

THE UNIVERSITY OF MANITOBA

DESIGN AND FABRICATION OF A CONTROLLED ATMOSPHERE UNIT FOR STUDIES ON  
MORTALITY OF ADULTS AND EGGS OF RUSTY GRAIN BEETLE, Cryptolestes  
ferrugineus (Stephens) (Coleoptera: Cucujidae)

by

RAMESH BABU MANICKAM

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(STEPHENS) (COLEOPTERA: CUCUJIDAE)

BY

RAMESH BABU MANICKAM

A thesis submitted to the Faculty of Graduate Studies of  
the University of Manitoba in partial fulfillment of the requirements  
of the degree of

MASTER OF SCIENCE

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## ABSTRACT

A compact, portable controlled-atmosphere unit capable of generating desired gaseous composition in the laboratory using three gases ( $O_2$ ,  $CO_2$ ,  $N_2$ ) in the range of concentrations of 0 to 100% for each gas was designed and fabricated. The gas mixture can be conditioned to any three relative humidities using saturated salt solutions. The unit can also maintain the pressure of the gas mixture at any level between 0 to 250 kPa (gage) and the flow rate between 0 to 90 cc/min. The unit was used for determining the effect of gas composition, exposure time, temperature and relative humidity on the mortality of adults and eggs of rusty grain beetles, Cryptolestes ferrugineus (Stephens). During a single experiment, the unit can handle up to six different exposure times.  $CO_2$  levels of 70, 80 and 90%,  $O_2$  levels of 0, 4 and 8% and relative humidity of 65, 75 and 85% at a pressure of 35 kPa (gage) and flow rate of  $55 \pm 2$  cc/min at six exposure times of 24, 48, 60, 72, 84 and 96 h were used to study the mortality of adults of C. ferrugineus at 10, 15 and 20°C. For studying the mortality of eggs of C. ferrugineus, only two levels of  $O_2$  (0 and 4%) and two temperatures (10 and 20°C) were used at the same  $CO_2$  concentrations, relative humidities, pressure and flow rate.

For gas compositions containing  $CO_2$  in the range of 68 to 91.7%,  $O_2$  in the range of 0 to 5.0% and the balance  $N_2$ , the mortality of adults was higher than eggs in a given exposure period. The mortality of eggs was more influenced by change in  $O_2$  from 5 to 0% than was the

mortality of adults, whereas a change in CO<sub>2</sub> from 68.0 to 91.7% increased adult mortality more than that of eggs. Gas compositions and relative humidity (60 to 84%) affected the mortality of eggs and adults more than the other variables did. For adult mortality, more interaction was observed between CO<sub>2</sub> and O<sub>2</sub> with temperature (9.0 to 20.5°C), whereas for egg mortality, the O<sub>2</sub> and relative humidity synergism was greater than other interactions. Maximum mortality for both adults (99%) and eggs (85%) was obtained at high CO<sub>2</sub> (88 to 91.7%), low O<sub>2</sub> (0 to 0.5%), the higher temperatures (19.5 to 20.5°C) and lower relative humidities (60.0 to 63.9%) at an exposure of 96 h.

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## TABLE OF CONTENTS

ABSTRACT .....	i
ACKNOWLEDGEMENTS .....	iii
TABLE OF CONTENTS .....	iv
LIST OF TABLES .....	vii
LIST OF FIGURES .....	viii
1. INTRODUCTION .....	1
2. OBJECTIVES .....	6
3. LITERATURE REVIEW .....	7
3.1. Infestation in Stored Grain .....	7
3.2. Definition of Basic Terms .....	8
3.3. Mechanism of Mortality of Insects in Controlled Atmosphere Storage .....	9
3.4. Development of a Data Base on Controlled (modified) Atmosphere Storage .....	10
3.5. Factors Influencing the Effectiveness of Controlled Atmosphere Storage .....	11
3.5.1. Effect of Temperature on Mortality of Stored-Product Insects in Controlled Atmospheres .....	11
3.5.2. Effect of Relative Humidity on Mortality of Stored-Product Insects in Controlled Atmospheres .....	13
3.5.3. Effect of Gas Composition on Mortality of Stored-Product Insects in Controlled Atmospheres.....	16
3.5.3.1. Pure N <sub>2</sub> or CO <sub>2</sub> Atmospheres .....	17
3.5.3.2. Effect of Low O <sub>2</sub> Atmosphere .....	17
3.5.3.3. Effect of CO <sub>2</sub> Atmosphere .....	19

