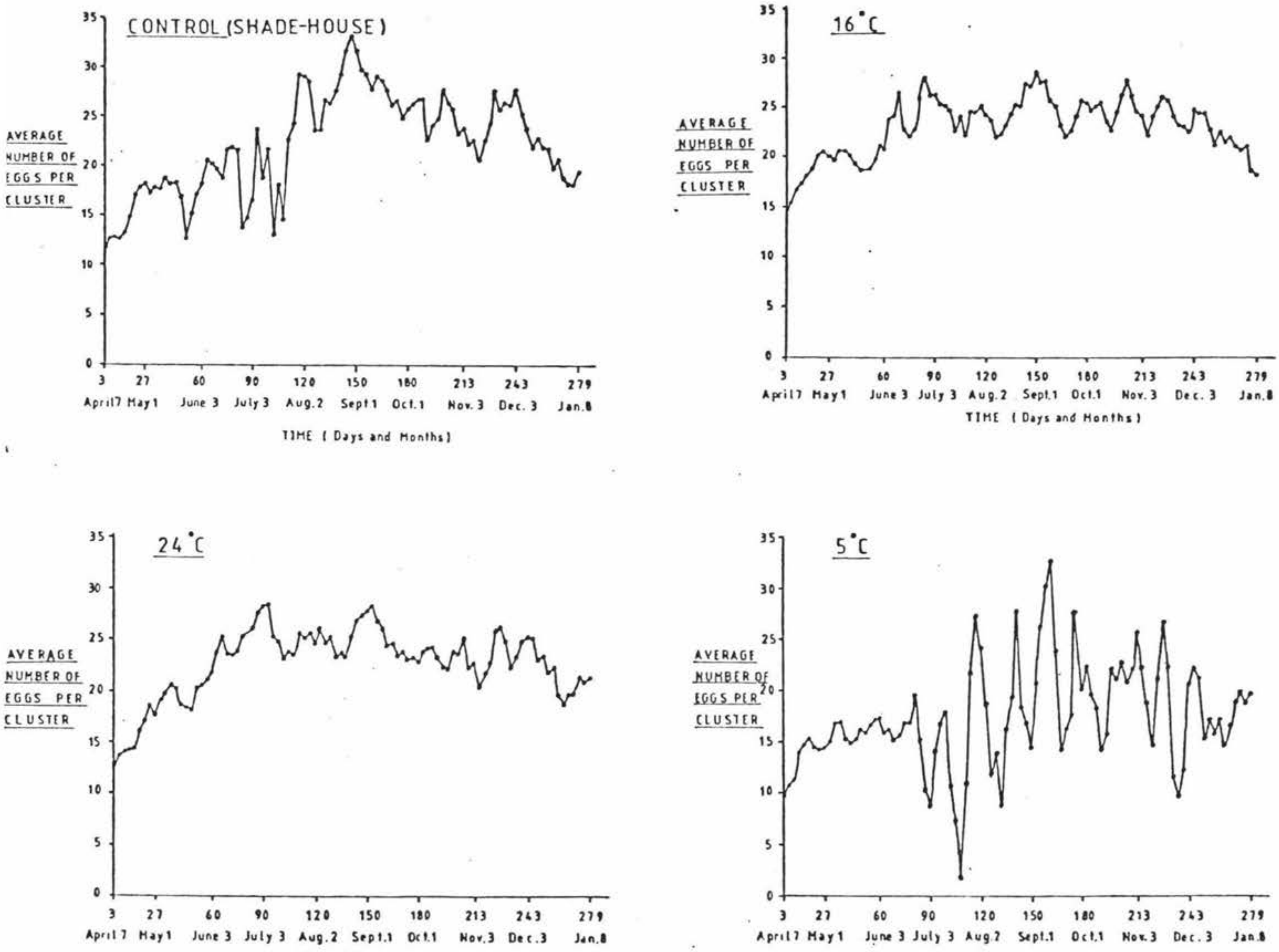


Fig. 7 Three point running means of average number of eggs per cluster.

Shade-house with 24 °C t_{∞} = 1.22

Shade-house with 5 °C t_{∞} = 6.66

There was no significant difference at the 1% level for the 16 °C and 24 °C temperatures, but there was a significant difference for the 5°C temperature at the 1% level. Temperature did not affect the number of eggs per cluster, except at 5 °C.

CLUSTER DISTRIBUTION

Figure 8 shows the number of clusters oviposited by 150 slugs on each collection date. There is a seasonal pattern for the Shade-house, being higher in Summer, and lower in Winter. At 24°C and 16°C there is no seasonal patern. At 5°C there is a decrease in the number of clusters oviposited after the first month, and a constant low level was then maintained till the conclusion of the experiment. Table X shows that a higher temperature favours oviposition by slugs. The temperature best suited for oviposition is 16 °C, and the temperature least favourable for oviposition is 5 °C (Appendix IV).

To test for differences in cluster numbers for the five boxes held at the same temperature, a One-way analysis of varience was carried out. Results are;

Shade-house	$F_{4,460}$	= 2.194
16 °C	$F_{4,460}$	= 0.441
24 °C	$F_{4,460}$	= 1.330
5 °C	$F_{4,460}$	= 0.496

These results show that there was no significant difference at the 1 % level.

A t-test was carried out to test for differences in cluster numbers between Shade-house and the other three temperatures. Results are;

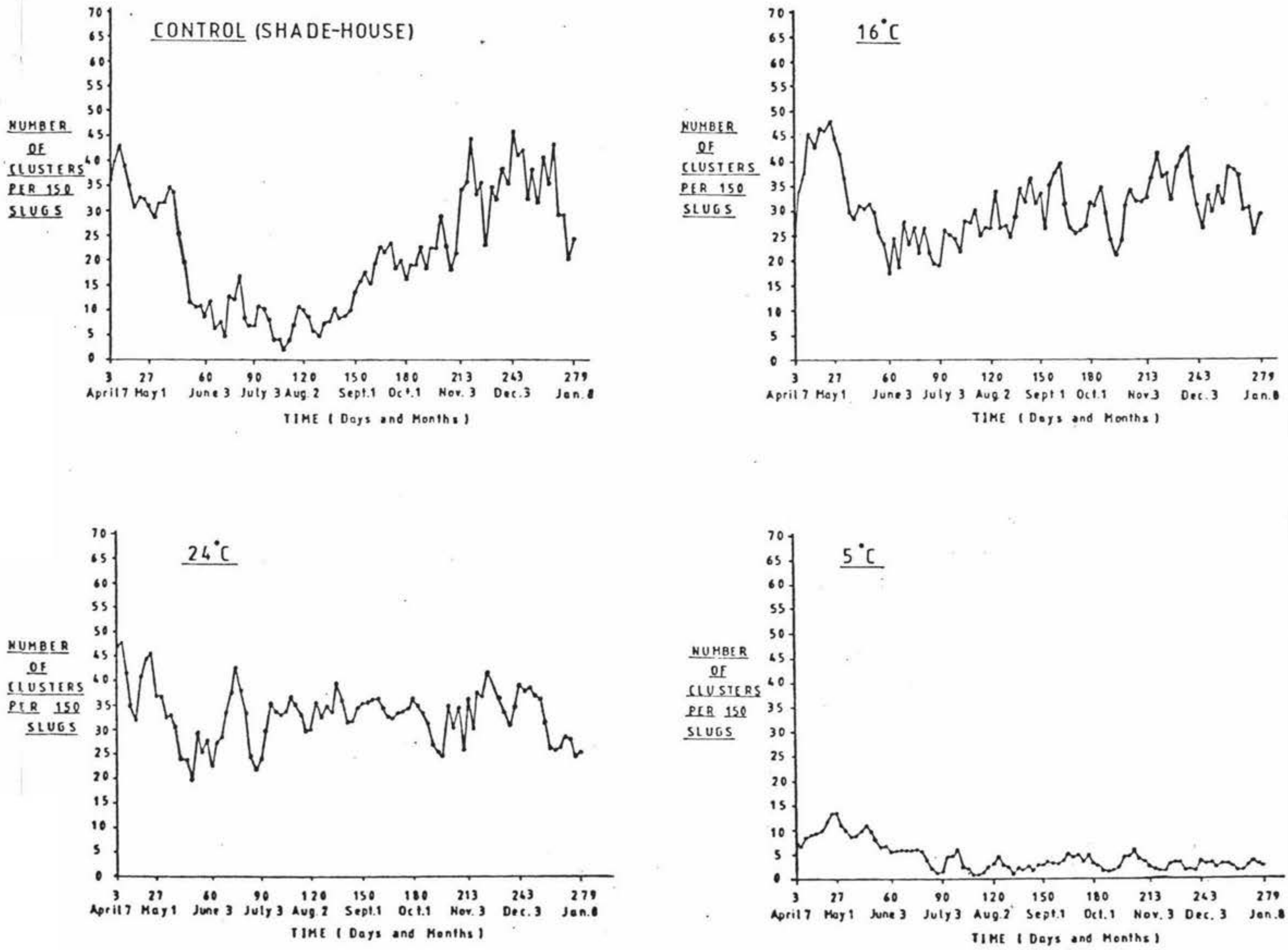


Fig. 8 Three point running means of clusters oviposited by 150 slugs on each collection day. Taken from Appendix IV.

TABLE X

THE TOTAL NUMBER OF CLUSTERS OVIPOSITED FOR EACH BOX. THE AVERAGE NUMBER OF CLUSTERS PER 150 SLUGS FOR EACH COLLECTION DATE, AND THE AVERAGE NUMBER OF CLUSTERS FOR EACH SLUG USED IN THE EXPERIMENT.

Location.	Box number	Total number of clusters	Standard Deviation
Control (Shade-House)	6	427	3.350
	7	321	3.174
	8	428	3.873
	9	447	3.847
	10	391	3.488
Total		2014	14.777
Average clusters per 150 slugs per collection day		21.66	
Average No. of clusters per slug		1.275	
16 °C	16	581	3.053
	17	559	3.396
	18	568	2.958
	19	609	2.929
	20	566	3.006
Total		2883	9.995
Average clusters per 150 slugs per collection day		31.00	
Average No. of clusters per slug		1.368	
24 °C	1	650	2.689
	2	639	2.814
	3	587	3.001
	4	587	2.558
	5	593	2.666
Total		3056	8.431
Average clusters per 150 slugs per collection day.		32.86	
Average No. of clusters per slug		1.097	
5 °C	11	72	0.934
	12	84	1.216
	13	89	1.042
	14	73	0.907
	15	82	1.214
Total		400	3.557
Average clusters per 150 slugs per collection day.		4.30	
Average No. of clusters per slug		0.415	

Shade-house with 16°C t_{184} = 5.02
" " " 24°C t_{184} = 6.31
" " " 5°C t_{184} = 10.96

Results show a significant difference at the 1% level.

NUMBER OF EGGS LAID PER SLUG and THE TOTAL NUMBER OF EGGS FOR EACH OF THE FOUR TEMPERATURES

The total number of eggs collected for the duration of the experiment are recorded (Appendix V) as the total number of eggs counted for each collection date at each temperature.

Appendix VI has recorded, the average number of eggs per 150 slugs for each collection date.The cumulative totals of slugs and eggs are recorded in Appendix VII . Corresponding graphs are Figures 9, 10, 11, and 12 respectively. Egg totals and averages are on table XI.

Figure 9 shows that slugs in the Shade-house have a higher oviposition rate in the Summer months, and a lower rate in the colder Winter months. The 16°C and 24°C graphs do not exhibit such a seasonal pattern, and at 5°C, after an initial increase in the first month, a constant low level is maintained. Figure 10 shows a similar pattern for the average number of eggs per slug.

Figure 11 shows the monthly average, and 9 months average of eggs oviposited per slug. The 16 °C temperature has the highest average oviposition rate of 31.8 eggs per slug, and the 5°C temperature has the lowest oviposition rate of 7.68 eggs per slug.

Cumulative totals of slugs and eggs are shown on Fig.12 . The line with least slope has the most eggs oviposited per slug. This line is the 16°C temperature. The line with steepest slope is the 5°C line, and has the least number of eggs oviposited per slug.

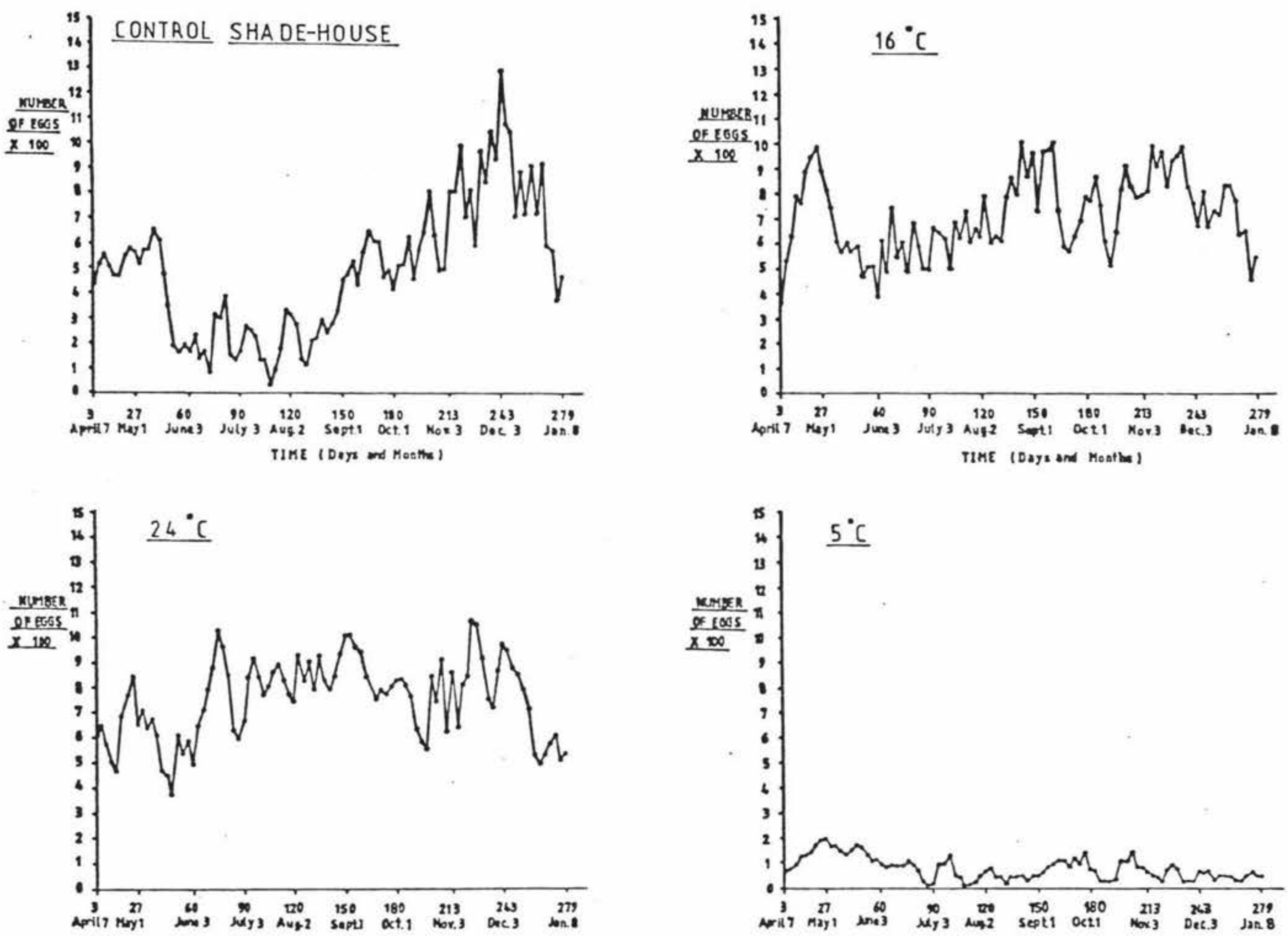


Fig. 9 Three point running means of number of eggs laid for each collection date.

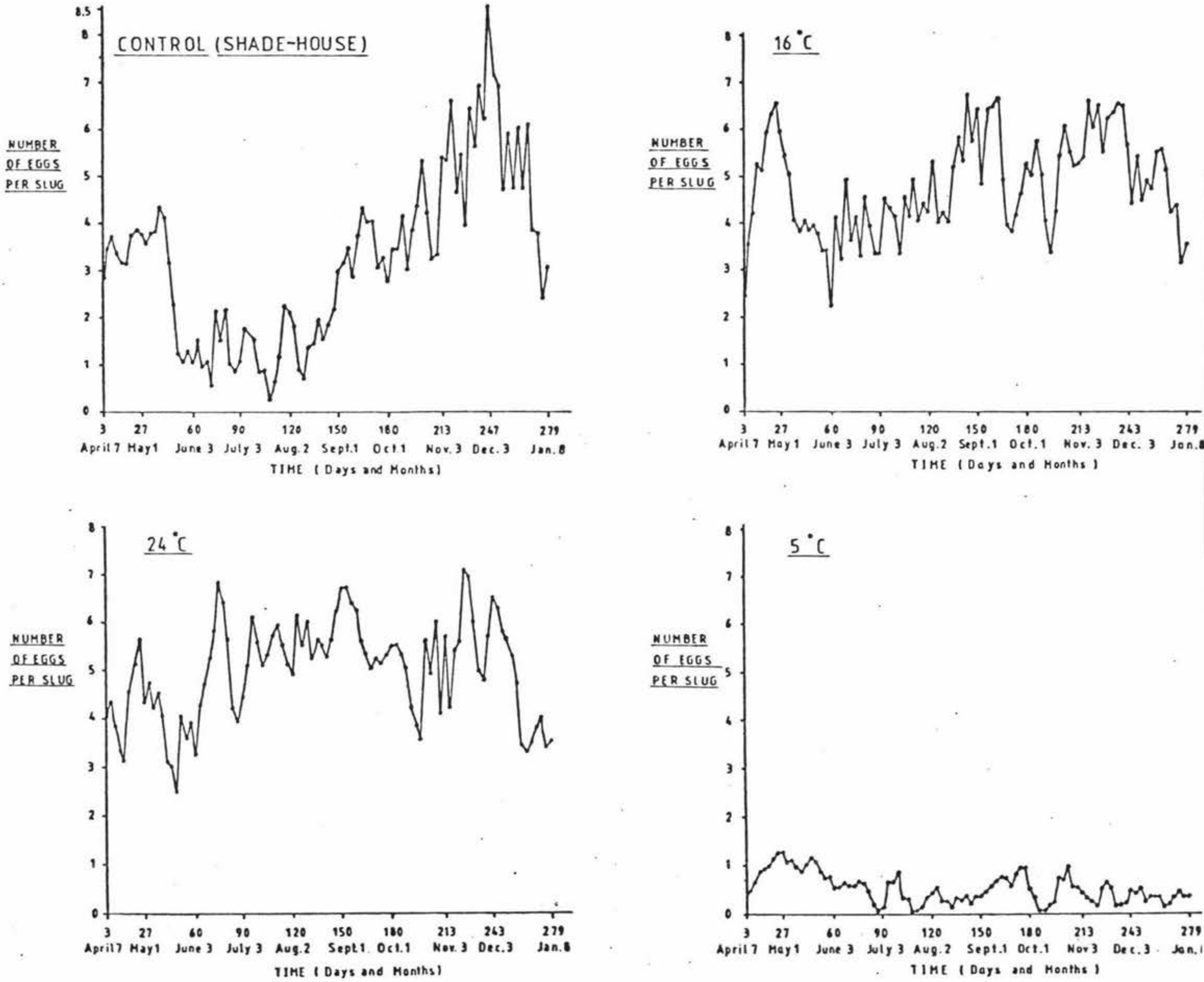


Fig. 10 The average number of eggs per slug per collection day.

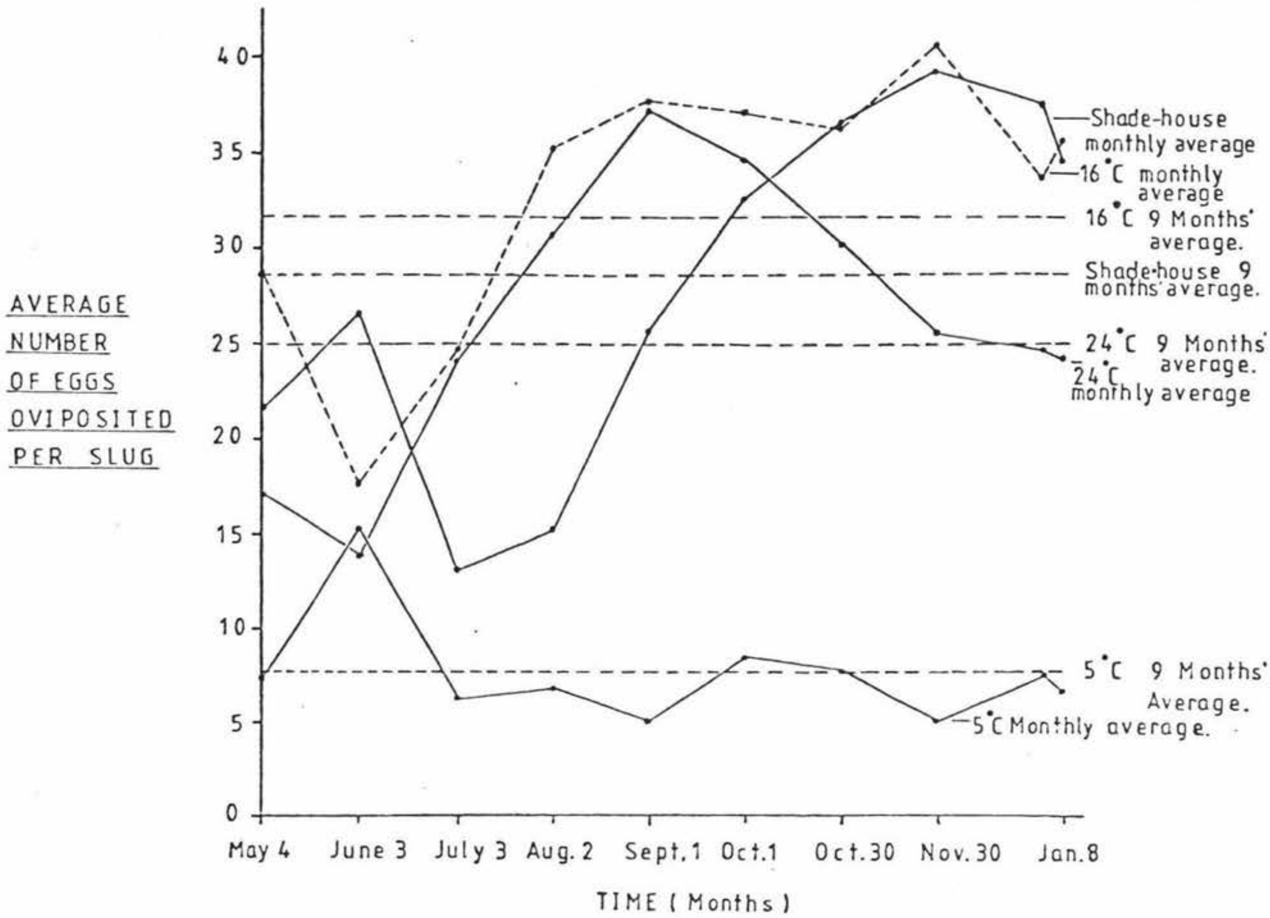


Fig. 11. Comparisons of the average number of eggs oviposited with Time. Monthly and total averages are shown.