3.5.4.	Effect of Time of Exposure on Mortality ....	21
3.5.5.	Susceptibility of Species and Life Stages of Insects. ....	22
3.5.6.	Effect of Flow Rate on Mortality .....	24
3.6.	Advantage and Disadvantage of Controlled Atmosphere Storage .....	24
3.7.	Devices Used in Laboratories for Control of Stored-Product Pests in Controlled Atmospheres .....	26
3.7.1.	Anesthetizing Devices .....	26
3.7.2.	Controlled Atmosphere Units .....	27
3.8.	Summary of Literature Review .....	28
4.	MATERIALS AND METHODS .....	31
4.1.	Components of the Unit .....	31
4.1.1.	Cylinder - Regulator Details .....	31
4.1.2.	Flowmeter - Calibration Details .....	31
4.1.3.	Blender - Design Details .....	34
4.1.4.	Gas Sampling Port - Gas Composition Analysis .....	37
4.1.5.	Relative Humidity Units .....	38
4.1.6.	Insect Chamber Details .....	39
4.1.7.	Exhaust Assembly .....	41
4.2.	Rearing of Adults and Eggs of <u>C. ferrugineus</u> .....	42
4.3.	Experimental Design .....	42
4.4.	Experimental Methods .....	43
5.	RESULTS AND DISCUSSION .....	46
5.1.	Precision of the Controlled Atmosphere Unit .....	46
5.2.	Mortality of <u>C. ferrugineus</u> Adults .....	51



5.2.1. General Linear Model and Statistical Analysis .....	51
5.2.2. Effect of Gas Compositions .....	53
5.2.3. Effect of Temperature .....	64
5.2.4. Effect of Relative Humidity .....	64
5.2.5. Interactions Between Variables .....	68
5.3. Mortality of <u>C. ferrugineus</u> Eggs .....	69
5.3.1. Effect of Gas Composition .....	70
5.3.2. Effect of Temperature and Relative Humidity .....	76
6. CONCLUSIONS .....	78
7. RECOMMENDATIONS FOR FURTHER STUDIES .....	80
8. REFERENCES .....	82
9. APPENDICES .....	89
Appendix A1. Summary of Database .....	90
Appendix A2. Insect Name, Insect Stage, Temperature, Relative Humidity, CO <sub>2</sub> , O <sub>2</sub> , Exposure Time, Insects Mortality, Author, Year - Sorted Listing of Controlled Atmosphere Storage Data Base .....	95
Appendix B. Standrad Deviation (S.D) of Mortality of <u>C. ferrugineus</u> Adults and Eggs over the Mean Mortality .....	160

LIST OF TABLES

PAGE

Table 5.1.	The Mortality of <u>C. ferrugineus</u> Adults Exposed to Different Gas Compositions at 74% relative humidity and Two Temperatures .....	65
Table 5.2.	The Mortality of <u>C. ferrugineus</u> Adults Exposed to Different Gas Compositions at 10 and 20°C for Three Relative Humidities .....	67

LIST OF FIGURES

PAGE

Fig. 4.1.	Schematic Diagram of Controlled Atmosphere Unit .....	32
Fig. 4.2.	Design Details of Blender .....	35
Fig. 4.3.	Design Details of A Baffle Used in Blender .....	36
Fig. 4.4.	Design Details of Insect Chamber .....	40
Fig. 5.1.	Mean and Measured Values of Carbon Dioxide .....	47
Fig. 5.2.	Mean and Measured Values of Oxygen .....	48
Fig. 5.3.	Mean and Measured Values of Relative Humidity .....	49
Fig. 5.4.	Mortality of <u>C. ferrugineus</u> Adults Exposed to Various Carbon Dioxide Concentrations at 15°C Temperature, 0% Oxygen and 74% Relative Humidity. ....	54
Fig. 5.5.	Mortality of <u>C. ferrugineus</u> Adults Exposed to Various Carbon Dioxide Concentrations at 15°C Temperature, 4% Oxygen and 74% Relative Humidity. ....	55
Fig. 5.6.	Mortality of <u>C. ferrugineus</u> Adults Exposed to Various Carbon Dioxide Concentrations at 15°C Temperature, 8% Oxygen and 74% Relative Humidity. ....	56
Fig. 5.7.	Mortality of <u>C. ferrugineus</u> Adults Exposed to Various Carbon Dioxide Concentrations at 20°C Temperature, 0% Oxygen and 74% Relative Humidity. ....	58
Fig. 5.8.	Mortality of <u>C. ferrugineus</u> Adults Exposed to Various Carbon Dioxide Concentrations at 20°C Temperature, 4% Oxygen and 74% Relative Humidity. ....	59
Fig. 5.9.	Mortality of <u>C. ferrugineus</u> Adults Exposed to Various Carbon Dioxide Concentrations at 20°C Temperature, 8% Oxygen and 74% Relative Humidity. ....	60
Fig. 5.10.	Mortality of <u>C. ferrugineus</u> Adults Exposed to Various Carbon Dioxide Concentrations at 10°C Temperature, 0% Oxygen and 74% Relative Humidity. ....	61
Fig. 5.11.	Mortality of <u>C. ferrugineus</u> Adults Exposed to Various Carbon Dioxide Concentrations at 10°C Temperature, 4% Oxygen and 74% Relative Humidity. ....	62

Fig. 5.12. Mortality of <u>C. ferrugineus</u> Adults Exposed to Various Carbon Dioxide Concentrations at 10°C Temperature, 8% Oxygen and 74% Relative Humidity. ....	63
Fig. 5.13. Mortality of <u>C. ferrugineus</u> during Developmental Stage in Atmospheric Air (Smith, 1965) .....	66
Fig. 5.14. Mortality of <u>C. ferrugineus</u> Eggs Exposed to Various Carbon Dioxide Concentrations at 10°C Temperature, 4% Oxygen and 74% Relative Humidity. ....	71
Fig. 5.15. Mortality of <u>C. ferrugineus</u> Eggs Exposed to Various Carbon Dioxide Concentrations at 20°C Temperature, 4% Oxygen and 74% Relative Humidity. ....	72
Fig. 5.16. Mortality of <u>C. ferrugineus</u> Eggs Exposed to Various Carbon Dioxide Concentrations at 10°C Temperature, 0% Oxygen and 74% Relative Humidity. ....	74
Fig. 5.17. Mortality of <u>C. ferrugineus</u> Eggs Exposed to Various Carbon Dioxide Concentrations at 20°C Temperature, 0% Oxygen and 74% Relative Humidity. ....	75

## 1. INTRODUCTION

Farmers, food storage, transportation and processing industries, and consumers suffer a large monetary loss from stored-product pests (insects, mites, rodents and birds) either directly by contamination or by feeding or indirectly by stimulation of microfloral spoilage by producing moisture and heat through respiration. These pests cause damage to the grains, reduce their nutritive value and finally make the stored products unfit for human consumption. White and Lambkin (1988) reported that an average of 3 to 4 germs of wheat grains were attacked during the development of an individual larva of the red flour beetle, Tribolium castaneum (Herbst) (Coleoptera: Tenebrionidae) at temperatures of 22.5 to 37°C and 40 to 60% relative humidity. If conditions [15% grain moisture and 25-30°C for the rusty grain beetle, Cryptolestes ferrugineus (Stephens) (Coleoptera: Cucujidae)] are favorable, even a few insects can start a large infestation and cause grain spoilage. Populations of C. ferrugineus can increase 60-fold in one generation during 4 weeks at 32°C (Howe, 1965).

A survey of 2919 primary grain elevators in western Canada in 1969-71 indicated that 15% of elevators and 42% of the surrounding farms had grains infested with insects (Sinha, 1972). Based on the data collected from empty granaries, Smith (1985) reported that live rusty grain beetles were found on 53, 32 and 24% of farms in Manitoba, Saskatchewan and Alberta, respectively. Madrid (1986) reported, based on a survey of stored grain on farms near Winnipeg, that 80% of the

bins containing wheat, oats and barley had insects. Grain samples collected from elevator bins during the periods June-July, 1987 and February, 1988 revealed that 70 and 72% of grain samples had insect infestations, respectively although infestation levels on farms and in elevators varied considerably from one year to the next (Madrid, 1988).