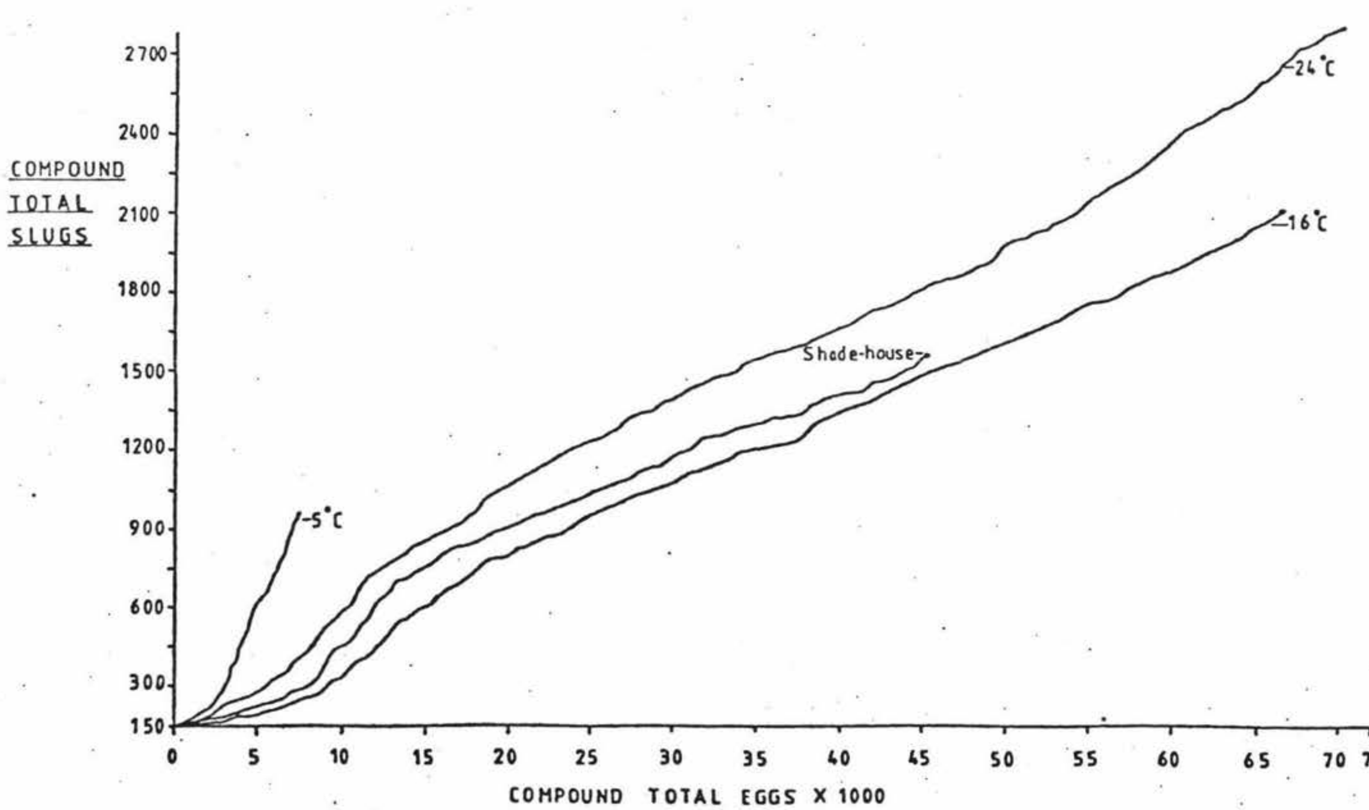


Fig. 12 Seasonal cumulative total of slugs versus eggs for the four temperatures. The period covered is from April 7,1979 to January 8, 1980. (Appendix VII)

TABLE XI

THE TEMPERATURE TOTALS AND THE AVERAGE NUMBER OF EGGS OVIPOSITED.

Location	Box number	Total number of eggs.	Standard deviation
Shade-house	6	10171	90.913
	7	7379	84.104
	8	9398	91.284
	9	9695	81.055
	10	8742	81.095
Seasonal total		45385	348.031
Seasonal average number of eggs per slug		28.74	
Average number of eggs per 150 slugs per collection day.		488.01	348.03
16°C	16	13712	83.453
	17	13046	89.869
	18	13240	82.697
	19	13855	79.724
	20	13094	77.676
Seasonal total		66947	258.590
Seasonal average number of eggs per slug		31.76	
Average number of eggs per 150 slugs per collection day		719.86	258.59
24°C	1	14719	67.732
	2	14492	82.328
	3	13552	75.070
	4	13908	80.345
	5	13352	75.288
Seasonal total		70023	234.841
Seasonal average number of eggs per slug		25.15	
Average number of eggs per 150 slugs per collection day		752.94	234.84
5°C	11	1337	19.142
	12	1477	23.518
	13	1730	24.205
	14	1464	19.566
	15	1392	21.960
Seasonal total		7400	63.712
Seasonal average number of eggs per slug		7.68	
Average number of eggs per 150 slugs per collection day		79.57	63.71

To determine if there were differences in the total number of eggs oviposited between the five boxes held at each temperature, a One-way analysis of varience has been carried out.Results are;

Shade-house $F_{4,460} = 1.764$

16 °C $F_{4,460} = 0.223$

24 °C $F_{4,460} = 0.720$

5 °C $F_{4,460} = 0.510$

These results show that there is no significant difference at the 1% level.

To test for differences between temperatures, a t-test was carried out making comparisons with the Shade-house. Results are;

Shade-house with 16°C $t_{91} = 5.10$

" " " 24°C $t_{91} = 6.02$

" " " 5°C $t_{91} = 11.07$

Results show that at all temperatures there is a significant difference at the 1% level.

EFFECT OF TEMPERATURE, HUMIDITY, and EVAPORATION RATE ON OVIPOSITION IN SHADE-HOUSE

The maximum, minimum, and temperature at the time of collection were recorded (Appendix VIII) at the time of collection. The maximum and minimum temperatures were those recorded since the previous collection day. These temperatures were plotted with the number of eggs collected on the same collection date, and are shown on Fig. 13. To determine if there was a correlation between temperature and number of eggs oviposited, correlation co-efficients were calculated and are as follows;

Maximum temperature	vs eggs oviposited	$r = 0.640$
Minimum temperature	vs eggs oviposited	$r = 0.634$
Temperature at collection time	vs eggs oviposited	$r = 0.486$

These values show that there is a strong correlation between temperature and numbers of eggs oviposited $p = 0.001$
As the temperature increases, so does the oviposition rate.

Three-point running means were taken from daily recordings of the percent relative humidity (% R.H.) and the evaporation rate (E.R.). These were plotted on figures 14 and 15 along with the number of eggs oviposited by that date to show the relationship, if any, between them. Correlation co-efficients were worked out for the % R.H. and E.R. with the number of eggs laid by the slugs by that date. Values obtained are as follows;

Relative humidity	with eggs oviposited	$r = -0.312$
Evaporation rate	with eggs oviposited	$r = 0.574$

The R.H. correlation value is negative showing that as the R.H. increases the number of eggs oviposited will decrease $p = 0.01$.
The E.R. correlation value is strongly positive $p = 0.001$ showing that as the E.R. increases, the number of eggs oviposited will increase.
To oviposit slugs prefer an elevated temperature with increasing E.R.

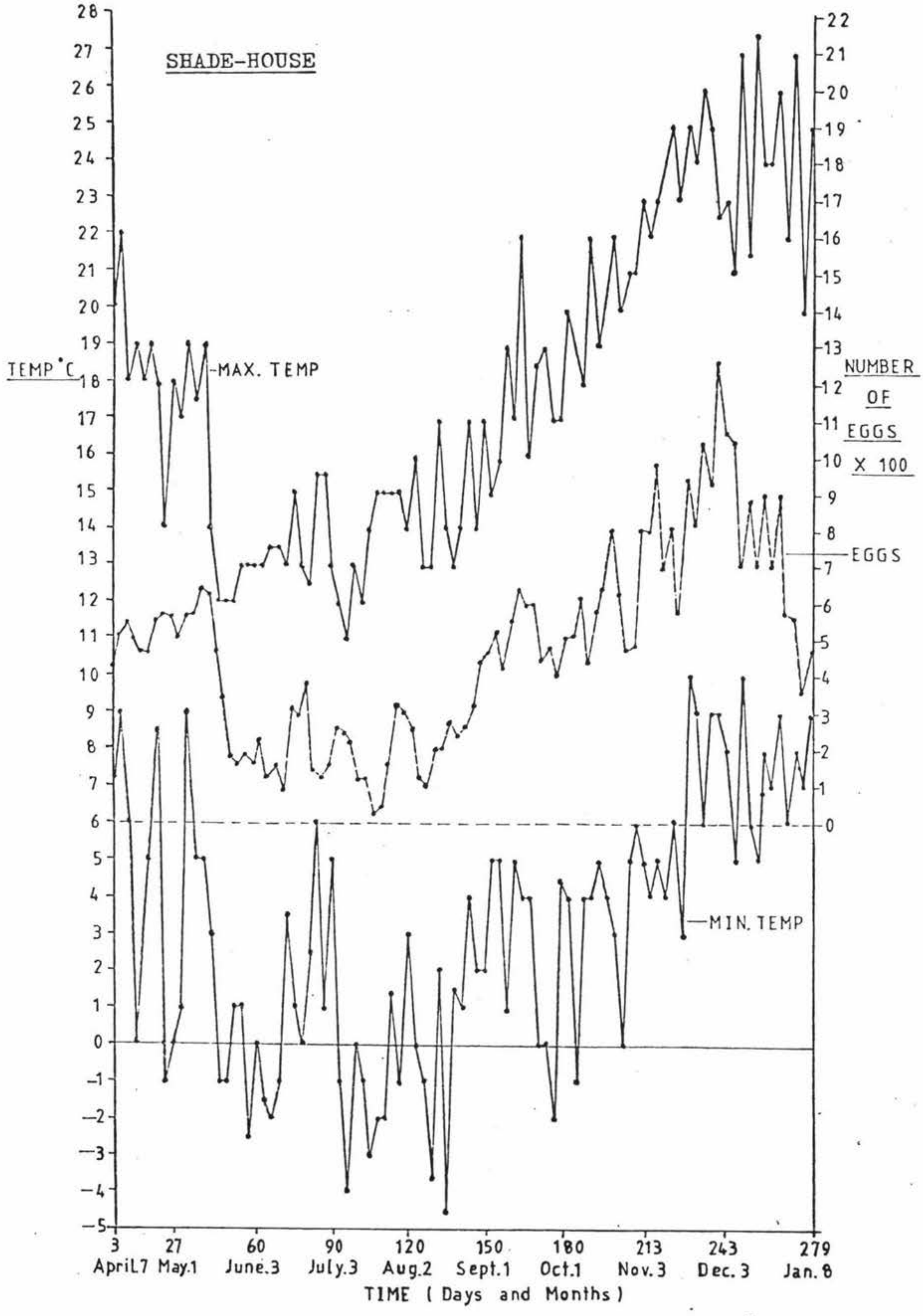


Fig. 13 Comparison of eggs oviposited in Shade-house with Maximum and Minimum Temperature, for each collection date.(3-point running means were plotted for the eggs)

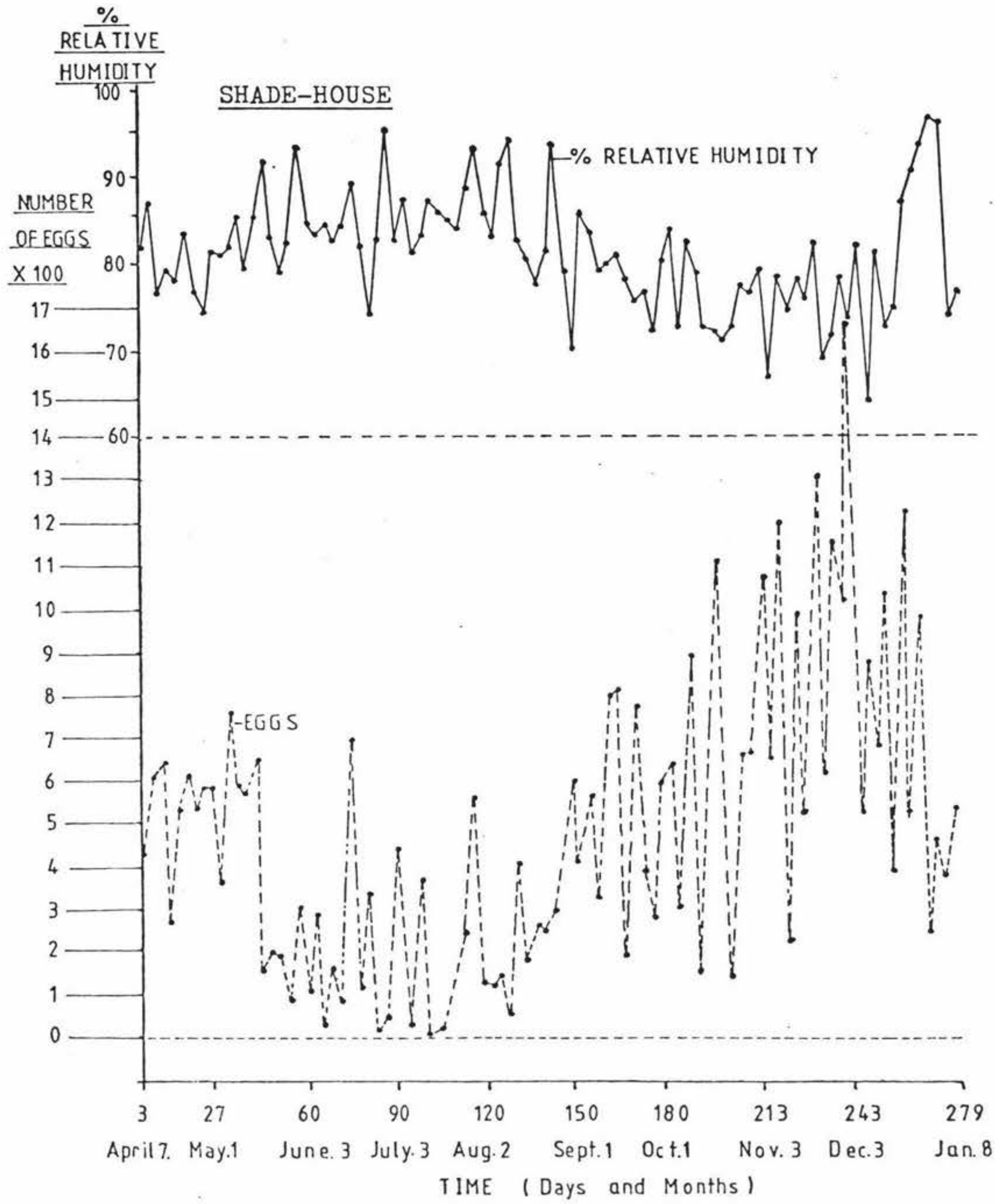


Fig. 14 Comparison of total eggs oviposited in the Shade-house with % Relative Humidity.

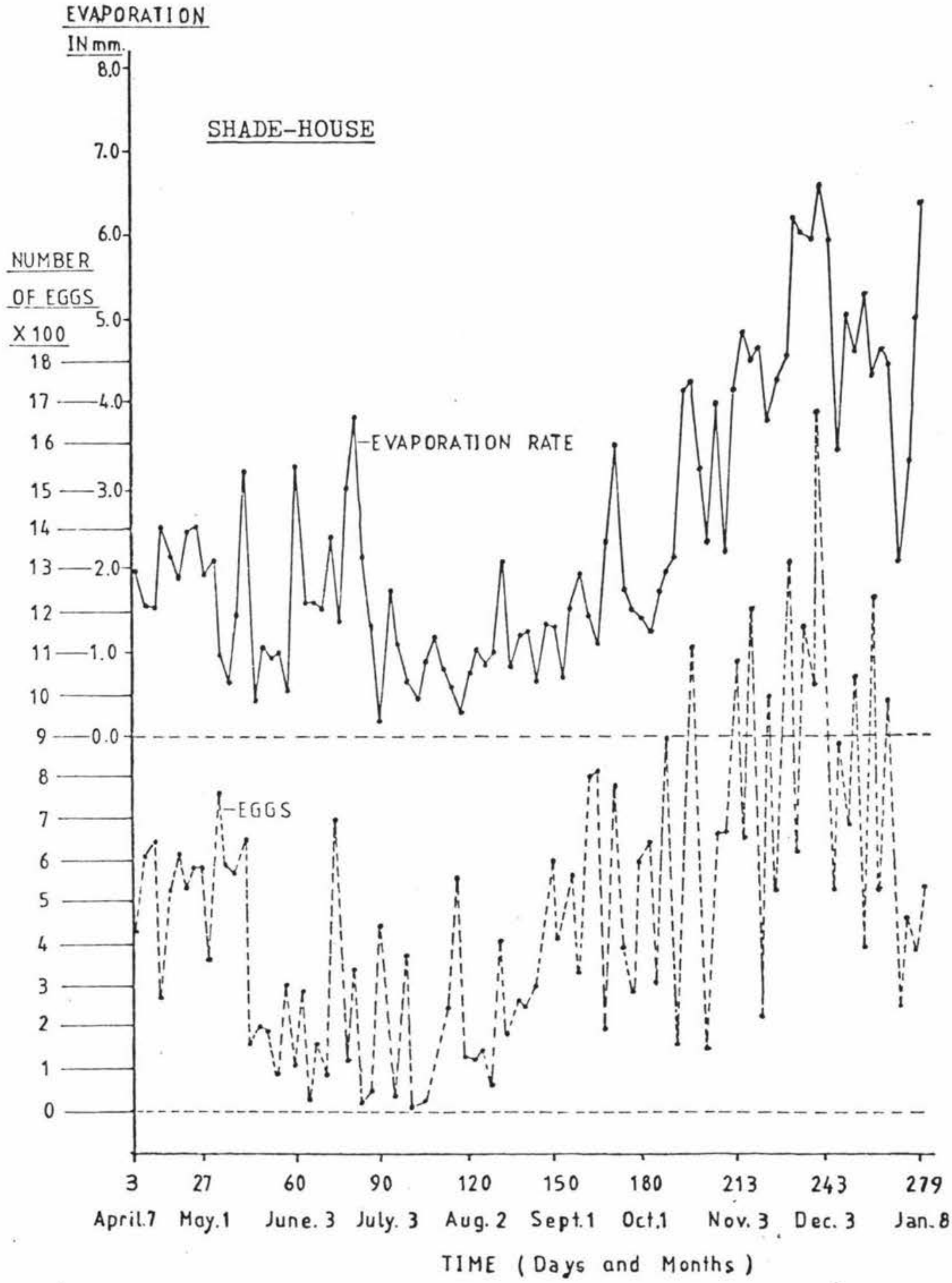


Fig. 15 Comparison of total eggs oviposited in the Shade-house with Evaporation Rate in mm. per unit Time.

EFFECT OF TEMPERATURE ON HATCHING SUCCESS

The results of this part of the experiment are plotted on Fig.16 . The seasonal pattern of all four temperatures show a similar trend by a greater hatching success in the warmer Summer months, and a very much lower hatching success, tending towards zero in the Winter months of July to October. The time taken for eggs to hatch is temperature dependent, taking shorter for warmer temperatures, and very much longer for the lower temperatures.

The seasonal variation at the four temperatures of the fate of the eggs incubated, is shown on Fig. 16. The data are in Appendix IX. The seasonal totals, and the averages calculated from these are shown on Table XII , plus the expected deviation from the mean.

The hatching range is the time taken from when the first egg hatched from that batch, to when the last egg hatched. This is temperature dependent. Development within the egg and failing to hatch, seems to occur in greater numbers at the 24°C temperature, and a possible cause could be a more favourable environment for moulds to attack the eggs.

A One-way analysis of varience has been calculated for the following to determine if there were significant differences between temperatures.

(1) Hatching success at different temperatures;

$F_{3,72}$ = 0.749 . Result shows no significant difference at the 1% level.

(2) Time taken for first egg to hatch at different temperatures.

$F_{3,56}$ = 56.460 . Results are significantly different from each other at the 1% level.

(3) Hatching range of eggs at the four different temperatures.

$F_{3,56}$ = 8.617 . Results are significantly different from each other at the 1 % level.