Chemical pesticides are commonly used to control insects in stored grain. These chemical methods may leave objectionable chemical residues in the treated commodity and the chemicals are generally hazardous to handle and apply. Also, some stored-product pests are developing resistance to chemicals (Bailey and Banks, 1980; White and Loschiavo, 1985). There are only a few insecticides that are permitted for use on or near stored products. The fumigant ethylene dibromide, which was widely used in the milling industry, was banned by the Canadian federal regulatory agencies in 1985, followed by a ban of most other fumigant formulations. The remaining commercial fumigants, phosphine and methyl bromide, are under regulatory review. There is, therefore, a need for acceptable and effective methods of preventing insect damage and contamination of agricultural products that would reduce or eliminate the dependence on chemical pesticides during storage (Storey, 1980a). Hence researchers have studied physical control methods (heating, cooling, controlled atmospheres), which do not leave any chemical residues on the stored-products and yet provide lethal environments to stored-product pests. Impact as both a shock and disturbance (Loschiavo, 1978), physical removal and physical exclusion (Banks, 1987) were tested by some researchers to control stored-product pests.

Visible light and sound also showed some promise, but they are not used commercially.

Controlled atmosphere storage involves alteration of the normal atmospheric gas composition to create an environment lethal to stored-product pests (Bailey and Banks, 1980). Different insects require different environments (temperature, relative humidity, gas composition, pressure and flow rate) for their survival or death in a specified time period. Even within the same insect species, different strains or populations survive and proliferate in different environments depending on their physiology. In addition, insect mortality in a controlled atmosphere is a function of insect stage/age, exposure time and the size of the initial insect population.

Researchers have studied extensively the mortality response of stored-product pests using lethal atmospheres since 1968 (Harein and Press, 1968). A data base (Appendix A) on controlled (modified) atmosphere grain storage was developed as a part of this study. The data base consisted of information about the gas composition, temperature, relative humidity, exposure time and mortality of 18 stored-product insects. The sources of data are given in section 3.4.

Briefly, CO<sub>2</sub> and N<sub>2</sub> have been used in the range of 0 to 100% by volume (ambient CO<sub>2</sub> in air is about 0.03% and N<sub>2</sub> is about 79%) and temperature in the range of 15 to 38.7°C in 89.5% of the studies. In a few studies, the flow rate was mentioned and in 86% of the studies,

the pressure was not reported. The O<sub>2</sub> levels were mostly used in the range of 0 to 10% by volume, and in some cases it was between 10 to 22% and was rarely above 22% (higher than the atmospheric level of about 21%). In 87% of the studies, relative humidity was in the range of 30 to 70%. In a few studies, however, maximum relative humidity of 100% or minimum relative humidity of 0 to 7% were also used. Exposure times were in the range of 24 to 700 h, although in 88.7% of studies exposure times of <200 h were used. Mortality response of adults were reported in 60% of the studies, whereas mortality of egg, larva and pupa were reported in 33, 10 and 27%, respectively. More than 1000 different environmental combinations have been used to study the mortality response of various pests and there is a potential for using the same or more environmental combinations in future work on different pests. The laboratory controlled-atmosphere units developed so far have limitations and generally produced operating conditions unique to individual studies.

There is a need for a versatile controlled atmosphere unit capable of producing any desired gaseous composition and a range of relative humidities, which can handle four to six exposure times for studying the mortality response of stored-product pests. The information from the data base showed that the mortality response of stored-product insects of Tribolium (Coleoptera: Tenebrionidae), Sitophilus (Coleoptera: Curculionidae) Oryzaephilus (Coleoptera: Cucujidae) species were investigated in detail at various trinary and binary mixtures of CO<sub>2</sub>, O<sub>2</sub> and N<sub>2</sub>. Only two studies (White et al., 1988;



Krishnamurthy et al., 1986) using controlled atmosphere were conducted on the mortality response of C. ferrugineus, which is one of the most economically important pests of stored cereals in western Canada (Sinha, 1972). The beetle consumes most of the germ portion of wheat and produces metabolic heat and moisture, which creates hot spots and microfloral spoilage of grains when insect populations are large. Therefore, a study was planned to determine the mortality of C. ferrugineus adults and eggs in high CO<sub>2</sub> (>70% by volume) and low O<sub>2</sub> (<10% by volume) atmospheres as affected by temperature (10 to 20°C) and relative humidity (65 to 85%) simulating fall and spring conditions of stored grain in Canada.