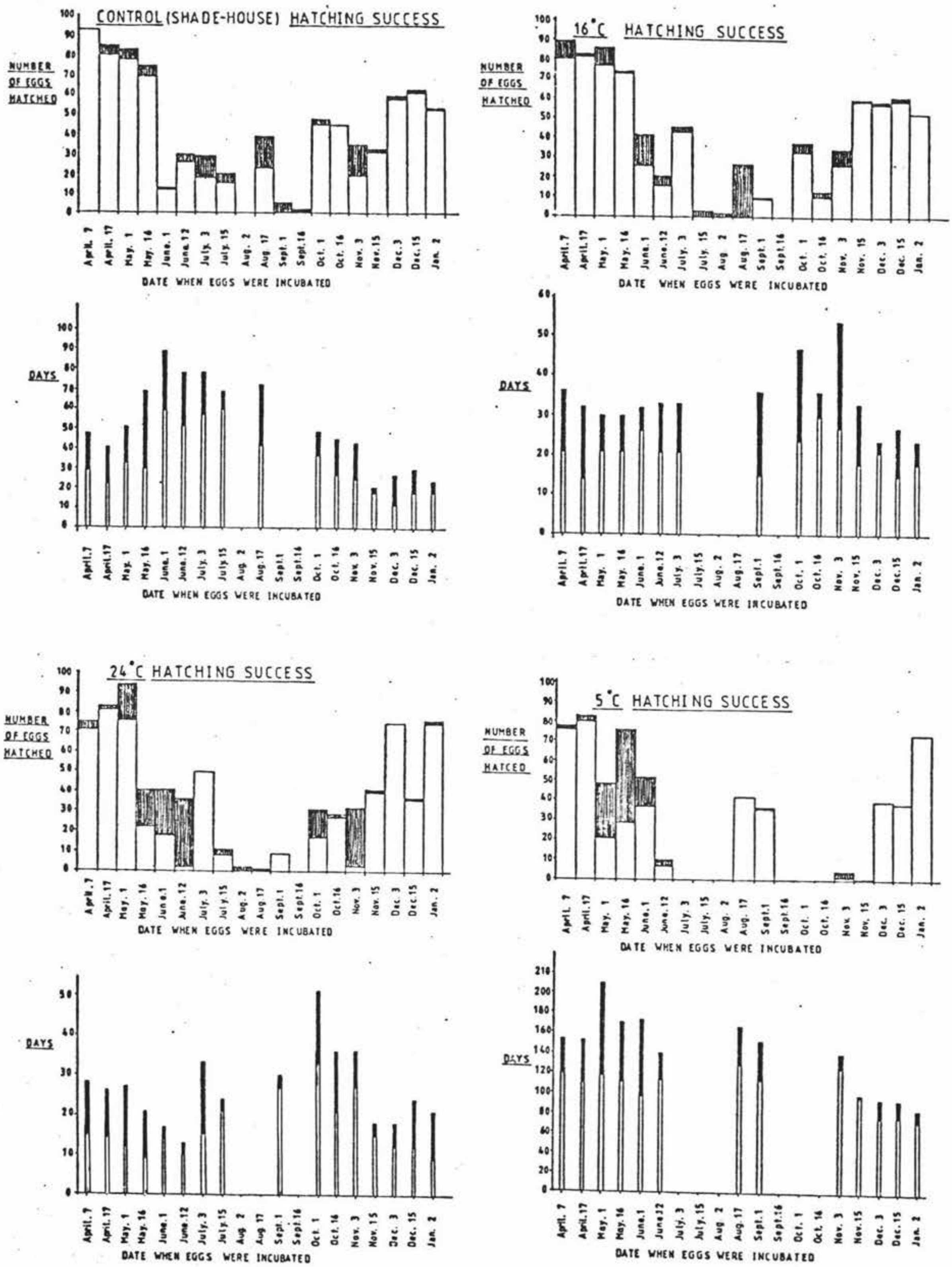
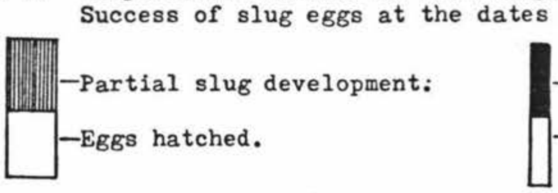


Fig. 16 Comparisons between the four temperatures for Hatching-Success of slug eggs at the dates shown.



—Partial slug development.

—Eggs hatched.

-Hatching Range (Days)

-Time taken for the first eggs to hatch. (Days)

Table XII

THE TOTALS AND AVERAGES OF THE FATE OF EGGS INCUBATED AT THE FOUR TEMPERATURES. SEASONAL TOTAL OF EGGS INCUBATED = 1900 AT EACH TEMPERATURE.

Location	Total eggs hatched	Total partial development	Total showing no development	Days taken for 1st egg to hatch.	Hatching range in days.
24°C					
Seasonal total	610	154	1136	264	159
Incubation averages	32.11%	8.10%	59.79%	16.5	9.94
Std. Dev.	±30.21%	±11.05%	±29.13%	±7.2	±5.64
16°C					
Seasonal total	703	99	1098	313	194
Incubation averages	37.00%	5.21%	57.79%	20.87	12.93
Std. Dev.	±29.82%	±6.63%	±29.29%	±4.55	±6.94
Control (Shade-house)					
Seasonal total	727	91	1082	539	295
Incubation averages	38.26%	4.79%	56.95 %	33.69	18.44
Std. Dev.	±29.21%	±5.30%	±28.32 %	±15.78	±9.48
5°C					
Seasonal total	483	103	1314	1344	494
Incubation averages	25.42%	5.42%	69.16%	103.38	38.00
Std. Dev.	±28.06%	±12.23%	±31.30%	±18.50	±31.25

THE EFFECT OF TEMPERATURE ON SLUG SURVIVAL

The adult slugs used in this experiment were selected at random from the field. The age of the slugs could not be determined by visual examination, and it was assumed that the slugs were mature on the basis of their body length (Materials + Methods). The slugs used for each temperature were randomly picked from the holding boxes, and the number of slugs used for each collection date for the duration of the experiment is shown on figure 17, and Appendix X. The cumulative number of slugs used in the experiment are shown on figure 12, and Appendix VII .

To test for differences in the number of slugs that died for each of the five boxes, held at each temperature for each collection date, a One-way analysis of varience was carried out. F values being;

Shade-house $F_{4,460} = 0.096$

16 °C $F_{4,460} = 0.117$

24 °C $F_{4,460} = 0.691$

5 °C $F_{4,460} = 0.548$

There was no significant difference at the 1% level between boxes.

To test for differences in the number of slugs that died between the temperatures, a t-test was done comparing the the three constant temperatures with Shade-house. t values obtained were ;

Shade-house with 16°C $t = 12.24$

" " " 24°C $t = 5.85$

" " " 5°C $t = 10.02$

Results show a significant difference at the 1% level between temperatures on slug survival. The average number of days that each slug survived for each temperature in the experiment is shown on Table XIII. Slugs survive for the longest period of time at 5°C, and shortest at 24 °C.

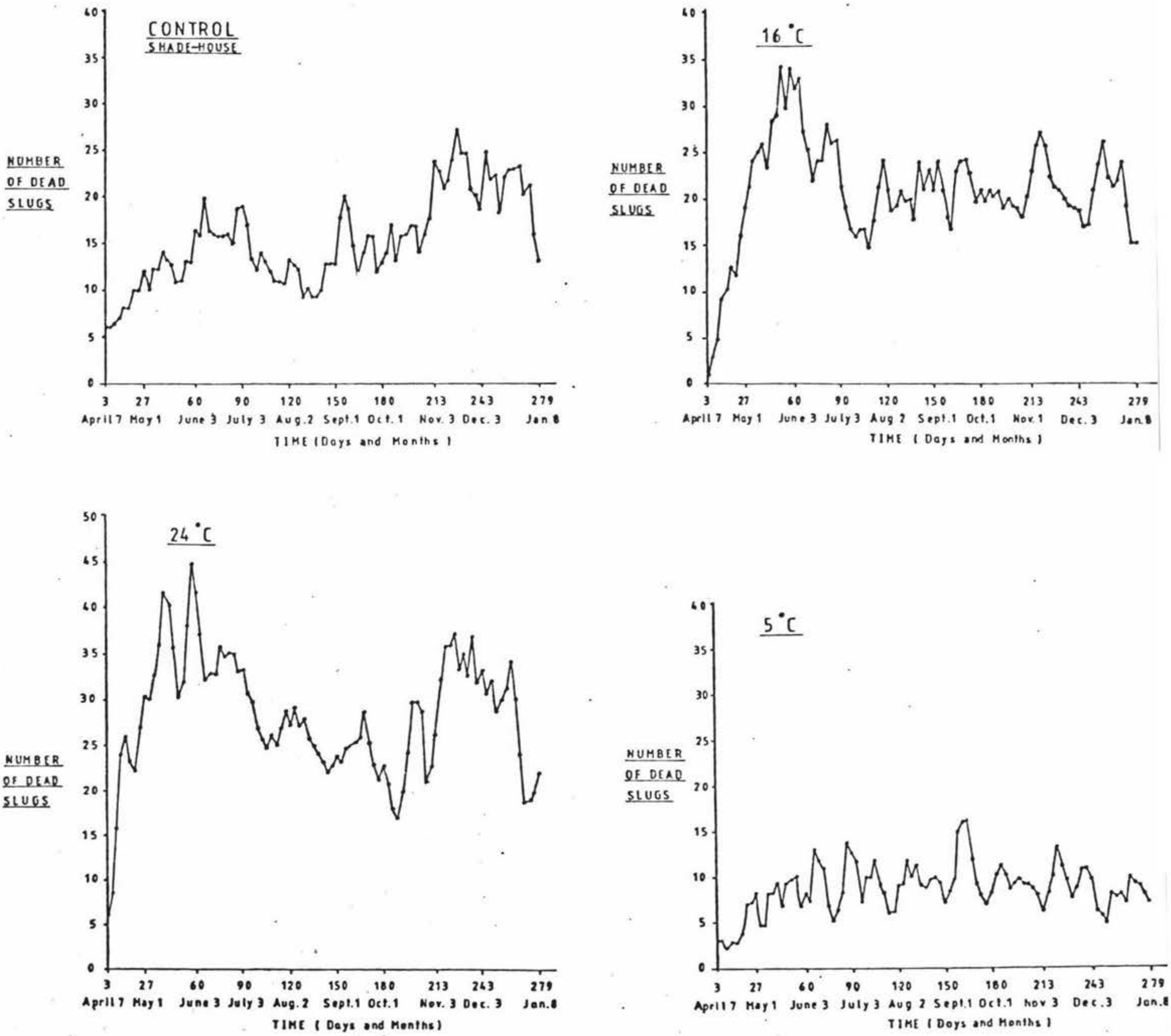


Fig. 17 The survival of slugs with Time.

TABLE XIII

THE NUMBER OF DAYS A SLUG CAN BE EXPECTED TO SURVIVE AT EACH OF THE FOUR TEMPERATURES

The formula for calculating slug survival is; $d = \frac{C \times D}{N - C}$

C = Constant number of 150 slugs.

D = Total number of days of experiment.

N = Number of slugs used.

d = Number of days slug survived in the experiment.

Location	Calculation	d = days of survival
Shade-house	$\frac{150 \times 279}{1429 - 150}$	= 32.72
16 °C	$\frac{150 \times 279}{1958 - 150}$	= 23.15
24 °C	$\frac{150 \times 279}{2634 - 150}$	= 16.85
5 °C	$\frac{150 \times 279}{813 - 150}$	= 63.12

PART B

THE EFFECTS CAUSED BY AGRICULTURAL and HORTICULTURAL CHEMICALS ON THE SLUGS D.RETICULATUM and D.PANORMITANUM

BIOCIDES USED AS BAITS (INGESTION)

All 83 chemicals used in this experiment were tested (screened) as baits against the two species of adult slugs. The mean percentage killed for days 2,5,8,and 10, are shown on Table XIV . Biocides that showed killing potential were used against juvenile slugs, and these results are also recorded on the same table. Biocides that showed biocidal activity against the slugs were the insecticides methamidophos, methiocarb, methomyl, and phorate, the herbicides chlorpropham, ioxynil, paraquat, and 2,4,5-T, the molluscicide metaldehyde, and 12 of the combinations.

BIOCIDES USED AS CONTACT (SPRAY)

All 83 chemicals were tested for contact biocidal properties against the adults of the two slug species, and their eggs. The mean percentage of slugs killed for the days 2,5,8,and 10, are shown on Table XV. This table also shows the percentage of eggs killed. Mortality rate of eggs is calculated in relation to the number of eggs hatched in the control for that batch.

$$\% \text{ killed} = 100 \times \frac{\text{No. of control eggs hatched} - \text{No. treated eggs hatched}}{\text{No. of control eggs hatched}}$$

With eggs, where pathogenic organisms such as bacteria and fungi have been inhibited by the biocidal treatment, the number of eggs hatched was greater than in the controls. These numbers are marked by a (+) symbol. Biocides that showed biocidal activity against the slugs are the fungicides benomyl, carbendazim, thiophanate and thiram, the insecticides carbaryl, dazomet, methiocarb, methomyl, and phorate.

TABLE XIV

THE PERCENTAGE OF SLUGS THAT HAVE DIED FOLLOWING THE INGESTION OF BIOCIDES. THE NUMBER OF REPEATS ARE SHOWN WITH RESULTS FOR DAYS 2,5,8, and 10, FOR BOTH AGES AND SPECIES.

Biocide	Number of repeats	D.panormitanum ADULTS % of slugs dead				D.panormitanum JUVENILES % of slugs dead				D.reticulatum ADULTS % of slugs dead				D.reticulatum JUVENILES % of slugs dead			
Day number		2	5	8	10	2	5	8	10	2	5	8	10	2	5	8	10
Fungicide																	
Benomyl	3	3.3	10.0	26.7	30.0		6.7	10.0	10.0		3.3	10.0	10.0		3.3	3.3	6.7
Captafol	3	3.3	10.0	13.3	23.3		13.3	16.7	16.7	13.3	26.7	40.0	53.3				3.3
Captan	1		20.0	20.0	20.0				-				20.0				-
Carbaryl+Mancozeb	3	6.7	10.0	36.7	46.7		10.0	13.3	13.3	3.3	20.0	33.3	40.0	3.3	33.3	46.7	66.7
Carbendazim	1				-				-				-				-
Copperoxychloride	1				10.0				-		10.0	10.0	20.0				-
Dichlofluanid	3		4.0	8.0	8.0		3.3	23.3	26.7		6.0	12.0	18.0	6.7	13.3	33.3	40.0
Dimethirimol	3	3.3	6.7	16.7	20.0		3.3	3.3	3.3		3.3	20.0	23.3	3.3	10.0	16.7	16.7
Dinocap	1		10.0	20.0	40.0				-		10.0	20.0	20.3				-
Maneb	1				20.0				-				10.0				-
Propineb	1			10.0	20.0				-		10.0	10.0	20.0				-
Pyrazophos	3		3.3	10.0	13.3	6.7	6.7	16.7	36.7		6.7	13.3	16.7		13.3	20.0	20.0
Thiophanate	1				10.0				-	10.0	20.0	40.0	40.0				-
Thiophanate-methyl	1				20.0				-				-				-
Thiram	1				-				-				20.0				-
Vinclozolin	1				10.0				-		20.0	30.0	30.0				-
Insecticides																	
Arsenate of Lead	3	6.7	13.3	16.7	33.3		6.7	6.7	6.7	3.3	10.0	23.3	30.0		6.7	6.7	6.7
Carbaryl	3	10.0	20.0	35.0	45.0		16.7	16.7	20.0	5.0	12.5	27.8	37.5		3.3	3.3	13.4
Dazomet	1	10.0	10.0	20.0	20.0				-		10.0	20.0	20.0				-
D.D.T.	3	3.3	10.0	23.3	33.3		13.3	20.0	20.0		3.3	10.0	16.7	3.3	23.3	33.3	43.3
Demeton-s-methyl	3			16.7	30.0		16.7	26.7	30.0		3.3	23.3	36.7	3.3	23.3	43.3	50.0
Fensulfothion	1				10.0				-	10.0	10.0	20.0	40.0				-
Gamma - HCH	3	3.3	6.7	20.0	26.7		3.3	13.3	16.7	6.7	10.0	13.3	16.7	3.3	20.0	40.0	46.7
Malathion	1		20.0	30.0	30.0							10.0	30.0				-
Maldison	3		6.7	13.3	20.0		13.3	20.0	50.0		3.3	6.7	10.0		26.7	50.0	63.3
Methamidophos	3	3.3	6.7	33.3	33.3	10.0	60.0	76.7	80.0	3.3	20.0	40.0	56.7	13.3	50.0	70.0	80.0
Methiocarb	3	40.0	73.3	96.7	96.7	50.0	86.7	100.	100.	53.3	70.0	83.3	93.3	46.7	93.3	100.	100.
Methomyl (liquid)	3	23.3	60.0	83.3	100.	43.3	80.0	86.7	90.0	13.3	43.3	76.7	90.0	30.0	36.7	43.3	43.3
Methomyl (powder)	3	36.7	70.0	96.7	96.7	60.0	90.0	93.3	93.3	40.0	76.7	93.3	96.7	26.7	73.3	100.	100.
Mineral oil	1				-				-			30.0	30.0				-
Parathion-methyl	1			30.0	30.0				-			10.0	40.0				-
Phorate	3	26.7	80.0	86.7	93.3	20.0	63.3	73.3	76.7	20.0	100.	100.	100.	20.0	63.3	73.3	76.7
Rotenone	1			20.0	20.0							20.0	20.0				-

TABLE XIV cont..

THE PERCENTAGE OF SLUGS THAT HAVE DIED FOLLOWING THE INGESTION OF BIOCIDES. THE NUMBER OF REPEATS ARE SHOWN WITH RESULTS FOR DAYS 2,5,8,and 10, FOR BOTH AGES AND SPECIES.

Biocide	Number of repeats	*D.panormitanum* ADULTS % of slugs dead				*D.panormitanum* JUVENILES % of slugs dead				*D.reticulatum* ADULTS % of slugs dead				*D.reticulatum* JUVENILES % of slugs dead			
Day number		2	5	8	10	2	5	8	10	2	5	8	10	2	5	8	10
Herbicide																	
Alachlor	3		10.0	20.0	36.7		20.0	30.0	30.0	3.3	20.0	26.7	36.7	6.7	30.0	60.0	80.0
Aminotriazole + ammon. thiocyanate	1		10.0	20.0	20.0				-				0.0				
Aminotriazole	1				20.0				-		20.0	30.0	30.0				
Asulam	1				10.0				-			10.0	20.0				
Bentazone	1		10.0	20.0	30.0				-		20.0	20.0	20.0				
Chlorbufam+pyrazon	3	3.3	6.7	13.3	13.3			6.7	6.7		6.7	10.0	13.3				3.3
Chlorpropham	3		10.0	23.3	30.0		6.7	13.3	33.3	16.7	40.0	56.7	73.3	3.3	20.0	46.7	56.7
Chlorthal-dimethyl	1				10.0				-			10.0	10.0				
Dalapon	1				0.0				-			10.0	20.0				
Glyphosate	3	3.3	10.0	10.0	26.7	3.3	6.7	16.7	20.0		6.7	6.7	10.0	10.0	13.3	23.3	23.3
Ioxynil	3	16.7	46.7	50.0	60.0	10.0	40.0	50.0	56.7	33.3	83.3	86.7	90.0	16.7	56.7	66.7	70.0
Linuron	1		20.0	20.0	20.0				-		10.0	10.0	30.0				
Methabenzthiazuron	3		10.0	20.0	40.0		3.3	13.3	20.0	3.3	13.3	20.0	20.0		13.3	33.3	50.0
Methazole	1			30.0	40.0							20.0	20.0				
Metribuzin	1			10.0	30.0						10.0	20.0	30.0				
M.C.P.A.	3			23.3	33.3	30.0	43.3	56.7	66.7	3.3	20.0	23.3	26.7	13.3	50.0	63.3	76.7
Paraquat (dichloride)	3	3.3	3.3	36.7	63.3		10.0	43.3	96.7		10.0	40.0	60.0		33.3	76.7	90.0
Paraquat (dimethylsulphate)	3	3.3	13.3	46.7	70.0	10.0	16.7	36.7	90.0		10.0	63.3	83.3	10.0	16.7	56.7	83.3
Paraquat-diquat	3		10.0	16.7	23.3			20.0	23.3	3.3	13.3	16.7	20.0	6.7	26.7	50.0	63.3
Picloram + 2,4,5-T	3	6.7	20.0	33.3	36.7	6.7	16.7	16.7	26.7		10.0	23.3	30.0	3.3	13.3	36.7	43.3
Prometryne	3	3.3	13.3	23.3	43.3	6.7	26.7	30.0	30.0		10.0	26.7	43.3	6.7	13.3	16.7	20.0
Propachlor	1		10.0	20.0	20.0				-		10.0	10.0	10.0				
Propyzamide	1			30.0	30.0				-			10.0	20.0				
Sodium chlorate	1		10.0	20.0	30.0				-			10.0	10.0				
Sulfallate	3		3.3	20.0	30.0		3.3	13.3	20.0	3.3	6.7	13.3	26.7			3.3	13.3
2,4-D	1		10.0	20.0	30.0				-		10.0	20.0	30.0				
2,4,5-T	4	13.3	20.0	30.0	45.0	10.0	15.0	30.0	32.5	20.0	27.5	55.0	67.5	2.5	7.5	15.0	17.5

TABLE XIV cont..

THE PERCENTAGE OF SLUGS THAT HAVE DIED FOLLOWING THE INGESTION OF BIOCIDES. THE NUMBER OF REPEATS ARE SHOWN WITH RESULTS FOR DAYS 2,5,8,and 10, FOR BOTH AGES AND SPECIES.

Biocides	Number of repeats	*D.panormitanum* ADULTS % of slugs dead				*D.panormitanum* JUVENILES % of slugs dead				*D.reticulatum* ADULTS % of slugs dead				*D.reticulatum* JUVENILES % of slugs dead			
Day number		2	5	8	10	2	5	8	10	2	5	8	10	2	5	8	10
Chemicals																	
Alkylarylpolyglycol	1			10.0	10.0				-			10.0	10.0				
Chloromethane sulfonamide.	1			10.0	10.0				-		20.0	30.0	30.0				
Coumatetralyl	1		10.0	30.0	30.0				-		10.0	10.0	60.0				
Cupric sulphate	1			10.0	10.0				-				20.0				
Diethylene dioxide	1	10.0	10.0	10.0	10.0				-		10.0	20.0	20.0				
Maleic hydrazide	1			10.0	30.0				-			10.0	10.0				
Metaldehyde 3%	3	30.0	50.0	76.7	83.3	40.0	50.0	100	100	20.0	50.0	63.3	73.3	60.0	73.3	86.7	96.7
Potassium cyanide	1		10.0	10.0	30.0				-	10.0	10.0	10.0	20.0				
Strychnine hydrochloride	1		20.0	50.0	50.0				-				10.0				
Combinations																	
Alachlor + carbaryl	3	3.3	20.0	26.7	26.7	3.3	26.7	26.7	26.7			3.3	3.3			16.7	26.7
Alachlor + ioxynil	3	6.7	13.3	23.3	23.3	3.3	26.7	36.7	36.7			20.0	20.0	3.3	6.7	23.3	26.7
Alachlor + methiocarb	3	43.3	83.3	86.7	86.7	16.7	43.3	46.7	60.0	23.3	53.3	66.7	80.0	20.0	46.7	66.7	66.7
Alachlor + methomyl	3	26.7	63.3	73.3	83.3	20.0	43.3	46.7	46.7	13.3	50.0	60.0	76.7		33.3	36.7	50.0
Alachlor + 2,4,5-T	3		10.0	16.7	16.7	10.0	16.7	16.7	23.3			10.0	10.0			3.3	13.3
Carbaryl + ioxynil	3	3.3	20.0	26.7	26.7	3.3	30.0	30.0	30.0	40.0	53.3	60.0	63.3		20.0	23.3	33.3
Carbaryl + methiocarb	3	70.0	93.3	100	100	50.0	70.0	73.3	73.3	76.7	93.3	96.7	96.7	80.0	80.0	83.3	90.0
Carbaryl + methomyl	3	76.7	90.0	96.7	96.7	60.0	73.3	76.7	80.0	56.7	73.3	76.7	76.7	76.7	80.0	90.0	96.7
Carbaryl + 2,4,5-T	3	33.3	46.7	63.3	63.3	6.7	16.7	26.7	26.7	46.7	50.0	66.7	66.7	6.7	6.7	10.0	10.0
Ioxynil + methiocarb	3	36.7	73.3	83.3	83.3	16.7	23.3	30.0	33.3	66.7	83.3	93.3	93.3	13.3	70.0	80.0	80.0
Ioxynil + methomyl	3	40.0	66.7	80.0	90.0	30.0	66.7	73.3	73.3	70.0	100	100	100	26.7	66.7	66.7	76.7
Ioxynil + 2,4,5-T	3	66.7	86.7	96.7	96.7	6.7	26.7	26.7	26.7	40.0	73.3	86.7	96.7	6.7	13.3	16.7	20.0
Methiocarb + methomyl	3	70.0	86.7	96.7	96.7	90.0	93.3	93.3	93.3	70.0	86.7	86.7	96.7	80.0	83.3	86.7	93.3
Methiocarb + 2,4,5-T	3	16.7	50.0	76.7	76.7	60.0	76.7	76.7	76.7	43.3	80.0	86.7	90.0	90.0	100	100	100
Methomyl + 2,4,5-T	3	46.7	86.7	93.3	96.7	16.7	40.0	60.0	66.7	56.7	90.0	93.3	93.3		26.7	50.0	63.3

TABLE XV

THE PERCENTAGE OF SLUGS THAT HAVE DIED BY DAY 2,5,8, and 10 FOLLOWING CONTACT WITH BIOCIDES. THE PERCENTAGE OF EGGS THAT FAILED TO DEVELOP AND HATCH COMPARED TO CONTROLS IS SHOWN. THE (+) SIGN INDICATES THE PERCENTAGE INCREASE IN HATCHING OF EGGS OVER CONTROL.

Biocides	Adult repeats	*D.panormitanum* % Adults dead				Repeats	Eggs % not hatch	Eggs % control hatch	*D.reticulatum* % Adults dead				Repeats	Eggs % not hatch	Eggs % control hatch
Day number		2	5	8	10				2	5	8	10			
Fungicides															
Benomyl	1				-	4	100	56.0				-	4	100	56.0
Captafol	3		6.7	20.0	23.3	4	2	53.7		16.7	16.7	20.0	2	+5	65.0
Captan	1			10.0	10.0	2	3	54.0				-	2	+7	57.0
Carbaryl + Mancozeb	1				-	4	14	51.5				-	4	16	71.7
Carbendazim	3		3.3	6.7	16.7	4	100	53.8		10.0	10.0	13.3	4	100	66.3
Copper oxychloride	1				-	4	+8	50.8				-	2	+9	79.5
Dichlofluanid	1		10.0	10.0	10.0	4	5	53.7				-	2	+9	73.0
Dimethirimol	3		13.3	23.3	26.7	4	13	51.4		6.7	13.3	13.3	4	+10	59.5
Dinocap	1				10.0	4	2	41.3				-	2	9	79.5
Maneb	1				10.0	4	18	57.0				10.0	2	9	62.3
Propineb	1				-	2	2	54.0				-	2	+2	79.5
Pyrazophos	3			10.0	13.3	2	4	51.5		6.7	13.3	20.0	2	+4	62.3
Thiophanate	1			10.0	10.0	4	83	47.4				-	4	100	68.7
Thiophanate-methyl	1				10.0	4	99	54.0			10.0	10.0	4	100	71.8
Thiram	1				-	4	92	50.4				-	4	100	63.2
Vinclozolin	1				-	4	5	47.3				-	2	4	82.0
Insecticides															
Arsenate of lead	3		16.7	23.3	23.3	2	+15	43.5	3.3	10.0	20.0	33.3	2	+38	56.0
Carbaryl	3	3.3	26.7	30.0	30.0	4	56	57.5		30.0	43.3	46.7	4	67	69.2
Dazomet	3	6.7	63.3	80.0	83.3	4	19	46.3	3.3	60.0	86.7	90.0	2	+8	79.0
D.D.T.	3	3.3	13.3	13.3	23.3	4	+2	55.8		6.7	16.7	23.3	2	+2	73.0
Demeton-S-methyl	1		10.0	10.0	10.0	2	+3	73.5				-	2	+1	79.0
Fensulfothion	1				-	4	17	51.5		10.0	10.0	10.0	2	8	57.0
Gamma - HCH	1			10.0	10.0	4	1	54.3				10.0	2	+13	72.5
Malathion	1				-	2	+3	73.5		10.0	10.0	10.0	2	+11	72.5
Maldison	1		10.0	10.0	10.0	4	4	52.8				-	2	0	72.5
Methamidophos	1				10.0	4	0	53.7				-	2	+25	65.0
Methiocarb	3	6.7	16.7	33.3	33.3	4	95	46.4		6.7	20.0	26.7	4	96	62.3
Methomyl (liquid)	3	6.7	16.7	30.0	36.7	4	6	46.7	6.7	36.7	50.0	53.3	4	44	70.8
Methomyl (powder)	1		10.0	10.0	10.0	4	82	53.8		10.0	10.0	10.0	4	94	74.5
Mineral oil	3		3.3	6.7	13.3	4	+6	46.3		3.3	6.7	6.7	2	+3	79.0
Parathion-methyl	1		10.0	10.0	10.0	4	11	50.4				10.0	4	47	68.8
Phorate	3	20.0	46.7	76.7	93.3	2	6	51.5	43.3	80.0	100	100	2	4	57.0
Rotenone	1				-	4	35	56.5			10.0	10.0	2	+3	79.5

TABLE XV cont..

THE PERCENTAGE OF SLUGS THAT HAVE DIED BY DAY 2,5,8, and 10, FOLLOWING CONTACT WITH BIOCIDES. THE PERCENTAGE OF EGGS THAT FAILED TO DEVELOP AND HATCH COMPARED TO CONTROL IS SHOWN. THE (+) SIGN INDICATES THE PERCENTAGE INCREASE IN HATCHING OF EGGS OVER CONTROL.

Biocides	Adult repeats	D.panormitanum % Adults dead				Repeats	Eggs % not hatch	Eggs % control hatch	D.reticulatum % Adults dead				Repeats	Eggs % not hatch	Eggs % control hatch
Day number		2	5	8	10				2	5	8	10			
Herbicides															
Alachlor	1				-	4	59	51.4				-	4	100	71.3
Aminotriazole + Ammon. thiocyanate	1				-	4	38	51.3				-	2	+12	65.0
Aminotriazole	1				-	4	+8	51.7				-	2	+26	56.0
Asulam	1				-	4	+16	51.7		10.0	10.0	10.0	2	+ 9	56.0
Bentazone	1				-	4	+26	51.7				-	2	+ 3	73.0
Chlorbufam + pyrazon	1				-	4	3	44.7				-	4	+ 8	70.5
Chlorpropham	1				-	4	57	61.0				-	4	41	71.3
Chlorthal-dimethyl	1				-	4	+8	58.8				-	2	+11	79.5
Dalapon	1				-	2	1	51.5				10.0	2	+20	62.3
Glyphosate	3	3.3	3.3	10.0	16.7	2	6	73.5		3.3	10.0	13.3	2	+7	72.5
Ioxynil	1				-	4	11	46.7				-	4	+20	61.7
Linuron	1				-	2	13	53.5				-	4	20	68.5
Methabenzthiazuron	1				-	4	+1	49.2				-	2	+29	65.0
Methazole	1				-	4	54	56.3				10.0	4	7	68.5
Metribuzin	1		10.0	10.0	10.0	4	+8	46.3				-	4	23	71.8
M.C.P.A.	1				-	4	27	53.7			10.0	10.0	2	+32	65.0
Paraquat (dichloride)	1				-	4	100	41.4				-	4	100	77.3
" " (dimetylsulphate)	1				-	4	100	54.4				-	4	100	65.5
Paraquat-diquat	3		3.3	3.3	6.7	4	+18	51.7		10.0	16.7	26.7	2	2	73.0
Picloram + 2,4,5-T	3			6.7	6.7	2	+10	45.5		3.3	16.7	16.7	2	6	62.3
Prometryne	1				10.0	4	30	48.8				-	2	10	62.3
Propachlor	1				10.0	4	97	61.3				-	4	100	74.0
Propyzamide	1		10.0	10.0	10.0	4	99	44.3				-	4	100	68.5
Sodium chlorate	1				-	2	0	45.5				-	2	10	82.0
Sulfallate	1			10.0	10.0	4	+1	46.7				10.0	2	39	62.3
2,4-D	3	3.3	3.3	6.7	16.7	4	+20	52.3	10.0	16.7	20.0	23.3	2	+14	72.5
2,4,5-T	3	10.0	16.7	26.7	33.3	4	+8	60.0	30.0	56.7	63.3	63.3	4	11	60.4

TABLE XV cont..

THE PERCENTAGE OF SLUGS THAT HAVE DIED BY DAY 2,5,8, and 10, FOLLOWING CONTACT WITH BIOCIDES. THE PERCENTAGE OF EGGS THAT FAILED TO DEVELOP AND HATCH COMPARED TO CONTROLS IS SHOWN. THE (+) SIGN INDICATES THE PERCENTAGE INCREASE IN HATCHING OF EGGS OVER CONTROL.

Biocides	Adult repeats	*D.panormitanum* % Adults dead				Repeats	Eggs % not hatch	Eggs % control hatch	*D.reticulatum* % Adults dead				Repeats	Eggs % not hatch	Eggs % control hatch
Day number		2	5	8	10				2	5	8	10			
Chemicals															
Alkylarylpolyglycol	1				10.0	4	59	53.0			10.0	10.0	2	4	79.5
Chloromethane sulfonamide	3		3.3	6.7	6.7	4	2	44.8			10.0	16.7	2	+2	72.5
Coumatetralyl	1				-	2	+15	40.5				-	4	7	71.5
Cupric sulphate	3	16.7	56.7	66.7	73.3	4	86	53.8		13.3	20.0	26.7	4	92	66.0
Diethylene dioxide	3	3.3	20.0	23.3	23.3	4	+3	52.2		3.3	3.3	3.3	2	+10	73.0
Maleic hydrazide	1		10.0	10.0	10.0	4	+6	42.8				-	2	+1	57.0
Metaldehyde (20%)	3	60.0	83.3	90.0	90.0	4	100	44.9	30.0	56.7	83.3	93.3	4	100	68.3
Potassium cyanide	1		20.0	30.0	30.0	4	+3	54.5	10.0	20.0	20.0	20.0	2	+23	72.5
Strychnine hydrochloride	1		10.0	10.0	10.0	4	+11	46.3				-	4	44	81.0
M.C.P.A. (fumigant)	3		3.3	3.3	3.3					6.7	6.7	6.7			
Methiocarb (fumigant)	3	3.3	16.7	20.0	26.7				3.3	33.3	60.0	60.0			
Combinations															
Alachlor + carbaryl	3	33.3	53.3	60.0	63.3	4	74	57.5	3.3	26.7	26.7	30.0	4	88	69.5
Alachlor + ioxynil	3	6.7	6.7	13.3	13.3	4	22	62.8	6.7	13.3	16.7	16.7	4	89	70.5
Alachlor + methiocarb	3	6.7	30.0	36.7	43.3	4	100	56.5		6.7	6.7	10.0	4	100	73.8
Alachlor + methomyl	3	20.0	73.3	80.0	83.3	4	29	54.0		46.6	53.3	53.3	4	97	78.0
Alachlor + 2,4,5-T	3	26.7	56.7	56.7	56.7	4	26	46.3	36.7	56.7	56.7	56.7	4	100	61.0
Carbaryl + ioxynil	3	20.0	50.0	56.7	56.7	4	66	62.8	13.3	46.7	53.3	53.3	4	47	62.3
Carbaryl + methiocarb	3	13.3	76.7	93.3	96.7	4	97	47.8		76.7	86.7	86.7	4	69	69.5
Carbaryl + methomyl	3	33.3	96.7	100	100	4	91	62.8		96.7	100	100	4	82	65.3
Carbaryl + 2,4,5-T	3	23.3	63.3	73.3	73.3	4	64	46.3	56.7	93.3	96.7	100	4	60	66.3
Ioxynil + methiocarb	3		16.7	23.3	26.7	4	88	56.5	6.7	33.3	46.7	46.7	4	57	70.5
Ioxynil + methomyl	3	13.3	43.3	46.7	50.0	4	31	62.8		36.7	46.7	50.0	4	37	78.0
Ioxynil + 2,4,5-T	3	10.0	20.0	26.7	26.7	4	6	47.8	10.0	40.0	50.0	50.0	4	+6	66.3
Methiocarb + methomyl	3	40.0	86.7	96.7	100	4	100	54.0	3.3	76.7	83.3	90.0	4	99	70.5
Methiocarb + 2,4,5-T	3	43.3	73.3	73.3	73.3	4	96	47.8	56.7	63.3	66.7	70.0	4	49	61.0
Methomyl + 2,4,5-T	3	30.0	70.0	80.0	83.3	4	25	47.8	60.0	76.7	90.0	93.3	4	68	66.3

The herbicides paraquat, propachlor, and propyzamide, showed biocidal activity, as did the molluscicide metaldehyde and ten of the combinations.

CONTROLS

Controls were kept for all biocide experiments. Results obtained were used to set significance levels, for the biocides that showed potential molluscicidal activity. Table XVIa indicates the levels of significance for the eggs killed. Table XVIb indicates how the non-significant level of 20% of slugs killed was calculated. An $L.D._{50}$ was the basis for repeats of biocides, and biocides that killed slugs over 50% were considered significant. Levels of significance were set as follows ;

0 - 20 % non-significant

21 - 50 % marginally significant (low toxicity)

51 - 80 % significant (intermediate toxicity)

81 - 100% highly significant

BIOCIDAL ACTIVITY

The biocides which showed a non-significant mortality in slugs, as compared to control are shown on Table XVII. Table XVIII shows the biocides which caused low toxicity in one or more species or age group. Table XIX indicates those biocides which show intermediate toxicity to the slugs, and Table XX shows the biocides that are highly toxic to the slugs. Of the combinations, fourteen out of the fifteen combinations were in the high toxicity group.

Of the 83 biocides and combinations, 10 had no effect on any age of either species, 32 showed low toxicity in at least one age group of the slugs, and 10 showed intermediate toxicity. For the remaining 31 biocides, high toxicity was shown towards the slugs.

Table XVI   Controls (a) Eggs

Controls were kept for every incubation date and for every batch of eggs. The number of eggs that did not hatch in the controls were counted and combined totals taken for both species. This was done to put results into four categories, namely, non-significant, low significance (low toxicity), significant(intermediate toxicity), and highly significant (high toxicity).

Combined results are;

$N = 89$

$\bar{X} = 39.64$

S.D. Qn-1 $= 14.01$

Taking results into whole figures of 40 ± 14, significance is taken as follows;

Non-significant	0 — 54
Low-significance	55 — 68
Intermediate-significance	69 — 82
Highly-significant	83 — 100

Controls (b) Slugs

Controls were kept and the number of dead slugs recorded for every test-date. Results are;

	D.panormitanum	*D.reticulatum*
Contact spray		
N	15	15
$\bar{X}$	0.93	1.0
S.D. Qn-1	1.16	0.93
Bait (Adults)		
N	16	16
$\bar{X}$	1.13	1.38
S.D. Qn-1	0.88	1.03
Bait (Juveniles)		
N	13	13
$\bar{X}$	1.0	0.92
S.D. Qn-1	1.0	1.04

Combined totals $= N = 88$ $\bar{X} = 1.07$ S.D. Qn-1 $= 0.99$

This gives a mean and standard deviation of approximately 1 ± 1 and gives results of 2/10 or 20 % as non-significant.

TABLE XVII

Biocides which did not show any toxic effects in all three treatments. Showing mean percentage of slugs killed after 10 days exposure, and mean percentage of eggs that failed to hatch.

	D.panormitanum				D.reticulatum			
Biocide	BAIT		SPRAY		BAIT		SPRAY	
Common name	Adult	Juvenile	Adult	Eggs %	Adult	Juvenile	Adult	Eggs %
Fungicide								
Captan	20.0	-	10.0	3	20.0	-	-	+7
Copper oxychloride	10.0	-	-	+8	20.0	-	-	+9
Maneb	20.0	-	10.0	18	10.0	-	10.0	9
Propineb	20.0	-	-	2	20.0	-	-	+2
Insecticide								
Rotenone	20.0	-	-	6	20.0	-	10.0	4
Herbicide								
Aminotriazole + ammon. thiocyanate	20.0	-	-	38	-	-	-	+12
Asulam	10.0	-	-	+16	20.0	-	10.0	+59
Chlorthal-dimethyl	10.0	-	-	+8	10.0	-	-	+11
Chlorbufam + pyrazon	13.3	6.7	-	3	13.3	3.3	-	+8
Dalapon	-	-	-	1	20.0	-	10.0	+20
M.C.P.A. (fumigant)	-	-	3.3	-	-	-	6.7	-

TABLE XVIII

Biocides which show low toxicity (20 % — 50 %) with baits, and Adult contact, after 10 days exposure, and mean percentage of eggs that failed to hatch between 55 % — 68 % over control.

Biocide	D.panormitanum				D.reticulatum			
	BAIT		SPRAY		BAIT		SPRAY	
Common name	Adult	Juvenile	Adult	Eggs %	Adult	Juvenile	Adult	Eggs %
Fungicide								
Dichlofluanid	8.0	26.7	10.0	5	18.0	40.0	0.0	+9
Dimethirimol	20.0	3.3	26.7	13	23.3	16.7	13.3	+10
Dinocap	40.0	-	10.0	2	20.0	-	0.0	9
Pyrazophos	13.3	36.7	13.3	4	16.7	20.0	20.0	+4
Vinclozolin	10.0	-	0.0	5	30.0	-	0.0	4
Insecticides								
Arsenate of lead	33.3	6.7	23.3	+15	30.0	6.7	33.3	+38
Carbaryl	45.0	20.0	30.0	56	37.5	13.4	46.7	67
D.D.T.	33.3	20.0	23.3	+2	16.7	43.3	23.3	+2
Demeton-S-methyl	30.0	30.0	10.0	+3	36.7	50.0	0.0	+1
Fensulfothion	10.0	-	0.0	17	40.0	-	10.0	8
Gamma - HCH	26.7	16.7	10.0	1	16.7	46.7	10.0	+13
Malathion	30.0	-	0.0	+3	30.0	-	10.0	+11
Mineral oil	0.0	-	13.3	+6	30.0	-	6.7	+3
Parathion-methyl	30.0	-	10.0	11	40.0	-	10.0	47
Herbicides								
Aminotriazole	20.0	-	0.0	+8	30.0	-	0.0	+26
Bentazone	30.0	-	0.0	+26	20.0	-	0.0	+3
Glyphosate	26.7	20.0	16.7	6	10.0	23.3	13.3	+7
Linuron	20.0	-	0.0	13	30.0	-	0.0	20
Methabenzthiazuron	40.0	20.0	0.0	+1	20.0	50.0	0.0	+29
Methazole	40.0	-	0.0	54	20.0	-	10.0	7
Metribuzin	30.0	-	10.0	+8	30.0	-	0.0	23
Picloram + 2,4,5-T	36.7	26.7	6.7	+10	30.0	43.3	16.7	6
Prometryne	43.3	30.0	10.0	30	43.3	20.0	0.0	10
Sodium Chlorate	30.0	-	0.0	0	10.0	-	0.0	10
Sulfallate	30.0	20.0	10.0	+1	26.7	13.3	10.0	39
2,4-D	30.0	-	16.7	+20	30.0	-	23.3	+14
Chemicals								
Alkylpolyglycol	10.0	-	10.0	59	10.0	-	10.0	4
Chlormethane sulfonamide	10.0	-	6.7	2	30.0	-	16.7	+2
Diethylene dioxide	10.0	-	23.3	+3	20.0	-	3.3	+10
Maleic hydrozide	30.0	-	10.0	+6	10.0	-	0.0	+1
Potassium cyanide	30.0	-	30.0	+3	20.0	-	20.0	+23
Strychnine hydrochloride	50.0	-	10.0	+11	10.0	-	0.0	44

TABLE XIX

Biocides which show intermediate toxicity (51 % — 80 %) with baits, and adult contact, after 10 days exposure, and mean percentage of eggs that failed to hatch between 69% — 82% over control.

	D.panormitanum				*D.reticulatum*			
Biocide	BAIT		SPRAY		BAIT		SPRAY	
Common name	Adult	Juvenile	Adult	Eggs %	Adult	Juvenile	Adult	Eggs %
Fungicide								
Captafol	23.3	16.7	23.3	2	53.3	3.3	20.0	+5
Carbaryl + mancozeb	46.7	13.3	0.0	14	40.0	66.7	0.0	16
Insecticides								
Maldison	20.0	50.0	10.0	4	10.0	63.3	0.0	0
Methamidophos	33.3	80.0	10.0	0	56.7	80.0	0.0	+25
Herbicides								
Chlorpropham	30.0	33.3	0.0	57	73.3	56.7	0.0	41
M.C.P.A.	33.3	66.7	0.0	27	26.7	76.7	10.0	+32
Paraquat-diquat	23.3	23.3	6.7	+18	20.0	63.3	26.7	2
2,4,5-T	45.0	32.5	33.3	+8	67.5	17.5	63.3	11
Chemicals								
Coumatetralyl	30.0	-	0.0	+15	60.0	-	0.0	7
Methiocarb (fumigant)	-	-	26.7	-	-	-	60.0	-
Combinations								
Carbaryl + ioxynil	26.7	30.0	56.7	66	63.3	33.3	53.3	47

TABLE XX

Biocides which show high toxicity (81 % — 100 %) with baits, and adult contact, after 10 days exposure, and mean percentage of eggs that failed to hatch between 83 % — 100 % over control.