## 2. OBJECTIVES

The objectives of this study were:

1. to design and fabricate a versatile controlled-atmosphere unit capable of generating desired gaseous composition using any of three gases (CO<sub>2</sub>, O<sub>2</sub> or N<sub>2</sub>) ranging in concentration from 0 to 100%,
2. to make the unit capable of conditioning gases to any three relative humidity using saturated salt solutions and of handling six exposure times in a single experiment conducted for studying the biological response of stored-product pests, and
3. to use the developed unit for determining the effect of gas compositions and exposure times on the mortality of adults and eggs of C. ferrugineus as affected by temperature and relative humidity.

### 3. LITERATURE REVIEW

#### 3.1. Infestation in Stored Grain

Infestations usually occur in stored grain when the crops are harvested warm or damp or are stored longer than usual because of low sales or high production. In Canada, the annual average wheat production between 1977 to 1986 was 23.2 Mt of which 10.5 Mt was stored in farm storages for more than a year (Anon, 1986). Even though quantitative losses of stored-products due to insects, mites and microflora are not very high in Canada, harvesting and variable storage conditions provide suitable environments for survival and reproduction of some stored-product insects, which produce significant qualitative losses. Sources of infestation are uncleaned granaries, trucks and grain handling equipment previously used to store and transfer infested grain. Heating, caking and sprouting on the surface of the grain bulk are the first obvious signs of heavy infestation (Sinha et al. 1986). C. ferrugineus is an economically important pest and does the most insect-initiated damage to farm-stored wheat in Canada. The beetle consumes germ portions of wheat grains. If temperature and relative humidity of the intergranular storage atmosphere are favorable, C. ferrugineus can produce high metabolic heat and moisture, which create hot spots and initiate microfloral spoilage of grains. Very little work (White et al., 1988) has been done on the mortality of different life stages of C. ferrugineus in high CO<sub>2</sub> (>60%) and low O<sub>2</sub> atmospheres at relatively cool temperature (<20°C).

### 3.2. Definition of Basic Terms

Stored-product pests can be effectively controlled by storing the grain in an atmosphere lethal to them. Common terms used to define lethal atmosphere grain storage are: air-tight, modified and controlled. In air-tight (hermetic) atmosphere storage, the respiration and basic metabolism of the components (stored-product, insect and microfloras) reduce the available  $O_2$  and increase  $CO_2$ . In modified atmosphere storage, the atmosphere is modified by introducing  $CO_2$  or  $N_2$  at a specified concentration. Controlled atmosphere storage involves the precise alteration and maintenance of the proportion of normal atmospheric gases,  $N_2$ ,  $CO_2$  and  $O_2$  (Bailey and Banks, 1980) at a specified pressure and flow rate. The terms: controlled atmosphere and modified atmosphere are used interchangeably.

Air-tight storage has been used for a long time to control insects in stored grain (Cotton, 1961). The depletion of  $O_2$  and rise in  $CO_2$  in air-tight storages create lethal environments for stored-product pests. The production of  $CO_2$  and consumption of  $O_2$  in air-tight storage is a function of moisture content of the stored-product which is directly related to the respiration rate of microflora and seeds (Diawara et al. 1987). The efficacy of air-tight storage in controlling insects is species dependent. Sinha and Mookherjee (1967) reported that adults of T. castaneum died after short exposure in air-tight storages while 100% mortality of Sitophilus granarius (L.) and S. oryzae (L.) was obtained after an exposure of 30 days. Oxley and Wicken (1963)

reported that Q. surinamensis (L.) and Cryptolestes species survived until 22 days in an air-tight environment. Longer exposure might have killed these insects.