	D.panormitanum				D.reticulatum			
Biocide	BAIT		SPRAY		BAIT		SPRAY	
Common name	Adult	Juvenile	Adult	Eggs %	Adult	Juvenile	Adult	Eggs %
Fungicide								
Benomyl	30.0	10.0	0.0	100	10.0	6.7	0.0	100
Carbendazim	0.0	-	16.7	100	0.0	-	13.3	100
Thiophanate	10.0	-	10.0	83	40.0	-	0.0	100
Thiophanate-methyl	20.0	-	10.0	99	0.0	-	10.0	100
Thiram	0.0	-	0.0	92	20.0	-	0.0	100
Insecticides								
Dazomet	20.0	-	83.3	19	20.0	-	90.0	+8
Methiocarb	96.7	100	33.3	95	93.3	100	27.7	96
Methomyl (liquid)	100	90.0	36.7	6	90.0	43.3	53.3	44
Methomyl (powder)	96.7	93.3	10.0	82	96.7	100	10.0	94
Phorate	93.3	76.7	93.3	6	100	76.7	100	4
Herbicides								
Alachlor	36.7	30.0	0.0	59	36.7	80.0	0.0	100
Ioxynil	60.0	56.7	0.0	11	90.0	70.0	0.0	+20
Paraquat (dichloride)	63.3	96.7	0.0	100	60.0	90.0	0.0	100
" (dimethylsulphate)	70.0	90.0	0.0	100	83.3	83.3	0.0	100
Propachlor	20.0	-	10.0	97	10.0	-	0.0	100
Propyzamide	30.0	-	10.0	99	20.0	-	0.0	100
Chemicals								
Cupric sulphate	10.0	-	73.3	86	20.0	-	26.7	92
Metaldehyde (3 % bait)	83.3	100	-	-	73.3	96.7	-	-
" " (20 % spray)	-	-	90.0	100	-	-	93.3	100
Combinations								
Alachlor + carbaryl	26.7	26.7	63.3	74	3.3	26.7	30.0	88
Alachlor + ioxynil	23.3	36.7	13.3	22	20.0	26.7	16.7	89
Alachlor + methomyl	83.3	46.7	83.3	29	76.7	50.0	53.3	97
Alachlor + methiocarb	86.7	60.0	43.3	100	80.0	66.7	10.0	100
Alachlor + 2,4,5-T	16.7	23.3	56.7	26	10.0	13.3	56.7	100
Carbaryl + methiocarb	100	73.3	96.7	97	96.7	90.0	86.7	69
Carbaryl + methomyl	96.7	80.0	100	91	76.7	96.7	100	82
Carbaryl + 2,4,5-T	63.3	26.7	73.3	64	66.7	10.0	100	60
Ioxynil + methiocarb	83.3	33.3	26.7	88	93.3	80.0	46.7	57
Ioxynil + methomyl	90.0	73.3	50.0	31	100	76.7	50.0	37
Ioxynil + 2,4,5-T	96.7	26.7	26.7	6	96.7	20.0	50.0	+6
Methiocarb + methomyl	96.7	93.3	100	100	96.7	93.3	90.0	99
Methiocarb + 2,4,5-T	76.7	76.7	73.3	96	90.0	100	70.0	49
Methomyl + 2,4,5-T	96.7	66.7	83.3	25	93.3	63.3	93.3	68

TOXIC EFFECTS ON SPECIES

Table XXI shows the biocides that show species differences in their toxic effects. This difference in toxicity can be shown by the adults or the juveniles. The biocides that display species differences in toxicity are 3 fungicides, 3 insecticides, 6 herbicides, 3 chemicals, and 9 of the combinations.

TOXICITY DIFFERENCES WITH AGE

Toxicity differences with age (adults vs juveniles) is shown on Table XXII. Part(a) of this table shows that there are 8 biocides which show increased toxicity in juveniles as compared to the adults of the same species. Biocides that show this property are 2 fungicides, 2 insecticides, and 4 herbicides.

Part (b) of Table XXII tabulates the biocides which show a decreased toxicity in juvenile slugs as compared to the adults of the same species. Of the 12 biocides and combinations that show this effect 2 are fungicides, 3 are insecticides, 1 herbicide, and 6 are combinations.

COMBINATIONS OF BIOCIDES

TABLE XXIII shows the combinations of biocides which have synergistic and inhibitory effects, as compared to when each biocide was used alone.

In combination baits,there was a general inhibitory biocidal effect for both adults and juveniles. Exceptions were; Adults of each species with 2,4,5-T + carbaryl, and carbaryl + methiocarb, where a synergistic effect occured. In adult D. panormitanum a synergistic effect was observed with carbaryl + 2,4,5-T, and with juvenile D.reticulatum this effect was observed for carbaryl + methonyl, ioxynil + methomyl, and for methomyl + 2,4,5-T.

TABLE XXI

Biocides showing species differences in toxic effects in any of the three treatments.

Biocide		*D. panormitanum*				*D. reticulatum*			
		BAIT		SPRAY		BAIT		SPRAY	
Common name	Chemical Type	Adult	Juvenile	Adult	Eggs	Adult	Juvenile	Adult	Eggs
Alachlor	H		30.0		59		80.0		100
Alachlor + ioxynil	H+H				22				89
Alachlor + methomyl	H+I			83.3	29			53.3	97
Alachlor + 2,4,5-T	H+H				26				100
Alkylpolyglycol	C				59				4
Aminotriazole + ammom. thiocyanate	H	20.0			38	0.0			+12
Captafol	F	23.3	16.7		2	53.3	3.3		+5
Carbaryl + ioxynil	I+H	26.7	30.0		66	63.3	33.3		47
Carbaryl + mancozeb	I+F	46.7	13.3			40.0	66.7		
Carbaryl + methiocarb	I+I		73.3	96.7	97		90.0	86.7	69
Carbaryl + 2,4,5-T	I+H	26.7			66	63.3			47
Chlorpropham	H	30.0	33.3			73.3	56.7		
Cupric sulphate	C	10.0		73.3		20.0		26.7	
Dichlofluanid	F	8.0	27.7	10.0	5	18.0	40.0	0.0	+9
Gamma- HCH	I		16.7		1		46.7		+13
Ioxynil	H	60.0	56.7		11	90.0	70.0		+20
Ioxynil + methiocarb	H+I		33.3	26.7	88		80.0	46.7	57
Methazole	H	40.0			54	20.0			7
Methiocarb + 2,4,5-T	I+H	76.7	76.7		96	90.0	100		49
Methomyl (liquid)	I		90.0	36.7	6		43.3	53.3	44
Parathion - methyl	I				11				47
Strychnine hydrochloride	C	50.0			+11	10.0			44
2,4,5-T	H	45.0	32.5	33.3	+8	67.5	17.5	63.3	11

F = Fungicide

I = Insecticide

H = Herbicide

C = Chemicals

TABLE XXII

Biocides that show differences in toxicity with age. (Juveniles vs Adults)

(a) Biocides that show increased toxicity in Juveniles.

Biocides		D.panormitanum BAIT		D.reticulatum BAIT	
Common name	Chemical	Adult	Juvenile	Adult	Juvenile
Dichlofluanid	F	8.0	26.7	18.0	40.0
Maldison	I	20.0	50.0	10.0	63.3
M.C.P.A.	H	33.3	66.7	26.7	76.7
Methamidophos	I	33.3	80.0	56.7	80.0
Paraquat (dichloride)	H	63.3	96.7	60.0	90.0
" " (dimethylsulphate)	H	70.0	90.0	83.3	83.3
Paraquat - diquat	H	23.3	23.3	20.0	63.3
Pyrazophos	F	13.3	36.7	16.7	20.0
(b) Biocides that show decreased toxicity in Juveniles.					
Alachlor + methiocarb	H+I	86.7	60.0	80.0	66.7
Alachlor + methomyl	H+I	83.3	46.7	76.7	50.0
Arsenate of lead	I	33.3	6.7	30.0	6.7
Captafol	F	23.3	16.7	53.3	3.3
Carbaryl	I	45.0	20.0	37.5	13.3
Carbaryl + 2,4,5-T	I+H	63.3	26.7	66.7	10.0
Dimthirimol	F	20.0	3.3	23.3	16.7
Ioxynil + methiocarb	H+I	83.3	33.3	93.3	80.0
Ioxynil + 2,4,5-T	H+H	96.7	26.7	96.7	20.0
Methomyl (liquid)	I	100	90.0	90.0	43.3
Methomyl + 2,4,5-T	I+H	96.7	66.7	93.3	63.3
2,4,5-T	H	45.0	32.5	67.5	17.5

F = Fungicide

I = Insecticide

H = Herbicide

TABLE XXIII

Combinations of biocides showing synergistic (↑), and inhibitory (↓) effects.

The (↔) indicates no significant differences in toxicity.

	D.panormitanum				*D.reticulatum*			
Biocide	BAIT		SPRAY		BAIT		SPRAY	
Common name	Adult	Juveniles	Adult	Eggs	Adult	Juveniles	Adult	Eggs
Alachlor + carbaryl	↓	↓	↑↑	↑	↓↓	↓↓	↓	↓
Alachlor + ioxynil	↓	↔	↑	↓↓	↓↓	↓↓	↑	↑↑
Alachlor + methiocarb	↔	↓↓	↑	↑	↔	↓↓	↓	↔
Alachlor + methomyl	↔	↓	↑↑	↓	↔	↓	↔	↔
Alachlor + 2,4,5-T	↓	↓	↑	↓	↓↓	↓↓	↓	↔
Carbaryl + methiocarb	↑	↓	↑↑	↑	↑	↓	↑↑	↓
Carbaryl + methomyl	↔	↔	↑↑	↑↑	↓	↑↑	↑↑	↑
Carbaryl + 2,4,5-T	↑	↔	↑↑	↔	↔	↓	↑↑	↔
Ioxynil + carbaryl	↓	↓	↑↑	↑	↓	↓↓	↑↑	↓
Ioxynil + methiocarb	↓	↓↓	↑	↓	↔	↓	↑	↓
Ioxynil + metyomyl	↔	↓	↑	↑	↔	↑	↔	↓
Ioxynil + 2,4,5-T	↑↑	↓↓	↔	↔	↑	↓↓	↔	↔
Methiocarb + methomyl	↔	↔	↑↑	↑	↔	↔	↑↑	↑
Methiocarb + 2,4,5-T	↓	↓	↑↑	↔	↔	↔	↑	↓↓
Methomyl + 2,4,5-T	↔	↓	↑↑	↑↑	↑	↑	↑↑	↑

(↕↕) = Strong effects.

In biocidal combination sprays (contact) there was a general synergistic biocidal effect on both slug species. Exceptions for D.reticulatum were; alachlor + methiocarb, alachlor + 2,4,5-T, and alachlor + methiocarb, where an inhibitory biocidal effect on slugs was evident.

Mixed results were obtained from combination sprays when used as an ovicide. Effectiveness depended on the species exposed to the biocide,and results could not be predicted on the basis of knowing single chemical effects.

TOXICITY OF BIOCIDES

In general fungicides and herbicides showed a high toxicity mainly with slug's eggs. Ioxynil and paraquat also showed high toxicity when used as a bait. Insecticides tended to be most effective when ingested. Metaldehyde and phorate were effective contact molluscicides when applied alone, although cupric sulphate and methomyl showed some promise. Dazomet caused a reluctance by slugs to cross the the treated area to their food source, and as a result died of starvation in the refuge area.

Of the four chemicals tested with known molluscicidal properties, only metaldehyde was effective against all ages of both species in all three treatments. Methiocarb and methomyl were effective as a bait, and ovicide, but not as a contact molluscicide.Carbaryl as a bait and spray showed low toxicity for all ages and both species of slugs.

Methiocarb combined with carbaryl or methomyl was highly effective as a spray and adult bait. All other combinations showed increases or decreases in effectiveness according to their own respective combined properties.

DISCUSION

BIOLOGY OF SLUGS

In searching for the two slug species to use in the experiments, the slugs were found only where introduced grasses were growing. None were found in native forest or bush stands. Pastures around Massey University provided an almost equal population of D.panormitanum and D.reticulatum in Winter and Spring, but towards Summer D.reticulatum became increasingly more difficult to find. This occurred as the soil dried out, and pasture cover was removed by grazing animals.

The orchard area provided an interesting situation (Table II). The species ratio of slugs was 1:12 in favour of D.panormitanum, and would suggest that some factor prevented the establishment of D.reticulatum. These factors could be environmental, or be caused by the sprays used on the fruit trees that killed the slugs or their eggs.

Slugs brought into the laboratory from the field laid fewer eggs than laboratory-bred slugs. Hunter (1968) found that D.reticulatum brought in from the field laid 23-25 eggs, and laboratory-bred D.reticulatum an average of of 32.5 eggs. In this experiment Laboratory-bred D.reticulatum laid an average of 53.4 eggs per slug, and D.panormitanum an average of 59.8 eggs per slug. These figures show that there is a marked increase in the number of eggs laid per slug as compared to those obtained by Hunter (1968). Cluster size for D.reticulatum was 2-3 per slug (Stephenson, 1968), and this is comparable with the 3-4 clusters obtained for D.panormitanum and D.reticulatum that were laboratory-bred. The average number of clusters per slug for D.panormitanum brought in from the field and kept in Shade-house was 1.28.

More eggs were laid by slugs kept in groups, than when kept singly. Table VI shows that a 5.5 fold increase was obtained when slugs were grouped.

D.panormitanum and D.reticulatum have two generations per year in Palmerston North. Slug eggs laid in May-June hatch 50-60 days later, and can grow into mature adults and lay their eggs 90-100 days after hatching. Eggs laid in November hatch three weeks later, and with the same rate of growth as the Autumn generation , eggs can be laid by these slugs in April to June. Tables III and IV show that the eggs of the Autumn generation were laid over a period of three months with peak numbers being laid in the middle half of this time span.

Egg-laying peaks were seen in the Shade-house during May and December, and slug death peaks from June to July, and from November to January. It is likely that slugs do not live long after laying their eggs.

The peak egg-laying period coincides with an increase in temperature and evaporation-rate (Fig. 13 and 15). Lower numbers of eggs were laid at lower temperatures and evaporation-rate. No eggs were laid on several occasions when the daily minimum temperature was $0^{\circ}C$.

The seasonal rhythm of slugs was altered when kept at constant temperatures. Egg numbers laid were higher at elevated temperatures, and lower at $5^{\circ}C$. The seasonal pattern seen in Shade-house was not present at the constant temperatures. In contrast the hatching success of eggs was not affected by the constant temperatures, and followed the seasonal pattern of Shade-house except at $5^{\circ}C$ where there was an extended Winter from June to November. It is likely that some unknown innate mechanism within the slugs or eggs operates that prevents hatching of eggs all year round. This mechanism does not seem to be affected by incubating the eggs at constant temperatures.

Slugs are poikilothermic, and a decrease in temperature decreases the metabolic rate and other body processes. Fig. 12 shows that the line with steepest slope was at $5^{\circ}C$, and this temperature shows the least number of eggs oviposited for each slug used in the experiment. In contrast the $16^{\circ}C$ temperature shows the least slope, and the greatest number of eggs oviposited per slug. Therefore it is likely that maximum egg production will occur at the $16^{\circ}C$ temperature.

An increase in humidity increases the activity of slugs. Observations have shown slugs to feed on vegetation on days with high humidity and when drizzle was falling. Slugs show an inverse relationship between humidity and oviposition rate (Fig. 14). Soils close to 100% saturation will not allow for normal slug development (Carrick, 1942). To prevent desiccation of eggs, these are laid in damp places such as under rotting wood and stones.

The incubation period of eggs of A. hortensis at different temperatures (Hunter, 1968), is similar in length to the incubation period of D. panormitanum eggs as shown on Fig. 18. This graph shows that incubation times for eggs do not differ greatly between the two species.

In relation to growth of pastures and plants, the majority of slug-eggs develop during the Winter months. Very few eggs hatch during this period (Fig. 16), and this coincides with minimal Winter pasture or plant growth. Autumn sown grain and crops palatable to slugs suffer damage caused by the Autumn hatching generation that overwinter to lay eggs in early to late Spring. The Spring sown grains and crops are mostly damaged by adults of the previous generation, and slugs hatched in the Spring.

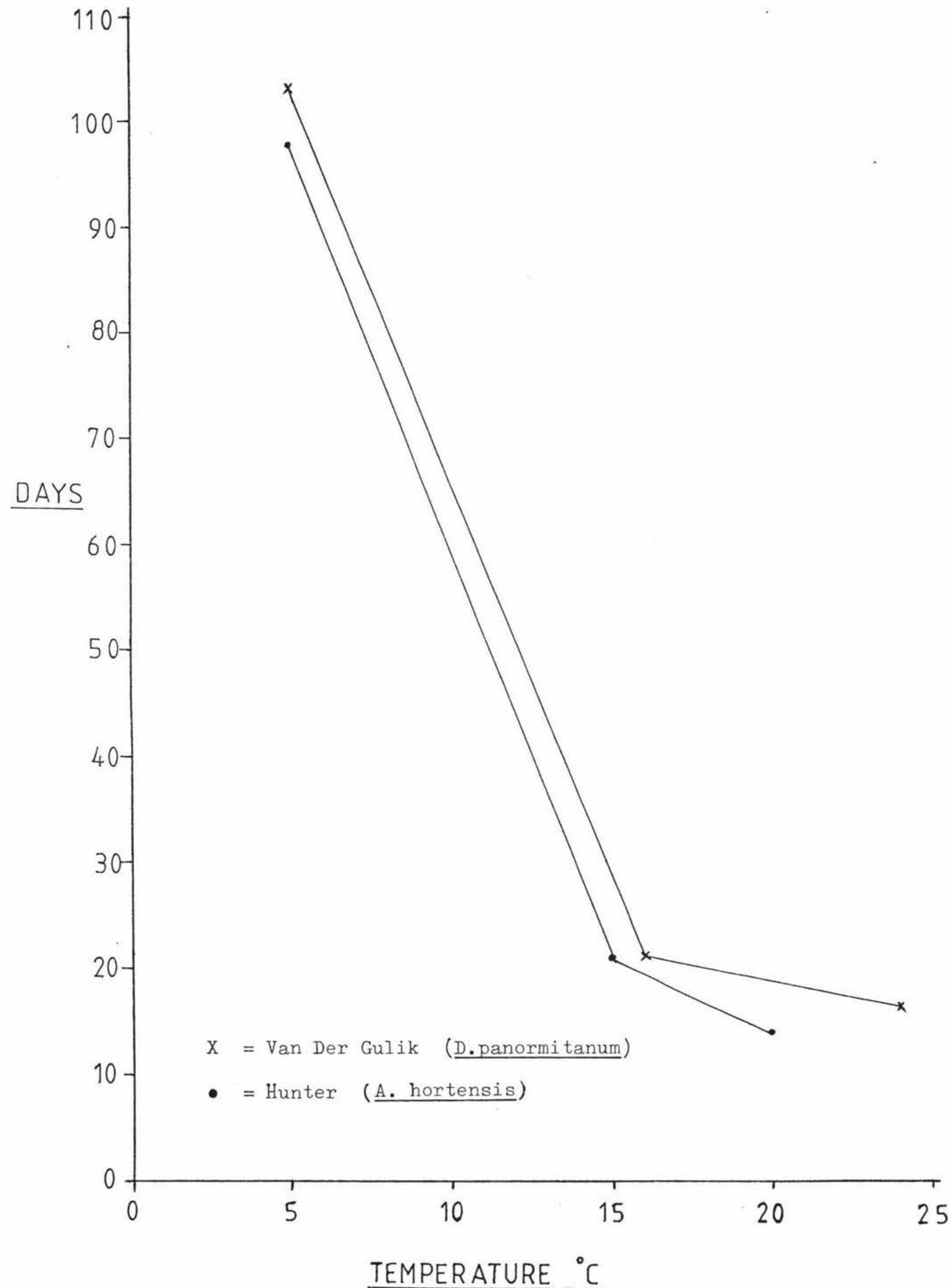


FIG. 18 Days taken for slug eggs to hatch vs Temperature.

D.panormitanum brought in from the field lived an average of 32.7 days in Shade-house, 23.2 days at 16°C, 16.9 days at 24°C, and 63.1 days at 5°C. Slugs at 5°C lived twice as long as those in Shade-house, and 3.7 times longer than those at 24°C. No comparison can be made with literature as none has been written on this subject. The life-span of the two laboratory-bred species was 151 $\pm$ 19 days for D.reticulatum , and 171 $\pm$ 19 days for D.panormitanum. No comparison could be made between the laboratory-bred slugs and field collected slugs, as the age of field collected slugs cannot readily be determined.

In conclusion, egg-laying is a function of Temperature, Humidity, and Evaporation-rate. More eggs are laid at higher temperatures and increased evaporation-rate, and lower humidity. Slugs need to be in contact with each other for maximum rates of oviposition to occur. Oviposition sites are not as important as the moisture content of the site. The survival time of slugs is increased at the lower temperatures.

DISCUSSION

BIOCIDAL EFFECTS

Biocides used against the slugs D.reticulatum, and D.panormitanum, in general showed an equal response. There are species differences as shown on table XXI , and differences in toxicity with age (table XXII). The chemicals giving species differences were, alachlor, chlorpropham, ioxynil, 2,4,5-T, and combinations with 2,4,5-T, which in general showed a higher toxicity in D.reticulatum. Dazomet, a soil fumigant, prevented slugs from reaching their food source, and they died in the refuge area from starvation. D.panormitanum are cannibalistic, and this may account for lower deaths in this species with Dazomet.

The five fungicides on table XX showed high toxicity by killing the eggs of both slug species. Captafol and the combination of carbaryl with mancozeb showed intermediate toxicity as a bait and adult spray in one or more age group and species.

The insecticides methiocarb, methomyl, and phorate, showed high toxicity when ingested. Phorate gave high toxicity when used as an adult spray, but was not effective as an ovicide. Methomyl and methiocarb generally showed low toxicity as an adult spray, but high toxicity as an ovicide. Maldisón and methamidophos showed intermediate toxicity mainly with juveniles and adult D.reticulatum, when ingested.

Of the four insecticides with known molluscicidal properties, methomyl, methiocarb, and phorate, were in the high toxicity range, and carbaryl in the low toxicity range under laboratory conditions. Trials would have to be done to evaluate these chemicals against the two slug species under field conditions.

Herbicides that showed high toxicity were mainly effective against slug eggs, and had no effect as an adult spray (Table XX). Ioxynil showed no ovicidal activity, but was effective as a bait for both ages and species.

Of the chemicals, cupric-sulphate showed some promise as a contact spray and ovicide.

Metaldehyde as 3 % pellets, and 20 % spray was highly effective in all treatments for both ages and both species.

Fourteen of the fifteen combinations gave high toxicity in at least one age or species for any of the three treatments. The chemical combinations that were comparable to metaldehyde in effectiveness were; carbaryl + methiocarb, carbaryl + methomyl, and methiocarb + methomyl. These three were combinations of insecticides, and would pose no problems when applied to crops.

Of the 83 chemicals and combinations tested, 30 (36%) were in the high toxicity category, and ten (12%) showed intermediate toxicity. Five fungicides and four herbicides killed slug eggs effectively at rates significantly lower than those recomended by the manufacturer. None of the chemicals tested in the laboratory were tried in the field, but it would not be unreasonable to suppose that some of the 40 chemicals that show high and intermediate toxicity would kill slugs as part of their normal use. A table has been constructed to show which of the high and intermediate toxic biocides can be used with certain crops, (table XXIV). All of the chemicals shown on this table may be used during the management of the crop. Taking onions as an example the following chemicals may be used for the preparation and management of the crop; one pre-emergence herbicide,

TABLE XXIV

BIOCIDES IN THE HIGH TOXICITY RANGE AND THEIR USE IN CROPS.

Biocide: Crop	Alachlor	Benomyl	Captafol	Carbaryl-mancozeb	Carbaryl-methiocarb	Carbaryl-methomyl	Carbendazim	Chlorpropham	Cupric sulphate	Dazomet	Ioxynil	Maldison	M.C.P.A.	Metaldehyde 3%	Methamidophos	Methiocarb	Methiocarb-methomyl	Methomyl	Paraquat	Paraquat-diquat	Phorate	Propachlor	Propyzamide	Thiophanate	Thiophanate-methyl	Thiram	2,4,5-T
Chemical type:	H	F	F	I+F	I	I	F	H	F	I	H	I	H	M	I	I	I	I	H	H	I	H	H	F	F	F	H
Artichoke														X													
Asparagus		X												X													
Beans	p	X			X	X	X					X		X	X		X	X	p	p	X	p	X	X	X	X	
Beetroot					X	X						X		X			X	X	p	p	X						
Beet-silver					X	X						X		X			X	X	p	p	X						
Broccoli	p		X		X	X		p				X		X	X	o	X	X	p	p	X	p		X	X	X	
Brussel sprouts	p		X		X	X		p				X		X	X	o	X	X	p	p	X	p		X	X	X	
Cabbage	p		X		X	X		p				X		X	X	o	X	X	p	p	X	p		X	X	X	
Cape-gooseberry														X													
Capsicum														X													
Carrots					X	X								X			X	X	p	p	X			X	X		
Cauliflower	p	X	X		X	X	X	p				X		X	X	o	X	X	p	p	X	p		X	X	X	
Celery		X	X		X	X	X							X	X		X	X	p	p	X			X	X		
Corn-sweet	p				X	X					X	X		X	X		X	X	p	p	X	p					
Cucurbits		X					X							X				X	p	p				X	X		
Egg-plant												X		X					p	p							
Endive		X	X		X	X	X							X	X	o	X	X	p	p	X		p				
Grapes		X					X		X					X										X	X		
Kohl-rabbi														X				X									
Leeks	p				X	X					X	X		X			X		p	p	X	p				X	
Lettuce		X	X		X	X	X	p				X		X	X	o	X		p	p	X		p	X	X	X	
Onions	X				X	X		X			X	X		X			X	X	p	p	X	p		X	X	X	
Ornimentals		X	X				X							X										X	X	X	
Parsley					X	X								X					p	p							
Parsnips			X		X	X								X			X	X	p	p	X			X	X		
Peas	p	X			X	X	X					X		X			X	X	p	p	X	p	X	X	X	X	
Potato			X	X	X	X			X			X		X	X		X	X	p	p	X						
Radish	p				X	X								X		o	X	X	p	p		p					
Rhubarb														X					I	I							
Soil-treatment										p									p	p						X	
Spinach					X	X								X			X	X	p	p	X						
Strawberry		X	X		X	X	X					X		X			X		I	I				X	X		
Swede	p		X		X	X						X		X		o	X	X	p	p	X	p				X	
Tomato		X		X	X	X	X					X		X			X	X			X			X	X	X	
Turnip					X	X						X		X			X	X	p	p	X	p				X	
Grass		X					X						X	X				X									X
Clover					X	X							X	X		o	X	X									
Barley		X			X	X	X		X		X	X	X	X			X	X	p	p				X	X		
Lucerne					X	X								X			X	X					X				
Lupin														X				X									
Maize	p				X	X					X			X		o	X	X	p	p	X	p					
Millet														X													
Mustard		X												X													
Oats					X	X	X		X		X			X		o	X	X	p	p							
Soya-beans	p				X	X						X		X			X	X	p	p							
Sudax														X													
Wheat		X			X	X	X				X		X	X		o	X	X	p	p				X	X		

H = Herbicide F = Fungicide I = Inter-row P = Pre-emergence

I = Insecticide M = Molluscicide X = Post-emergence O = Pre+post-emergence two to four post-emergence herbicides depending on the type of weeds present in the crop, one systemic insecticide sprayed at 10 - 14 day intervals from the ½-way stage to maturity to combat thrips, two fugicides to control rots such as botrytis, sclerotinia,and other fungus diseases. A total of eight chemicals could be used on this onion crop, and although onions are not regarded as being prone to attack by slugs, the chemicals used can prevent a build-up of slugs and eggs, and so be of benefit to any brassica crops which may be planted on a rotation basis.

Crops most affected by slugs are those which are palatable, like legumes, cereals, and leafy crops such as brassicas, and those of the genus Lactuca, which provide a refuge as well as food for the slugs.

All of the herbicide and insecticide combinations must be field-tested before recommendations can be made as to their use. Combinations of this type can alter herbicide selectivity and may become phytotoxic, and cause damage to,desirable plants. The insecticide-insecticide combinations are usually compatable. Herbicide-herbicide combinations would show different properties, and may loose their selectivity, and become broad spectrum sprays. Field trials would show how the properties of combined biocides are altered. At present the most widely used combinations of chemicals used in the field are fungicides with insecticides, and these may well give toxic effects when ingested, or come in contact with slugs or their eggs. Further work will have to be done to confirm the properties of commonly used combinations, and the degree of control that these will have on slugs.

From this study it is shown that many of the commonly used biocides show some molluscicidal effect as part of their normal use, and slug control could be enhanced if chemicals were selected with this in mind.

- APPENDIX I -

Taxonomy

Phylum : Mollusca. These animals have soft,fleshy,unsegmented bodies, covered by ciliated epithelium interspersed with cells which secrete mucus.

Class : Gastropoda. The visceral mass is characteristically rotated through 180° relative to the foot (torsion). At some stage a helical shell is present. They have a broad ventral sole or foot used in locomotion.

Subclass: Pulmonata. Gills are absent being replaced by a'lung'. Torsion of the visceral sac has transposed the respiratory and excretory organs from a posterior to an anterio-lateral position, resulting in these and other internal organs becoming atrophied and functionless on the left side.

Order : Stylommatophora. Two pairs of tentacles are present, the posterior pair bearing eyes at their tips, and the lower pair bear sense organs of touch and smell.

Super-family: Zonitacae. Slugs with a small calcareous shell almost always completely enclosed by the mantle.

Family : Limicidae. Mantle with respiratory orifice well behind middle of right margin. Keel at posterior end of body not nearly reaching the mantle. The shell is thick, with the nucleus near to left posterior and with growth lines. The sole is tripartite. There is no epiphallus or atrial glands and no spermatophore is produced. A penial sarcobelum (stimulatory) may be present.

Genus : Deroceras. The body is spotted or unpatterned (no bands). The posterior end is truncated. The genital opening is immediately behind the tentacles. The right ocular retractor lies to the left of both penis and oviduct. A penial sarcobelum is present, more or less developed, and frequently with appendages. The genital retractor arises from the diaphragm inserted into the penis. The intestine has one fowardly-directed loop, and the right lobe of the liver forms the apex of the visceral mass.

Species : Deroceras (Agriolimax) reticulatum (Muller, 1774)

The diagnostic feature is that the rear of the foot is truncated and not sloping gently to a point as in limax. This species is the commonist of all slug species. The extended length is up to 50 mm. The colour is extremely variable from a bluish-black to the occasional albino, but is usually a general greyish-brown to yellow. Darker grooves and patches are scattered over the dorsal surface. The foot is usually cream with a darker zone towards the centre. The mucus is clear in undisturbed animals, but becomes milky on irritation. The shell is up to 4.7 x 3.2 mm , the right border more convex than the left. The slug contracts into a hemisphere when disturbed. The eggs are about 3 x 2.5 mm , are translucent with a few calcareous granules.

Species : Deroceras (Deroceras) panormitanum (Lessona & Pollonera, 1882)

This species is 30-40 mm long when extended, with the head and neck being extended somewhat in front of the mantle. The body is a dark translucent chestnut-brown, grey-brown, or grey with the mantle paler over the pallial region. The back and mantle are more or less flecked with dark brown; the respiratory orifice has a pale border; the sole is grey; the mucus is thin and colourless; The tail is truncated, and the shell is 4 x 2.5 mm with the right border sometimes slightly concave. The most obvious difference between this species and D.reticulatum, lies in its greater activity and faster movements.

Appendix II

BIOCIDES TESTED AGAINST THE SLUGS D.reticulatum AND D.panormitanum.

Common name	Manufacturers formulation	Spray rate a.i./ha	Spray rate eggs. a.i./ha	Bait % a.i.
Fungicides				
Benomyl	50% w/w	250 g	94.3 g	2.0
Captafol	40 g/l	280 g	7.5 g	1.6
Captan	100 g/kg	4 kg	18.9 g	0.4
Carbaryl-mancozeb	190+190g/kg	1.2+1.2 kg	35.8+35.8 g	0.8+0.8
Carbendazim	500 g/kg	250 g	94.3 g	2.0
Copper-oxychloride	500 g/kg	3 kg	94.3 g	2.0
Dichlofluanid	500 g/kg	1 kg	94.3 g	2.0
Dimethirimol	125 g/l	375 g	23.6 g	0.5
Dinocap	22.5% w/v	189 g	42.4 g	0.9
Maneb	80 % w/v	1.6 kg	150.9 g	3.2
Propineb	700 g/kg	1.4 kg	132.0 g	2.8
Pyrazophos	300 g/l	15 g	56.6 g	1.2
Thiophanate	800 g/kg	744 g	150.9 g	3.2
Thiophanate-methyl	800 g/kg	450 g	150.9 g	3.2
Thiram	800 g/kg	1.6 kg	150.9 g	3.2
Vinclozolin	500 g/kg	500 g	94.3 g	2.0
Insecticides				
Arsenate of lead	32 % w/v	979 g	60.4 g	1.3
Carbaryl	800 g/kg	1.54 kg	150.9 g	3.2
Dazomet	990 g/kg	454 kg	186.7 g	3.9
D.D.T	50% w/w	930 g	94.3 g	2.0
Demeton-s-methyl	30% w/v	336 g	56.6 g	1.2
Fensulfothion	10% w/w	3.3 kg	18.9 g	0.4
Gamma- HCH	20% w/v	1.4 kg	37.7 g	0.8
Malathion	50% w/v	1.7 kg	94.3 g	2.0
Maldison	500 g/l	1.0 kg	94.3 g	2.0

Cont.....

Appendix II Cont...

Common name	Manufacturers formulation	Spray rate a.i./ha	Spray rate eggs. a.i./ha	Bait % a.i.
Methamidophos	600 g/l	600 g	113.2 g	2.4
Methiocarb	750 g/kg	112 g	141.5 g	3.0
Methiocarb (fum.)	750 g/kg	525 g	-	-
Methomyl (liq.)	200 g/l	400 g	37.7 g	0.8
Methomyl (powd.)	90 % w/v	396 g	169.8 g	3.6
Mineral oil	970 ml/l	30 ml	183.0 g	3.8
Parathion-methyl	600 g/l	420 ml	113.2 g	2.4
Phorate	99 % w/v	2.2 kg	186.7 g	0.9
Rotenone	5 g/kg	127 g	1.0 g	0.02
Herbicides				
Alachlor	500 g/l	3.5 kg	94.3 g	2.0
Aminotriazole	900 g/kg	3.1 kg	169.8 g	3.6
Aminotriazole + ammon.thiocyanate	200+183g/kg	4.4+4.0 kg	37.7+34.5 g	0.8+0.7
Asulam	400 g/l	1.6 kg	75.5 g	1.6
Bentazone	480 g/l	1.4 kg	90.5 g	1.9
Chlorbufam + pyrazon	200+200g/kg	1 + 1 kg	37.7+37.7 g	0.8+0.8
Chlorpropham	333 g/l	1.2 kg	62.8 g	1.3
Chlorthal-dimethyl	750 g/kg	12 kg	141.5 g	3.0
Dalapon	74 % w/v	2.5 kg	139.6 g	3.0
Glyphosate	360 g/l	2.2 kg	67.9 g	1.4
Ioxynil	250 g/l	750 g	47.2 g	1.0
Linuron	500 g/kg	750 g	94.3 g	2.0
Methabenzthiazuron	700 g/kg	1.4 kg	132.0 g	2.8
Methazole	750 g/kg	750 g	141.5 g	3.0
Metribuzin	500 g/kg	350 g	94.3 g	2.0
M.C.P.A.	37.5 % w/v	1.6 kg	70.7 g	1.5

Cont....

Appendix II Cont...

Common name	Manufacturers formulation	Spray rate a.i./ha	Spray rate eggs. a.i./ha	Bait % a.i.
Paraquat (dichloride)	200 g/l	1.4 kg	37.7 g	0.8
Paraquat (dimethylsulphate)	200 g/l	1.4 kg	37.7 g	0.8
Picloram-2,4,5-T	50+200g/l	150+600 g	9.4+37.7 g	0.2+0.8
Prometryne	50 % w/v	1.1 kg	94.3 g	2.0
Propachlor	650 g/kg	6.5 kg	122.6 g	2.6
Propyzamide	500 g/kg	1.5 kg	94.3 g	2.0
Sodium chlorate	580 g/kg	290 kg	109.4 g	2.3
Sulfallate	480 g/kg	6.7 kg	90.5 g	1.9
2,4-D	200 g/l	1.2 kg	37.7 g	1.3
2,4,5-T	36 % w/v	5.8 kg	67.9 g	1.4
Other biocides				
Alkylarylpolyglycol	1000 g/l	25 g	188.6 g	4.0
Chloromethane-sulfonamide	800 g/kg	1.5 kg	150.9 g	3.2
Coumatetralyl	7.5 g/kg	375 g	1.4 g	0.03
Cupric-sulphate	985 g/kg	40 kg	185.8 g	4.0
Diethylene-dioxide	990 g/kg	16 kg	186.7 g	4.0
Maleic hydrazide	30 % w/v	4.8 kg	56.6 g	1.2
Metaldehyde (pellet)	30 g/kg	-	-	3.0
" " (emulsion)	20 % w/v	6.0 kg	37.7 g	-
Potassium cyanide	98 % B.P.C.	6.0 kg	184.8 g	4.0
Strychnine-hydrochloride	98 % B.P.C.	2.5 kg	184.8 g	4.0

Appendix III

April 7 —— May 4

THE following tables show at 30 day periods, the average number of eggs per cluster oviposited by each collection day, by 150 slugs (*D. panormitanum*), at each of the four temperatures.

Table I

Collection Date 1979	Temperature at 5°C	Temperature Shade-house	Temperature at 16°C	Temperature at 24°C
April 7	9.71	11.75	14.52	12.81
April 10	11.50	13.86	16.61	14.54
April 13	12.58	13.10	18.48	14.68
April 16	18.11	10.96	17.35	13.50
April 19	13.57	16.06	18.20	15.21
April 22	14.38	17.25	21.30	19.53
April 25	15.53	17.80	21.53	16.30
April 28	12.83	18.84	18.56	19.86
May 1	14.92	18.28	19.67	17.00
May 4	17.25	14.87	20.55	20.89

Table Ia May 7 —— June 3

Collection Date 1979	Temperature at 5°C	Temperature Shade-house	Temperature at 16°C	Temperature at 24°C
May 7	18.33	20.08	22.54	20.93
May 10	15.33	17.97	18.64	19.84
May 13	12.00	18.13	19.44	19.87
May 16	17.54	18.72	20.27	16.30
May 19	16.42	18.37	16.39	19.29
May 22	14.50	13.73	19.38	19.11
May 25	17.00	16.42	20.62	23.00
May 28	18.14	15.80	19.36	19.79
May 31	16.20	19.31	24.10	20.27
June 3	17.25	19.60	19.18	25.64

Appendix III

TABLE Ib JUNE 6 —JULY 3

Collection Date 1979	Temperature at 5°C	Temperature Shade-house	Temperature at 16°C	Temperature at 24°C
June 6	13.88	22.92	28.56	25.61
June 9	17.00	18.00	24.92	24.47
June 12	14.25	18.44	26.11	21.08
June 15	15.86	19.50	17.33	25.14
June 18	20.14	27.23	22.67	25.76
June 21	14.67	18.83	28.64	24.75
June 24	24.00	19.00	26.88	25.97
June 27	7.00	4.00	28.78	27.58
June 30	0.00	21.00	22.75	29.06
July 3	19.00	24.78	27.72	27.89

TABLE Ic JULY 6 — August 2

Collection Date 1979	Temperature at 5°C	Temperature Shade-house	Temperature at 16°C	Temperature at 24°C
July 6	23.09	25.42	25.97	28.53
July 9	8.00	6.00	21.54	21.41
July 12	22.17	33.18	27.23	24.68
July 15	0.00	0.00	19.05	23.77
July 18	0.00	21.00	25.84	23.25
July 21	5.00	23.00	22.00	23.28
July 24	28.00	24.43	25.86	30.50
July 27	32.00	25.80	25.77	21.83
July 30	22.20	37.93	23.44	25.17
August 2	18.33	24.00	24.07	26.90

Appendix III

TABLE Id August 5— September 1

Collection Date 1979	Temperature at 5°C	Temperature Shade-house	Temperature at 16°C	Temperature at 24°C
Aug. 5	15.20	20.83	23.74	26.02
Aug. 8	0.00	26.17	18.33	21.38
Aug. 11	26.50	24.00	25.13	27.89
Aug. 14	0.00	29.93	26.31	20.74
Aug. 17	22.25	25.43	22.06	22.34
Aug. 20	36.00	27.30	28.05	27.36
Aug. 23	25.00	35.29	25.38	26.52
Aug. 26	4.00	33.22	29.11	26.45
Aug. 29	21.40	31.07	27.27	28.94
Sept. 1	17.67	33.50	30.17	28.23

TABLE Ie September 4— October 1

Collection Date 1979	Temperature at 5°C	Temperature Shade-house	Temperature at 16°C	Temperature at 24°C
Sept. 4	22.50	24.81	25.26	28.19
Sept. 7	38.75	30.05	27.46	23.84
Sept. 10	29.67	29.09	24.37	26.00
Sept. 13	22.00	28.36	23.78	23.57
Sept. 16	20.13	28.69	22.08	24.22
Sept. 19	0.00	26.43	21.08	22.54
Sept. 22	28.86	23.76	24.82	24.70
Sept. 25	23.67	29.85	26.62	21.76
Sept. 28	30.40	21.31	25.85	23.51
Oct. 1	6.00	26.77	24.32	23.03

Appendix III

TABLE If October 4— October 31

Collection Date 1979	Temperature at 5°C	Temperature Shade-house	Temperature at 16°C	Temperature at 24°C
Oct. 4	31.00	30.73	24.04	25.17
Oct. 7	15.00	22.62	27.16	24.12
Oct. 10	9.00	27.36	25.35	24.03
Oct. 13	19.00	18.44	18.75	21.69
Oct. 16	19.00	26.76	24.55	21.69
Oct. 19	28.50	28.90	30.29	23.66
Oct. 22	16.00	27.09	24.50	26.19
Oct. 25	23.57	22.14	25.62	21.20
Oct. 28	23.00	27.79	28.79	28.05
Oct. 31	20.00	20.18	19.61	17.33

TABLE Ig November 3— November 30

Collection Date 1979	Temperature at 5°C	Temperature Shade-house	Temperature at 16°C	Temperature at 24°C
Nov. 3	34.33	23.87	24.81	22.70
Nov. 6	13.00	23.14	21.93	21.29
Nov. 9	9.00	20.57	25.65	20.81
Nov. 12	21.67	18.42	28.19	25.55
Nov. 15	32.80	28.57	25.36	31.03
Nov. 18	26.00	26.14	24.19	22.34
Nov. 21	8.67	27.81	23.57	21.48
Nov. 24	0.00	22.93	22.56	23.07
Nov. 27	20.00	28.68	23.71	25.33
Nov. 30	17.50	26.82	22.07	26.02

Appendix III

TABLE Ih December 3—December 30

Collection Date 1979	Temperature at 5°C	Temperature Shade-house	Temperature at 16°C	Temperature at 24°C
Dec. 3	24.80	27.59	28.65	24.12
Dec. 6	15.00	21.32	23.18	24.93
Dec. 9	24.33	22.20	22.27	19.96
Dec. 12	7.00	21.94	23.46	25.58
Dec. 15	20.25	24.32	18.16	19.96
Dec. 18	20.33	19.70	26.68	21.16
Dec. 21	11.00	21.16	19.71	17.95
Dec. 24	13.00	18.32	19.68	17.08
Dec. 27	25.67	22.45	23.71	23.61
Dec. 30	18.00	15.69	19.50	18.62

TABLE Ii January 2—January 8

Collection Date 1980	Temperature at 5°C	Temperature Shade-house	Temperature at 16°C	Temperature at 24°C
Jan. 2	16.33	16.82	20.18	22.22
Jan. 5	21.00	22.18	16.65	22.05
Jan. 8	22.00	19.46	18.59	19.65

Appendix IV

TABLE II APRIL 7—— MAY 4

The following tables show at 30 day periods,the number of clusters of eggs oviposited by 150 slugs of the species D.panormitanum, by each collection day,at each of the four different temperatures.