### 3.3. Mechanism of Mortality of Insects in Controlled Atmospheres

The toxic atmospheres give an anesthetic effect to stored-product pests during the early stage of exposure. As the exposure time increases, suffocation of insects in lethal atmospheres increases and finally results in death. When the O<sub>2</sub> concentration in an atmosphere decreases and CO<sub>2</sub> increases, the respiration rate of insects increases. The respiration activity of insects is regulated at 10 or fewer pairs of openings called the spiracles located laterally along the body surface. Due to increased respiration, CO<sub>2</sub> in the storage atmosphere increases and causes further dilation of spiracles and moisture loss from the body of the insects. The insects may be killed due to this phenomenon of desiccation at low humidity. In Xenopsylla species (Siphonaptera: Pulicidae), an addition of 1% CO<sub>2</sub> in the atmosphere prolonged the spiracular opening period and an addition of 2% CO<sub>2</sub> caused permanent opening of spiracles (Wigglesworth, 1965). But for Tribolium confusum J. duVal, an addition of 1 to 2% CO<sub>2</sub> did not change the respiration rate of adult beetles. CO<sub>2</sub> concentrations of 3, 8 and 16% in air resulted in 11, 50 and 100%, respectively, reduction in the respiration rate after 2 h (Aliniyee, 1971b)

At high temperatures (35 to 45°C), chemical components in the body of insects become unstable and cell structure is highly disturbed.

Mortality of insects at high temperature is generally due to denaturing of intra-cellular proteins and change in membrane phospholipids. At low temperatures ( $<0^{\circ}\text{C}$ ), moisture in the cells crystalizes causing cellular dehydration and rupture. This results in the collapse of the cell, an increase in solutes and irreversible bio-chemical and physical damage (Evans, 1987a). At high relative humidity, (intergranular air within bulks of cereals with moisture content greater than 18%) and temperature, the rate of  $\text{O}_2$  consumption increases due to the high respiration rate of microflora, which results in increasing the  $\text{CO}_2$  concentration, which itself was found to be lethal to stored-product pests (Diawara et al. 1987).

#### 3.4. Development of a Data Base on Controlled (Modified) Atmosphere Storage

A data base to summarize the operating conditions and results obtained from controlled atmosphere studies on control of stored-product insects was developed. The data found in articles published in the Journal of Stored Product Research from 1968 to 1988, the Journal of Economic Entomology from 1960 to 1988, Controlled Atmosphere Storage of Grains edited by Shejbal (1980), Controlled Atmosphere and Fumigation edited by Ripp et al. (1983), and Proceedings of the Fourth International Working Conference on Stored-Product Protection edited by Donahaye and Navarro (1987) were summarized in the data base. The fields are: name (Latin) of the insect, life stages (adult, pupa, larva and egg), temperature ( $^{\circ}\text{C}$ ), relative humidity (%), gas compositions ( $\text{CO}_2$ ,  $\text{O}_2$ ,  $\text{N}_2$  and He), pressure (kPa), flowrate (cc/min), exposure (h),

mortality (%), author (first author), journal, volume, page numbers and year. For developing this data base software packages Dbase 3+ and 4 were used. A sorted listing based on CO<sub>2</sub>, O<sub>2</sub>, temperature, relative humidity, exposure time and author is presented in Appendix A2. The following sections of the literature review are based primarily on this data base.

### 3.5. Factors Influencing Effectiveness of Controlled Atmosphere Storage

The factors influencing the efficacy of controlled atmosphere storage in controlling stored-product insects are temperature, moisture content, gas composition (Jay, 1983; Bailey and Banks, 1980) insect species and life stage, age and initial insect population size, length of exposure, adsorption of CO<sub>2</sub> by grains (Jay, 1983), gas pressure (Navarro, 1972) and gas flow rate (Shejbal et al., 1973). The distribution pattern of different insect species (Navarro et al., 1981), temperature, moisture content and gas concentration gradients within a grain bulk should also be considered as factors influencing the mortality of insects in controlled atmosphere storage.

#### 3.5.1. Effect of Temperature on Mortality of Stored-product Insects in Controlled Atmosphere Storage of Grains

Navarro and Calderon (1980) studied the effect of temperature on mortality of T. castaneum, Rhyzopertha dominica (F.) (Coleoptera: Bostrichidae) and S. oryzae and reported that the time required to obtain a certain level of insect mortality at a fixed gas composition decreases with an increase in the temperature of the atmosphere. Storey

(1975a, 1980a) reported that when the temperature increased from 15 to 32°C, the exposure time decreased by 90% for obtaining 95% mortality of S. oryzae, S. granarius, R. dominica, T. castaneum and O. surinamensis. Bailey and Banks (1975) obtained complete mortality of S. granarius at 29.4°C in 2 weeks and at 23.9°C in 3 weeks, but at 18.3°C only 78% mortality was obtained after 12 weeks. For C. ferrugineus adults, exposure at 20°C resulted in more effective control than at 10 and 2.5°C (White et al., 1988). These results showed that in controlled atmosphere storage, the higher the temperature above a threshold limit, the shorter the exposure time required to obtain complete mortality of stored-product insects (Storey 1980a, Spratt et al. 1985). Banks and Annis (1977) extrapolated the available data on controlled atmosphere storage with 0.1% O<sub>2</sub> and a balance of N<sub>2</sub> at temperatures >20°C and predicted that it will take at least 15 weeks to obtain complete mortality of most stored-product insects at 18°C compared to 2 to 5 weeks at >20°C.

In most of the controlled atmosphere studies, temperatures ranging from 15 to 38°C were used. The information obtained from the database showed that only 6% of studies on controlled atmosphere storage used a temperature less than 10°C. Studies at 20 to 30°C are important because growth and development of the majority of the stored-product insects occur in this range and cease below 15°C. However, efficacy of controlled atmosphere storage should be studied at lower temperatures for an understanding of the mortality response of insects over a wide



range of temperatures experienced in the temperate Canadian climate, where control measures usually are used in cool grain.

### 3.5.2. Effect of Relative Humidity on Mortality of Stored-Product

#### Insects in Controlled Atmospheres

A component that has been neglected in most studies related to controlled atmosphere storage is water vapour as measured by relative humidity (Bailey and Banks 1980). Though relative humidity was reported in most of the studies, the influence of relative humidity in controlling stored-product pests was determined only in 25% of the controlled atmosphere studies. In a bulk grain storage ecosystem, moisture content of the stored-product is in equilibrium with the intergranular air (Muir, 1986). Survival of insects in stored grain is influenced by the relative humidity. For most of the stored-product insects, low relative humidity appears to be unfavorable for reproduction, however most can survive even at very low relative humidities (Howe, 1965). Survival at low relative humidity depends on the balance maintained by the insects between the losses and gains of water. Desiccation of insects at low relative humidity contributes to the mortality of insects (Bailey and Banks, 1980), however the role of relative humidity in causing the mortality by desiccation alone needs clarification (Navarro and Calderon, 1980).

Insects normally lose moisture by transpiration through integuments and by respiration through respiratory membranes. The water proof nature of the epicuticle (outer cover) greatly reduces the

transpiration through the integument (Edney, 1967). Water loss through respiratory membranes is controlled by spiracles. Spiracles are located at primary or secondary orifices of trachea. In a normal atmosphere, insects keep their spiracles constricted, and will open them just enough to satisfy O<sub>2</sub> requirements. In depleted O<sub>2</sub> atmospheres or elevated CO<sub>2</sub> atmospheres insects open their spiracles completely to obtain necessary O<sub>2</sub> and during this process moisture is released from the body. Excessive water loss from the body causes mortality. The frequency of opening of spiracles seems to be directly related to CO<sub>2</sub> and O<sub>2</sub> concentration. Mellanby (1934) found that rate of water loss was 2 to 7 times greater when low O<sub>2</sub> was used instead of atmospheric air. Experiments conducted by Wigglesworth (1935) at 0% relative humidity in low O<sub>2</sub> atmospheres revealed that complete opening of spiracles of some insects resulted in increased water loss by an amount 10 times greater than that found in normal atmospheric air. Bailey and Banks (1980) reported that in low relative humidity environments (<40%), water loss from the insect body was more pronounced in high CO<sub>2</sub> (>60%) atmospheres than in low CO<sub>2</sub> (10 to 30%) atmospheres. There also existed a relationship between relative humidity and O<sub>2</sub> concentration, in the absence of CO<sub>2</sub>. At high r.h, the insects required a very low O<sub>2</sub> concentration to obtain complete mortality (Navarro, 1978).