Collection Date 1979	Temperature at 5°C	Temperature Shade-house	Temperature at 16°C	Temperature at 24°C
April 7	7	36	25	47
April 10	6	44	43	48
April 13	12	49	44	29
April 16	9	24	49	28
April 19	7	32	35	39
April 22	13	36	56	56
April 25	15	30	47	38
April 28	12	31	41	42
May 1	13	32	46	30
May 4	8	23	38	38

TABLE IIa MAY 7—— JUNE 3

Collection Date 1979	Temperature at 5°C	Temperature Shade-house	Temperature at 16°C	Temperature at 24°C
May 7	9	39	26	29
May 10	9	33	25	32
May 13	8	32	34	30
May 16	13	36	34	10
May 19	12	8	23	31
May 22	4	15	37	19
May 25	8	12	29	38
May 28	7	5	11	19
May 31	5	16	30	26
June 3	4	5	11	22

Appendix IV

TABLE IIb JUNE 6 —— JULY 3

Collection Date 1979	Temperature at 5°C	Temperature Shade-house	Temperature at 16°C	Temperature at 24°C
June 6	8	13	32	33
June 9	6	1	13	30
June 12	4	9	38	38
June 15	7	4	18	44
June 18	7	26	24	46
June 21	3	6	22	24
June 24	1	18	33	30
June 27	2	1	9	19
June 30	0	2	16	17
July 3	2	18	32	36

TABLE IIc JULY 6 —— August 2

Collection Date 1979	Temperature at 5°C	Temperature Shade-house	Temperature at 16°C	Temperature 24°C
July 6	11	12	30	36
July 9	1	1	13	34
July 12	6	11	30	31
July 15	0	0	22	34
July 18	0	1	32	36
July 21	1	4	29	40
July 24	1	7	29	30
July 27	1	10	17	29
July 30	5	15	34	30
August 2	3	5	28	31

Appendix IV

TABLE IId AUGUST 5—— SEPTEMBER 1

Collection Date 1979	Temperature at 5°C	Temperature Shade-house	Temperature at 16°C	Temperature at 24°C
Aug. 5	5	6	39	46
Aug. 8	0	6	12	21
Aug. 11	2	2	30	38
Aug. 14	0	14	32	42
Aug. 17	4	7	34	38
Aug. 20	1	10	37	28
Aug. 23	2	7	24	29
Aug. 26	1	9	48	38
Aug. 29	5	14	22	36
Sept. 1	3	18	30	35

TABLE IIe SEPTEMBER 4—— OCTOBER 1

Collection Date 1979	Temperature at 5°C	Temperature Shade-house	Temperature at 16°C	Temperature at 24°C
Sept. 4	2	16	27	36
Sept. 7	4	19	48	37
Sept. 10	3	11	38	36
Sept. 13	4	28	32	30
Sept. 16	8	29	24	32
Sept. 19	0	7	24	35
Sept. 22	7	34	28	33
Sept. 25	3	13	26	33
Sept. 28	5	13	27	37
Oct. 1	1	22	41	39

Appendix IV

TABLE IIf OCTOBER 4— OCTOBER 31

Collection Date 1979	Temperature at 5°C	Temperature Shade-house	Temperature at 16°C	Temperature at 24°C
Oct. 4	2	22	24	29
Oct. 7	1	13	38	33
Oct. 10	1	33	26	32
Oct. 13	3	9	8	16
Oct. 16	2	25	29	29
Oct. 19	8	39	35	29
Oct. 22	3	23	28	47
Oct. 25	7	7	39	15
Oct. 28	2	24	28	42
Oct. 31	2	33	28	21

TABLE IIg NOVEMBER 3— NOVEMBER 30

Collection Date 1979	Temperature at 5°C	Temperature Shade-house	Temperature at 16°C	Temperature at 24°C
Nov. 3	3	46	41	46
Nov. 6	1	28	40	24
Nov. 9	1	60	43	43
Nov. 12	3	12	27	44
Nov. 15	5	35	42	38
Nov. 18	2	22	27	38
Nov. 21	3	48	46	33
Nov. 24	0	27	50	30
Nov. 27	3	41	31	30
Nov. 30	2	38	28	44

Appendix IV

TABLE IIh DECEMBER 3— DECEMBER 30

Collection Date 1979	Temperature at 5°C	Temperature Shade-house	Temperature at 16°C	Temperature at 24°C
Dec. 3	5	61	34	43
Dec. 6	2	25	17	27
Dec. 9	3	41	48	46
Dec. 12	2	31	24	38
Dec. 15	4	44	32	25
Dec. 18	3	20	38	32
Dec. 21	1	59	45	22
Dec. 24	1	28	31	24
Dec. 27	3	44	35	33
Dec. 30	4	16	24	29

TABLE IIi JANUARY 2— JANUARY 8

Collection Date 1980	Temperature at 5°C	Temperature Shade-house	Temperature at 16°C	Temperature at 24°C
Jan. 2	3	28	33	23
Jan. 5	2	17	17	22
Jan. 8	3	28	37	31

Appendix V

The following tables show at 30-day periods, the number of eggs oviposited by 150 slugs, D. panormitanum, by each collection day at each of four different temperatures.

TABLE III April 7 — May 4

Collection Day 1979	Temperature at 5°C	Temperature Shade-House	Temperature at 16°C	Temperature at 24°C	Temperature Totals (3-day)
April 7	68	423	363	602	1456
April 10	69	610	714	698	2091
April 13	151	642	813	426	2032
April 16	163	263	850	378	1654
April 19	95	514	637	593	1839
April 22	187	621	1193	1094	3095
April 25	233	534	1012	620	2399
April 28	154	584	761	834	2333
May 1	194	585	905	510	2194
May 4	138	342	781	794	2055
Totals	1452	5118	8029	6549	21148

Table IIIa May 7 — June 3

Collection Day 1979	Temperature at 5°C	Temperature Shade-House	Temperature at 16°C	Temperature at 24°C	Temperature Totals (3-day)
May 7	165	783	586	607	2141
May 10	138	593	466	635	1832
May 13	96	580	661	596	1933
May 16	228	674	689	163	1754
May 19	197	147	377	598	1319
May 22	58	206	717	363	1344
May 25	136	197	598	874	1805
May 28	127	79	213	376	795
May 31	81	309	723	527	1640
June 3	69	98	211	564	924
Totals	1295	3666	5241	5303	15505

Appendix V

TABLE IIIb JUNE 6 —— JULY 3

Collection Day 1979	Temperature at 5°C	Temperature Shade-house	Temperature at 16°C	Temperature at 24°C	Temperature Totals(3-day)
June 6	111	298	914	845	2168*
June 9	102	18	324	734	1178
June 12	57	166	992	801	2016
June 15	111	78	312	1106	1607
June 18	141	708	544	1185	2578
June 21	44	113	630	594	1381
June 24	24	342	887	779	2032
June 27	14	4	259	524	801
June 30	0	42	364	494	900
July 3	38	446	887	1004	2375
TOTALS	642	2215	6113	8066	17036

TABLE IIIc JULY 6 —— August 2

Collection Day 1979	Temperature at 5°C	Temperature Shade-house	Temperature at 16°C	Temperature at 24°C	Temperature Totals(3-day)
July 6	254	305	779	1027	2365
July 9	8	6	280	728	1022
July 12	133	365	817	765	2080
July 15	0	0	419	808	1227
July 18	0	21	827	837	1685
July 21	5	92	638	941	1676
July 24	28	171	751	915	1865
July 27	32	258	438	633	1361
July 30	111	569	797	7 5	2232
August 2	55	120	674	834	1683
TOTALS	626	1907	6420	8243	17196

Appendix V

TABLEIIId August 5— September 1

Collection Date 1979	Temperature at 5°C	Temperature Shade-house	Temperature at 16°C	Temperature at 24°C	Temperature Totals(3-day)
Aug. 5	76	125	926	1197	2324
Aug. 8	0	157	220	449	826
Aug. 11	53	48	754	1060	1915
Aug. 14	0	419	842	871	2132
Aug. 17	89	178	750	849	1866
Aug. 20	36	273	1038	766	2113
Aug. 23	50	247	609	769	1675
Aug. 26	4	299	1397	1005	2705
Aug. 29	107	435	600	1042	2184
Sept. 1	53	603	905	988	2549
TOTALS	468	2784	8041	8996	20289

TABLEIIIe September 4— October 1

Collection Date 1979	Temperature at 5°C	Temperature Shade-house	Temperature at 16°C	Temperature at 24°C	Temperature Totals(3-day)
Sept. 4	45	397	682	1015	2139
Sept. 7	155	571	1318	882	2926
Sept. 10	89	320	926	936	2271
Sept. 13	88	794	761	707	2350
Sept. 16	161	832	530	775	2298
Sept. 19	0	185	506	789	1480
Sept. 22	202	808	695	815	2520
Sept. 25	71	388	692	718	1869
Sept. 28	152	277	698	870	1997
Oct. 1	6	589	997	898	2490
TOTALS	969	5161	7805	8405	22340

Appendix V

TABLE IIIf October 4— October 31

Collection Date 1979	Temperature at 5°C	Temperature Shade-house	Temperature at 16°C	Temperature at 24°C	Temperature Totals(3-day)
Oct. 4	62	676	577	730	2045
Oct. 7	15	294	1032	796	2137
Oct. 10	9	903	659	769	2340
Oct. 13	57	166	150	347	720
Oct. 16	38	669	712	629	2048
Oct. 19	228	1127	1060	686	3101
Oct. 22	48	623	686	1231	2588
Oct. 25	165	155	999	318	1637
Oct. 28	46	667	806	1178	2697
Oct. 31	40	666	549	364	1619
TOTALS	708	5946	7230	7048	20932

TABLE IIIg November 3— November 30

Collection Date 1979	Temperature at 5°C	Temperature Shade-house	Temperature at 16°C	Temperature at 24°C	Temperature Totals(3-day)
Nov. 3	103	1098	1017	1044	3262
Nov. 6	13	648	877	511	2049
Nov. 9	9	1234	1103	895	3241
Nov. 12	65	221	761	1124	2171
Nov. 15	164	1000	1065	1179	3408
Nov. 18	52	575	653	849	2129
Nov. 21	26	1335	1084	709	3154
Nov. 24	0	619	1128	692	2439
Nov. 27	60	1176	735	760	2731
Nov. 30	35	1019	618	1145	2817
TOTALS	527	8925	9041	8908	27401

Appendix V

TABLE IIIh December 3— December 30

Collection date 1979	Temperature at 5°C	Temperature Shade-house	Temperature at 16°C	Temperature at 24°C	Temperature Totals(3-day)
Dec. 3	124	1683	974	1037	3818
Dec. 6	30	533	394	673	1630
Dec. 9	73	910	1069	918	2970
Dec. 12	14	680	563	972	2229
Dec. 15	81	1070	581	499	2231
Dec. 18	61	394	1014	677	2146
Dec. 21	11	1248	887	395	2541
Dec. 24	13	513	610	410	1546
Dec. 27	77	988	830	779	2674
Dec. 30	72	251	468	540	1331
TOTALS	556	8270	7390	6900	23116

TABLE IIIi January 2— January 8

Collection Date 1979	Temperature at 5°C	Temperature Shade-house	Temperature at 16°C	Temperature at 24°C	Temperature Totals(3-day)
Jan. 2	49	471	666	511	1697
Jan. 5	42	377	283	485	1187
Jan. 8	66	545	688	609	1908
TOTALS	157	1393	1637	1605	4792

Appendix VI

TABLE IV APRIL 7—— MAY 4

The following tables show at 30-day periods, the average number of eggs per slug in the population by each collection day, by 150 slugs D.panormitanum, at each of the four different temperatures.

Collection Date 1979	Temperature at 5°C	Temperature Shade-house	Temperature at 16°C	Temperature at 24°C
April 7	0.45	2.82	2.42	4.01
April 10	0.46	4.06	4.76	4.65
April 13	1.01	4.28	5.42	2.84
April 16	1.09	1.75	5.66	2.52
April 19	0.63	3.43	4.25	3.95
April 22	1.25	4.14	7.95	7.29
April 25	1.55	3.56	6.75	4.13
April 28	1.03	3.89	5.07	5.56
May 1	1.29	3.90	6.03	3.40
May 4	0.92	2.28	5.21	5.29

TABLE IVa MAY 7 —— JUNE 3

Collection Date 1979	Temperature at 5°C	Temperature Shade-house	Temperature at 16°C	Temperature at 24°C
May 7	1.10	5.22	3.91	4.05
May 10	0.92	3.95	3.11	4.23
May 13	0.64	3.87	4.41	3.97
May 16	1.52	4.49	4.59	1.09
May 19	1.31	0.98	2.51	3.99
May 22	0.39	1.37	4.78	2.42
May 25	0.91	1.31	3.99	5.83
May 28	0.85	0.53	1.42	2.51
May 31	0.54	2.06	4.82	3.51
June 3	0.46	0.65	1.41	3.76

Appendix VI

TABLE IVb JUNE 6 —— JULY 3

Collection Date 1979	Temperature at 5°C	Temperature Shade-house	Temperature at 16°C	Temperature at 24°C
June 6	0.74	1.97	6.09	5.63
June 9	0.68	0.12	2.16	4.89
June 12	0.38	1.11	6.61	5.34
June 15	0.74	0.52	2.08	7.37
June 18	0.94	4.72	3.63	7.90
June 21	0.29	0.75	4.20	3.96
June 24	0.16	2.28	5.91	5.19
June 27	0.09	0.03	1.73	3.49
June 30	0.00	0.28	2.43	3.29
July 3	0.25	2.97	5.91	6.69

TABLE IVc JULY 6 —— August 2

Collection Date 1979	Temperature at 5°C	Temperature Shade-house	Temperature at 16°C	Temperature at 24°C
July 6	1.69	2.35	5.19	6.85
July 9	0.05	0.04	1.87	4.85
July 12	0.89	2.43	5.45	5.10
July 15	0.00	0.00	2.79	5.39
July 18	0.00	0.14	5.51	5.58
July 21	0.03	0.61	4.25	6.27
July 24	0.19	1.14	5.01	6.10
July 27	0.21	1.72	2.92	4.22
July 30	0.74	3.79	5.31	5.03
August 2	0.37	0.80	4.49	5.56

Appendix VI

TABLE IVd AUGUST 5 — SEPTEMBER 1

Collection Date 1979	Temperature at 5°C	Temperature Shade-house	Temperature at 16°C	Temperature at 24°C
Aug. 5	0.51	0.83	6.17	7.98
Aug. 8	0.00	1.05	1.47	2.99
Aug. 11	0.35	0.32	5.03	7.07
Aug. 14	0.00	2.79	5.61	5.81
Aug. 17	0.59	1.19	5.00	5.66
Aug. 20	0.24	1.82	6.92	5.11
Aug. 23	0.33	1.65	4.06	5.13
Aug. 26	0.03	1.99	9.31	6.70
Aug. 29	0.71	2.90	4.00	6.95
Sept. 1	0.35	4.02	6.03	6.59

TABLE IVe SEPTEMBER 4 — OCTOBER 1

Collection Date 1979	Temperature at 5°C	Temperature Shade-house	Temperature at 16°C	Temperature at 24°C
Sept. 4	0.30	2.65	4.55	6.77
Sept. 7	1.03	3.81	8.79	5.88
Sept. 10	0.59	2.13	6.17	6.24
Sept. 13	0.59	5.29	5.07	4.71
Sept. 16	1.07	5.55	3.53	5.17
Sept. 19	0.00	1.23	3.37	5.26
Sept. 22	1.35	5.39	4.63	5.43
Sept. 25	0.47	2.59	4.61	4.79
Sept. 28	1.01	1.85	4.65	5.80
Oct. 1	0.04	3.93	6.65	5.99

Appendix VI

TABLE IVf OCTOBER 4— OCTOBER 31

Collection Date 1979	Temperature at 5°C	Temperature Shade-house	Temperature at 16°C	Temperature at 24°C
Oct. 4	0.00	4.51	3.85	4.87
Oct. 7	0.10	1.96	6.88	5.31
Oct. 10	0.06	6.02	4.39	5.13
Oct. 13	0.38	1.11	1.00	2.31
Oct. 16	0.25	4.46	4.75	4.19
Oct. 19	1.52	7.51	7.07	4.57
Oct. 22	0.32	4.15	4.57	8.21
Oct. 25	1.10	1.03	6.66	2.12
Oct. 28	0.31	4.45	5.37	7.85
Oct. 31	0.27	4.44	3.66	2.43

TABLE IVg NOVEMBER 3— NOVEMBER 30

Collection Date 1979	Temperature at 5°C	Temperature Shade-house	Temperature at 16°C	Temperature at 24°C
Nov. 3	0.69	7.32	6.76	6.96
Nov. 6	0.09	4.32	5.85	3.41
Nov. 9	0.06	8.23	7.35	5.97
Nov. 12	0.43	1.47	5.07	7.49
Nov. 15	1.09	6.67	7.10	7.86
Nov. 18	0.35	3.83	4.35	5.66
Nov. 21	0.17	8.90	7.23	4.73
Nov. 24	0.00	4.13	7.52	4.61
Nov. 27	0.40	7.84	4.90	5.07
Nov. 30	0.23	6.79	4.12	7.63

Appendix VI

TABLE IVh DECEMBER 3—— DECEMBER 30

Collection Date 1979	Temperature at 5°C	Temperature Shade-house	Temperature at 16°C	Temperature at 24°C
Dec. 3	0.83	11.22	6.49	6.91
Dec. 6	0.20	3.55	2.63	4.49
Dec. 9	0.49	6.07	7.13	6.12
Dec. 12	0.09	4.53	3.75	6.48
Dec. 15	0.54	7.13	3.87	3.33
Dec. 18	0.41	2.63	6.76	4.51
Dec. 21	0.07	8.32	5.91	2.63
Dec. 24	0.01	3.42	4.07	2.73
Dec. 27	0.51	6.59	5.53	5.19
Dec. 30	0.48	1.67	3.12	3.60

TABLE IVi JANUARY 2—— JANUARY 8

Collection Date 1980	Temperature at 5°C	Temperature Shade-house	Temperature at 16°C	Temperature at 24°C
Jan. 2	0.33	3.14	4.44	3.41
Jan. 5	0.28	2.51	1.89	3.23
Jan. 8	0.44	3.63	4.59	4.06

Appendix VII

Table VII April 7 — May 4

The following tables show at 30-day periods the compound totals of eggs oviposited, and compound total of slugs used, of the species D.panormitanum, at each of the four different temperatures.

Collection Date. 1979	5°C compoud total eggs	5°C compoud total slugs	Shade-House compound total eggs	Shade-House compound total slugs	16°C compound total eggs	16°C compound total slugs	24°C compound total eggs	24°C compound total slugs
April 7	68	153	423	156	363	151	602	156
April 10	137	156	1033	162	1077	156	1300	167
April 13	288	157	1675	169	1890	164	1726	197
April 16	415	161	1938	177	2740	179	2104	228
April 19	546	164	2452	186	3377	187	2697	245
April 22	733	168	3073	193	4570	202	3791	267
April 25	966	182	3607	207	5582	214	4411	295
April 28	1120	186	4191	216	6343	235	5245	326
May 1	1314	193	4776	229	7248	259	5755	358
May 4	1452	196	5118	237	8029	278	6549	385

Average number of eggs oviposited per slug at each of the four different temperatures.

April 7 — May 4

5°C $\frac{1452}{196} = 7.41$

Sh-Hs $\frac{5118}{237} = 21.59$

16°C $\frac{8029}{278} = 28.88$

24°C $\frac{6549}{385} = 17.01$

Appendix VII

Table VIIa May 7— June 3

Collection Date 1979	5°C Compound total eggs	5°C Compound total slugs	Shade-House Compound total eggs	Shade-House Compound total slugs	16°C Compound total eggs	16°C Compound total slugs	24°C Compound total eggs	24°C Compound total slugs
May 7	1617	200	5901	253	8615	307	7156	424
May 10	1755	218	6494	266	9081	334	7791	466
May 13	1851	221	7074	279	9742	356	8387	510
May 16	2 7	228	7748	293	10431	377	8550	545
May 19	2276	238	7895	304	10808	419	9148	573
May 22	2334	249	8101	312	11525	443	9511	601
May 25	2470	257	8298	326	12123	480	10385	641
May 28	2597	268	8377	343	12336	508	10761	687
May 31	2678	269	8686	351	13059	545	11288	735
June 3	2747	281	8784	375	13270	575	11852	769

Average number of eggs oviposited per slug at each of the four temperatures.

May 7 — June 3

$5^{\circ}C \quad \frac{1295}{85} = 15.24$

$\text{SH-Hs} \quad \frac{3666}{138} = 26.57$

$16^{\circ}C \quad \frac{5241}{297} = 17.65$

$24^{\circ}C \quad \frac{5303}{384} = 13.81$

April 7 — June 3

$5^{\circ}C \quad \frac{2747}{281} = 9.78$

$\text{Sh-Hs} \quad \frac{8784}{375} = 23.42$

$16^{\circ}C \quad \frac{13270}{575} = 23.08$

$24^{\circ}C \quad \frac{11852}{769} = 15.41$

Appendix VII

Table VIIb June 6 — July 3

Collection Date 1979	5°C Compound eggs	5°C total slugs	Shade-House Compound eggs	Shade-House total slugs	16°C Compound eggs	16°C total slugs	24°C Compound eggs	24°C total slugs
June 6	2858	290	9082	390	14184	607	12697	799
June 9	2960	308	9100	410	14508	627	13431	832
June 12	3017	316	9266	424	15500	651	14232	868
June 15	3128	323	9344	438	15812	673	15338	897
June 18	3269	328	10052	457	16356	701	16523	939
June 21	3313	332	10165	471	16986	723	17117	972
June 24	3337	342	10507	486	17873	757	17896	1003
June 27	3351	353	10511	502	18132	779	18420	1044
June 30	3351	373	10553	527	18496	802	18914	1072
July 3	3389	380	10999	543	19383	821	19918	1103

Average number of eggs oviposited per slug at each of the four different temperatures.

June 6 — July 3

5°C $\frac{642}{99} = 6.48$

Sh-Hs $\frac{2215}{168} = 13.18$

16°C $\frac{6113}{246} = 24.85$

24°C $\frac{8066}{334} = 24.15$

April 7 — July 3

5°C $\frac{3389}{380} = 8.92$

Sh-Hs $\frac{10999}{543} = 20.26$

16°C $\frac{19383}{821} = 23.61$

24°C $\frac{19918}{1103} = 18.06$

Appendix VII

Table VIIc July 6 — August 2

Collection Date 1979	5°C Compound eggs	total slugs	'Shade-House' Compound eggs	total slugs	16°C Compound eggs	total slugs	24°C Compound eggs	total slugs
July 6	3643	388	11304	553	20162	837	20995	1136
July 9	3651	395	11310	567	20442	852	21673	1161
July 12	3784	410	11675	580	21259	869	22438	1184
July 15	3784	418	11675	595	21678	887	23246	1213
July 18	3784	430	11696	606	22505	902	24083	1235
July 21	3789	437	11788	616	23143	913	25024	1263
July 24	3817	443	11959	628	23894	940	25939	1288
July 27	3849	448	11217	639	24332	966	26572	1315
July 30	3960	456	12786	648	25129	986	27327	1349
Aug. 2	4015	470	12906	668	25803	1003	28161	1370

Average number of eggs oviposited per slug at each of the four temperatures.

July 6 — August 2

5°C $\frac{626}{90} = 6.96$

Sh-Hs $\frac{1907}{125} = 15.26$

16°C $\frac{6420}{182} = 35.27$

24°C $\frac{8243}{267} = 30.87$

April 7 — August 2

5° $\frac{4115}{470} = 8.76$

Sh-Hs $\frac{12906}{668} = 19.32$

16°C $\frac{25803}{1003} = 25.73$

24°C $\frac{28161}{1370} = 20.56$

Appendix VII

Table VIId August 5 — September 1

Collection Date 1979	5°C Compound eggs	5°C total slugs	Shade-House Compound eggs	Shade-House total slugs	16°C Compound eggs	16°C total slugs	24°C Compound eggs	24°C total slugs
Aug. 5	4091	476	13031	677	26729	1022	29358	1403
Aug. 8	4091	491	13188	685	26949	1044	29807	1431
Aug. 11	4144	500	13236	696	27703	1066	30867	1454
Aug. 14	4144	510	13655	708	28545	1081	31738	1480
Aug. 17	4233	518	13833	713	29295	1104	32587	1506
Aug. 20	4269	526	14106	724	30333	1119	33353	1527
Aug. 23	4319	539	14353	738	30942	1153	34122	1550
Aug. 26	4323	548	14652	751	32339	1167	35127	1573
Aug. 29	4430	554	15087	762	32939	1190	36169	1595
Sept. 1	4483	560	15690	776	33844	1216	37157	1621

Average number of eggs oviposited per slug at each of the four temperatures.

August 5 — September 1

5°C $\frac{468}{90} = 5.20$

Sh-Hs $\frac{2784}{108} = 25.78$

16°C $\frac{8041}{213} = 37.75$

24°C $\frac{9356}{251} = 37.27$

April 7 — September 1

5°C $\frac{4483}{560} = 8.01$

Sh-Hs $\frac{15690}{776} = 20.22$

16°C $\frac{33844}{1216} = 27.83$

24°C $\frac{37342}{1621} = 23.04$

Appendix VII

Table VIIe September 4 — October 1

Collection Date 1979	5°C Compound eggs	total slugs	Shade-House Compound eggs	total slugs	16°C Compound eggs	total slugs	24°C Compound eggs	total slugs
Sept. 4	4528	573	16087	804	34526	1239	38172	1643
Sept. 7	4683	583	16658	820	35844	1253	39054	1669
Sept. 10	4772	605	16978	832	36770	1270	39990	1688
Sept. 13	4860	621	17772	848	37531	1289	40697	1719
Sept. 16	5021	632	18604	857	38061	1322	41472	1747
Sept. 19	5021	641	18789	874	38567	1342	42261	1774
Sept. 22	5223	649	19597	895	39262	1362	43076	1795
Sept. 25	5294	656	19985	904	39954	1383	43794	1816
Sept. 28	5446	662	20262	910	40652	1401	44664	1838
Oct . 1	5452	674	20851	934	41649	1425	45562	1863

Average number of eggs oviposited per slug at each of the four temperatures.

September 4 — October 1

5°C $\frac{969}{114} = 8.50$

Sh-Hs $\frac{5161}{158} = 32.66$

16°C $\frac{7805}{209} = 37.34$

24°C $\frac{8405}{242} = 34.73$

April 7 — October 1

5°C $\frac{5452}{674} = 8.09$

Sh-Hs $\frac{20851}{934} = 22.32$

16°C $\frac{41649}{1425} = 29.23$

24°C $\frac{45562}{1863} = 24.46$

Appendix VII

Table VIIf October 4 — October 31

Collection Date 1979	5°C Compound eggs	5°C total slugs	Shade-House Compound eggs	Shade-House total slugs	16°C Compound eggs	16°C total slugs	24°C Compound eggs	24°C total slugs
Oct. 4	5514	687	21527	946	42226	1442	46292	1878
Oct. 7	5529	696	21821	961	43258	1464	47088	1892
Oct. 10	5538	705	22724	974	43917	1486	47857	1914
Oct. 13	5595	713	22890	993	44067	1504	48204	1938
Oct. 16	5633	724	23559	1009	44779	1521	48833	1965
Oct. 19	5861	734	24686	1024	45839	1546	49519	2003
Oct. 22	5909	741	25309	1043	46525	1562	50750	2027
Oct. 25	6074	752	25464	1051	47524	1578	51068	2051
Oct. 28	6120	760	26131	1072	48330	1600	52246	2066
Oct. 31	6160	765	26797	1096	48879	1623	52610	2095

Average number of eggs oviposited per slug at each of the four different temperatures.

October 4 — October 31

5°C $\frac{708}{91} = 7.78$

Sh-Hs $\frac{5946}{162} = 36.70$

16°C $\frac{7230}{198} = 36.52$

24°C $\frac{7048}{232} = 30.38$

April 7 — October 31

5°C $\frac{6160}{765} = 8.05$

Sh-Hs $\frac{26797}{1096} = 24.45$

16°C $\frac{48879}{1623} = 30.12$

24°C $\frac{52610}{2095} = 25.11$

Appendix VII

Table VIIg November 3 — November 30

Collection Date 1979		5°C Compound eggs	total slugs	'Shade-House' Compound eggs	total slugs	16°C Compound eggs	total slugs	24°C Compound eggs	total slugs
Nov.	3	6263	771	27895	1122	49896	1647	53654	2130
Nov.	6	6276	785	28543	1140	50773	1677	54165	2163
Nov.	9	6285	796	29777	1158	51876	1705	55060	2202
Nov.	12	6350	811	29998	1187	52637	1724	56184	2238
Nov.	15	6514	819	30998	1212	53702	1744	57363	2275
Nov.	18	6566	825	31573	1240	54355	1769	58212	2302
Nov.	21	6592	834	32908	1261	55439	1787	58921	2343
Nov.	24	6592	845	33527	1286	56567	1804	59613	2373
Nov.	27	6652	857	34703	1302	57302	1827	60373	2413
Nov.	30	6687	867	35722	1322	57920	1844	61518	2439

Average number of eggs oviposited per slug at each of the four different temperatures.

November 3 — November 30

5°C $\frac{527}{102} = 5.17$

Sh-Hs $\frac{8925}{226} = 39.49$

16°C $\frac{9041}{221} = 40.91$

24°C $\frac{8908}{344} = 25.90$

April 7 — November 30

5°C $\frac{6687}{867} = 7.71$

Sh-Hs $\frac{35722}{1322} = 27.02$

16°C $\frac{57920}{1844} = 31.41$

24°C $\frac{61518}{2439} = 25.22$

Appendix VII

Table VIIh December 30 — January 8

Collection Date 1979	5°C Compound eggs	5°C total slugs	Shade-House Compound eggs	Shade-House total slugs	16°C Compound eggs	16°C total slugs	24°C Compound eggs	24°C total slugs
Dec. 3	6811	874	37405	1342	58894	1860	62553	2473
Dec. 6	6841	876	37938	1377	59288	1878	63228	2505
Dec. 9	6914	884	38848	1388	60357	1896	64146	2535
Dec. 12	6928	889	39528	1409	60920	1923	65118	2559
Dec. 15	7009	900	40598	1432	61501	1950	65617	2595
Dec. 18	7070	907	40992	1455	62515	1975	66294	2629
Dec. 21	7081	913	42240	1478	63402	1990	66689	2662
Dec. 24	7094	922	42753	1501	64012	2014	67099	2685
Dec. 27	7171	937	43741	1525	64842	2041	67818	2701
Dec. 30	7243	941	43992	1539	65310	2062	68418	2718
1980								
Jan. 2	7292	949	44463	1565	65976	2072	68929	2742
Jan. 5	7334	961	44840	1573	66259	2087	69414	2760
Jan. 8	7400	963	45385	1579	66947	2108	70023	2784

Average number of slug eggs oviposited per slug at each of the four temperatures.

December 3 — December 30

5°C $\frac{556}{74}$ = 7.51

Sh-Hs $\frac{8270}{219}$ = 37.76

16°C $\frac{7390}{218}$ = 33.90

24°C $\frac{6900}{279}$ = 24.73

January 2 — January 8

5°C $\frac{157}{22}$ = 7.14

Sh-Hs $\frac{1393}{40}$ = 34.83

16°C $\frac{1637}{46}$ = 35.59

24°C $\frac{1605}{66}$ = 24.32

April 7 — December 30

5°C $\frac{7243}{941}$ = 7.70

Sh-Hs $\frac{43992}{1539}$ = 28.58

16°C $\frac{65310}{2062}$ = 31.67

24°C $\frac{68418}{2718}$ = 25.17

April 7 — January 8 (1980)

5°C $\frac{7400}{963}$ = 7.68

Sh-Hs $\frac{45385}{1579}$ = 28.74

16°C $\frac{66947}{2108}$ = 31.76

24°C $\frac{70023}{2784}$ = 25.15

Appendix VIII

TABLE V APRIL 7—— MAY 4

The following tables show at 30 day periods, the number of eggs oviposited by 150 slugs of the species Deroceras panormitanum in the Shade-house, by each collection day (3-day intervals). The temperatures recorded are the maximum, minimum, and the temperature at the time of collection (usually at noon).

Collection Date 1979	Number of eggs oviposited	Temperature Maximum °C	Temperature Minimum °C	Temperature at time of colletion °C
April 7	423	20.0	7.0	19.0
April 10	610	22.0	9.0	18.0
April 13	642	18.0	6.0	6.0
April 16	263	19.0	0.0	17.0
April 19	514	18.0	3.0	13.0
April 22	621	19.0	5.0	18.0
April 25	534	18.0	8.5	14.0
April 28	584	14.0	-1.0	14.0
May 1	585	18.0	0.0	14.0
May 4	342	17.0	1.0	16.0

TABLE Va May 7—— June 3

Collection Date 1979	Number of eggs oviposited	Temperature Maximum °C	Temperature minimum °C	Temperature at time of collection °C
May 7	783	19.0	9.0	16.0
May 10	593	17.5	5.0	17.0
May 13	580	19.0	5.0	14.0
May 16	674	14.0	3.0	10.0
May 19	147	12.0	-1.0	11.5
May 22	206	12.0	-1.0	11.0
May 25	197	12.0	1.0	12.0
May 28	97	13.0	1.0	12.0
May 31	309	13.0	-2.5	9.0
June 3	98	13.0	0.0	11.0

Appendix VIII

TABLE Vb JUNE 6 —— JULY 3

Collection Date 1979	Number of eggs oviposited	Temperature Maximum °C	Temperature Minimum °C	Temperature at time of collection °C
June 6	298	13.0	-1.5	10.0
June 9	18	13.5	-2.0	12.0
June 12	166	13.5	-1.0	12.0
June 15	78	13.0	3.5	12.0
June 18	708	15.0	1.0	10.0
June 21	113	13.0	0.0	9.0
June 24	342	12.5	2.5	10.0
June 27	4	15.5	6.0	13.0
June 30	42	15.5	1.0	11.0
July 3	446	13.0	5.0	10.5

TABLE Vc JULY 6 —— August 2

Collection Date 1979	Number of eggs oviposited	Temperature Maximum °C	Temperature Minimum °C	Temperature at time of collection °C
July 6	305	12.0	-1.0	10.0
July 9	6	11.0	-4.0	10.0
July 12	365	13.0	0.0	9.5
July 15	0	12.0	-1.0	5.0
July 18	21	14.0	-3.0	13.0
July 21	92	15.0	-2.0	13.0
July 24	171	15.0	-2.0	15.0
July 27	258	15.0	1.5	12.0
July 30	569	15.0	-1.0	14.0
August 2	120	14.0	3.0	14.0

Appendix VIII

TABLE Vd AUGUST 5— SEPTEMBER 1

Collection Date 1979	Number of eggs oviposited	Temperature Maximum °C	Temperature Minimum °C	Temperature at time of collection °C
Aug. 5	125	16.0	0.0	11.0
Aug. 8	157	13.0	-1.0	11.5
Aug. 11	48	13.0	-3.5	12.0
Aug. 14	419	17.0	2.0	14.0
Aug. 17	178	14.0	-4.5	12.0
Aug. 20	273	13.0	1.5	8.0
Aug. 23	247	14.0	1.0	14.0
Aug. 26	299	17.0	4.0	13.0
Aug. 29	435	14.0	2.0	11.0
Sept. 1	603	17.0	2.0	13.0

TABLE Ve SEPTEMBER 4— OCTOBER 1

Collection Date 1979	Number of eggs oviposited	Temperature Maximum °C	Temperature Minimum °C	Temperature at time of collection °C
Sept. 4	397	15.0	5.0	14.0
Sept. 7	571	16.0	5.0	15.0
Sept. 10	320	19.0	1.0	12.0
Sept. 13	794	17.0	5.0	17.0
Sept. 16	832	22.0	4.0	12.0
Sept. 19	185	16.0	4.0	15.0
Sept. 22	808	18.5	0.0	18.5
Sept. 25	388	19.0	0.0	15.0
Sept. 28	277	17.0	-2.0	11.0
Oct. 1	589	17.0	4.5	17.0

Appendix VIII

TABLE Vf OCTOBER 4—— OCTOBER 31

Collection Date 1979	Number of eggs oviposited	Temperature Maximum °C	Temperature Minimum °C	Temperature at time of collection °C
Oct. 4	676	20.0	4.0	12.0
Oct. 7	294	19.0	-1.0	15.0
Oct. 10	903	18.0	4.0	17.0
Oct. 13	166	22.0	4.0	20.0
Oct. 16	699	19.0	5.0	17.0
Oct. 19	1127	20.5	4.0	19.0
Oct. 22	623	22.0	3.0	12.0
Oct. 25	155	20.0	0.0	20.0
Oct. 28	667	21.0	5.0	17.0
Oct. 31	666	21.0	6.0	17.0

TABLE Vg NOVEMBER 3—— NOVEMBER 30

Collection Date 1979	Number of eggs oviposited	Temperature Maximum °C	Temperature Minimum °C	Temperature at time of collection °C
Nov. 3	1098	23.0	5.0	18.0
Nov. 6	648	22.0	4.0	22.0
Nov. 9	1234	23.0	5.0	18.0
Nov. 12	221	24.0	4.0	19.0
Nov. 15	1000	25.0	6.0	12.0
Nov. 18	575	23.0	3.0	23.0
Nov. 21	1335	25.0	10.0	18.0
Nov. 24	619	24.0	9.0	13.0
Nov. 27	1176	26.0	6.0	21.5
Nov. 30	1019	25.0	9.0	17.0

Appendix VIII

TABLE Vh DECEMBER 3 — DECEMBER 30

Collection Date 1979	Number of eggs oviposited	Temperature Maximum °C	Temperature Minimum °C	Temperature at time of collection °C
Dec. 3	1683	22.5	9.0	17.0
Dec. 6	533	23.0	8.0	17.0
Dec. 9	910	21.0	5.0	19.0
Dec. 12	680	27.0	10.0	17.0
Dec. 15	1070	21.5	6.0	19.0
Dec. 18	394	27.5	5.0	19.0
Dec. 21	1248	24.0	8.0	23.5
Dec. 24	513	24.0	7.0	22.0
Dec. 27	988	26.0	9.0	17.0
Dec. 30	251	22.0	6.0	16.0

TABLE Vi JANUARY 2 — JANUARY 8

Collection Date 1980	Number of eggs oviposited	Temperature Maximum °C	Temperature Minimum °C	Temperature at time of collection °C
Jan. 2	471	27.0	8.0	18.0
Jan. 5	377	19.0	7.0	18.5
Jan. 8	545	25.0	9.0	23.0

APPENDIX IX

THE HATCHING SUCCESS AND FATE OF EGGS AT THE FOUR DIFFERENT TEMPERATURES.

THE TIME TO ACHIEVE THE PARAMETERS SHOWN IS IN DAYS.

	Control (Shade-House)						16 °C						24 °C						5 °C					
Date......	Number of eggs incubated	Time taken for 1st egg to hatch (days)	Hatching range (days)	Number of eggs hatched	Partial development within the egg	No development of egg	Number of eggs incubated	Time taken for 1st egg to hatch (days)	Hatching range (days)	Number of eggs hatched	Partial development within the egg	No development of egg	Number of eggs incubated	Time taken for 1st egg to hatch (days)	Hatching range (days)	Number of eggs hatched	Partial development within the egg	No development of egg	Number of eggs incubated	Time taken for 1st egg to hatch (days)	Hatching range (days)	Number of eggs hatched	Partial development within the egg	No development of egg
7/ 4/79	100	29	19	93	0	7	100	21	15	80	9	11	100	14	14	71	4	25	100	120	33	76	2	22
17/ 4/79	100	23	18	80	5	15	100	14	18	81	2	17	100	13	13	81	2	17	100	110	42	80	3	17
1/ 5/79	100	33	18	78	5	17	100	21	9	77	9	14	100	12	15	76	18	6	100	93	117	21	28	51
16/ 5/79	100	30	39	69	6	25	100	21	9	73	1	26	100	9	12	22	19	59	100	111	60	29	47	24
1/ 6/79	100	59	30	12	1	87	100	26	6	26	16	58	100	14	3	18	23	59	100	98	75	37	15	48
12/ 6/79	100	51	27	30	4	66	100	21	12	16	5	79	100	10	3	2	34	64	100	113	27	7	3	90
3/ 7/79	100	57	21	18	11	71	100	21	12	43	3	54	100	15	18	50	0	50	100	-	-	-	-	100
15/ 7/79	100	60	9	15	5	80	100	-	-	0	3	97	100	21	3	8	3	89	100	-	-	-	-	100
2/ 8/79	100	-	-	-	-	100	100	-	-	0	2	98	100	-	-	0	2	98	100	-	-	-	-	100
17/ 8/79	100	42	30	23	16	61	100	-	-	0	27	73	100	-	-	0	1	99	100	129	39	41	1	58
1/ 9/79	100	-	-	0	7	93	100	15	21	9	1	90	100	27	3	9	0	91	100	114	39	36	1	63
16/ 9/79	100	-	-	0	2	98	100	-	-	0	0	100	100	-	-	-	-	100	100	-	-	-	-	100
1/10/79	100	37	12	45	3	52	100	24	23	33	5	62	100	33	18	17	14	69	100	-	-	-	-	100
16/10/79	100	27	18	45	0	55	100	30	6	10	3	87	100	21	15	27	2	71	100	-	-	-	-	100
3/11/79	100	25	18	16	19	65	100	27	27	27	8	65	100	27	9	3	29	68	100	127	14	2	3	95
15/11/79	100	18	3	31	2	67	100	18	15	59	1	40	100	15	3	40	1	59	100	99	1	1	0	99
3/12/79	100	12	15	58	2	40	100	21	3	57	2	41	100	12	6	75	0	25	100	78	18	40	0	60
15/12/79	100	18	12	61	2	37	100	15	12	59	2	39	100	12	12	36	1	63	100	78	17	39	0	61
2/ 1/80	100	18	6	53	1	46	100	18	6	53	0	47	100	9	12	75	1	24	100	74	12	74	0	26

Appendix X

Table IX. April 7 — May 4

The following tables show at 30-day periods, the number of slugs of the species D.panormitanum, that have died by each collection day at each of the four temperatures. The results show the number that have died out of 150 slugs.

Collection Date 1979	Temperature at 5°C	Temperature Shade-House	Temperature at 16°C	Temperature at 24°C
April 7	3	6	1	6
April 10	3	6	5	11
April 13	1	7	8	30
April 16	4	8	15	31
April 19	3	9	8	17
April 22	4	7	15	22
April 25	14	14	12	28
April 28	4	9	21	31
May 1	7	13	24	32
May 4	3	8	19	27

Table IXa May 7 — June 3

Collection Date 1979	Temperature at 5°C	Temperature Shade-House	Temperature at 16°C	Temperature at 24°C
May 7	4	16	29	39
May 10	18	13	27	42
May 13	3	13	22	44
May 16	7	14	21	35
May 19	10	11	42	28
May 22	11	8	24	28
May 25	8	14	37	40
May 28	11	17	28	46
May 31	1	8	37	48
June 3	12	24	30	34

Appendix X

Table IXb June 6 — July 3

Collection Date 1979	Temperature at $5^{\circ}C$	Temperature Shade-House	Temperature at $16^{\circ}C$	Temperature at $24^{\circ}C$
June 6	9	15	32	30
June 9	18	20	20	33
June 12	8	14	24	36
June 15	7	14	22	29
June 18	5	19	28	42
June 21	4	14	22	33
June 24	10	15	34	31
June 27	11	16	22	41
June 30	20	25	23	28
July 3	7	16	19	31

Table IXc July 6 — August 2

Collection Date 1979	Temperature at $5^{\circ}C$	Temperature Shade-House	Temperature at $16^{\circ}C$	Temperature at $24^{\circ}C$
July 6	8	10	16	33
July 9	7	14	15	25
July 12	15	13	17	23
July 15	8	15	18	29
July 18	12	11	15	22
July 21	7	10	11	28
July 24	6	12	27	25
July 27	5	11	26	27
July 30	8	9	20	34
August 2	14	20	17	21

Appendix X

Table IXd August 5 — September 1

Collection Date 1979	Temperature at 5°C	Temperature Shade-House	Temperature at 16°C	Temperature at 24°C
Aug. 5	6	9	19	33
Aug. 8	15	8	22	28
Aug. 11	9	11	22	23
Aug. 14	10	12	15	26
Aug. 17	8	5	23	26
Aug. 20	8	11	15	21
Aug. 23	13	14	34	23
Aug. 26	9	13	14	23
Aug. 29	6	11	23	22
Sept. 1	6	14	26	26

Table IXe September 4 — October 1

Collection Date 1979	Temperature at 5°C	Temperature Shade-House	Temperature at 16°C	Temperature at 24°C
Sept. 4	13	28	23	22
Sept. 7	10	18	14	26
Sept. 10	22	10	17	19
Sept. 13	16	16	19	31
Sept. 16	11	9	33	28
Sept. 19	9	17	20	27
Sept. 22	8	21	20	21
Sept. 25	7	9	21	21
Sept. 28	6	6	18	22
Oct. 1	12	24	24	25

Appendix X

Table IXf October 4 — October 31

Collection Date 1979	Temperature at 5°C	Temperature Shade-House	Temperature at 16°C	Temperature at 24°C
Oct. 4	13	12	17	15
Oct. 7	9	15	22	14
Oct. 10	9	13	22	22
Oct. 13	8	19	18	24
Oct. 16	11	16	17	27
Oct. 19	10	15	25	38
Oct. 22	7	19	16	24
Oct. 25	11	8	16	24
Oct. 28	8	21	22	15
Oct. 31	5	24	23	29

Table IXg November 3 — November 30

Collection Day 1979	Temperature at 5°C	Temperature Shade-House	Temperature at 16°C	Temperature at 24°C
Nov. 3	6	26	24	35
Nov. 6	14	18	30	33
Nov. 9	11	18	28	39
Nov. 12	15	29	19	36
Nov. 15	8	25	20	37
Nov. 18	6	28	25	27
Nov. 21	9	21	18	41
Nov. 24	11	25	17	30
Nov. 27	12	16	23	40
Nov. 30	10	20	17	26

Appendix X

Table IXh December 3 — December 30

Collection Date 1979	Temperature at 5°C	Temperature Shade-House	Temperature at 16°C	Temperature at 24°C
Dec. 3	7	20	16	34
Dec. 6	2	35	18	32
Dec. 9	8	11	18	30
Dec. 12	5	21	27	24
Dec. 15	11	23	27	36
Dec. 18	7	23	25	34
Dec. 21	6	23	15	33
Dec. 24	9	23	24	23
Dec. 27	15	24	27	14
Dec. 30	4	14	21	17

Table IXi January 2 — January 8

Collection Date 1979	Temperature at 5°C	Temperature Shade-House	Temperature at 16°C	Temperature at 24°C
Jan. 2	8	26	10	24
Jan. 5	12	8	15	18
Jan. 8	2	6	21	24

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