Smith (1968) reported that the effect of relative humidity (40-60%) on the mortality of C. ferrugineus was less than the effect of temperature (25-35°C). However, greater mortality was obtained at the lower relative humidity of 40% at all temperatures. In most of the

controlled atmosphere studies, there is an agreement that mortality of most stored-product pests is higher at low relative humidities (<40%) than at high relative humidities (>60%). Some of the pests did not respond to the variations in relative humidity for example, survival of Plodia interpunctella (Hubner) (Lepidoptera: Phycitidae) was not affected by relative humidity because it was well adapted to survive at low relative humidities. In contrast, survival of Amyelois transitella (Walker) (Lepidoptera: Phycitidae) was greatly influenced by relative humidity (Soderstrom et al., 1986). When adults of T. castaneum and O. surinamensis were exposed to 9, 33, 54 and 68% relative humidity at 26.3°C with binary and trinary mixtures of O<sub>2</sub>, N<sub>2</sub> and CO<sub>2</sub>, greater mortality was obtained at 9% relative humidity compared to other relative humidities (Jay et al., 1971). For Ephestia cautella (Lepidoptera: Phycitidae) at 4.3% CO<sub>2</sub> and 3.2% O<sub>2</sub>, 20 to 25% relative humidity was required for complete mortality, whereas at the same gas composition, at 93% relative humidity, all the insects survived after the same exposure time of 120 h (Navarro and Calderon, 1980). Studies conducted by Navarro and Calderon (1974) on pupae of E. cautella at 21 and 55% relative humidity revealed that there was not much difference in mortality due to the change in relative humidity for CO<sub>2</sub> ranging from 0 to 88%. The mortality of T. castaneum and T. confusum adults in an atmosphere containing 45% CO<sub>2</sub> decreased, when the relative humidity increased from 38 to 100% and temperature decreased from 26.7 to 15°C (Aliniaze, 1971a). Jay and Pearman (1971) reported that the susceptibility of insects to CO<sub>2</sub> atmospheres increased with a decrease in relative humidity. Aliniaze (1972) reported that at low relative

humidity, a N<sub>2</sub> atmosphere is less lethal than a helium atmosphere. The data on the effect of relative humidity on the mortality of C. ferrugineus, and some species of other genera like Sitophilus, Sitotroga (Lepidoptera: Gelechiidae) and Rhyzopertha in controlled atmospheres are not available.

### 3.5.3. Effect of Gas Composition on the Mortality of Stored-Product Insects in Controlled Atmospheres

Many researchers (Lindgren and Vincent 1970; Jay and Pearman, 1973; Shejbal et al. 1973; Spratt 1979; Spratt et al. 1985; Storey, 1980a; Bailey and Banks, 1980; White et al., 1988) have studied the efficacy of controlled atmosphere storage in controlling specific stored-product pests. Since many stored-product insects are physiologically different, they require different atmosphere for survival. Therefore, Navarro (1978) cautioned not to generalize the results obtained from controlled atmosphere studies of one species to another. Many researchers (Harein and Press, 1968; Aliniazee, 1971a; Shejbal et al., 1973; Calderon and Navarro, 1979; Storey, 1980a and White et al., 1988) did considerable research to assess the lethal action of different concentrations of N<sub>2</sub>, CO<sub>2</sub> and O<sub>2</sub> as binary or trinary mixtures on stored-product pests at different temperatures and relative humidities. However not many recommendations were made, because of different operating conditions and test methods used by researchers on different strains or populations of stored-product insects.

### 3.5.3.1. Effect of Pure N<sub>2</sub> or CO<sub>2</sub> Atmosphere

A Pure N<sub>2</sub> atmosphere was better than a pure CO<sub>2</sub> atmosphere in controlling T. castaneum adults, however mortality was rapidly influenced by CO<sub>2</sub> in presence of O<sub>2</sub> at temperatures ranging from 15.6 to 37.8°C (Harein and Press, 1968). Lindgren and Vincent (1970) reported that there was no difference between the mortality response of S. oryzae and S. granarius exposed to pure N<sub>2</sub> or pure CO<sub>2</sub> atmospheres. Verma and Wahdi (1978) reported that pure CO<sub>2</sub> was significantly slower than N<sub>2</sub> in controlling T. castaneum adults and larvae and eggs of E. cautella and Oryzaephilus mercator (Fauvel) (Coleoptera: Cucujidae). However, a CO<sub>2</sub> atmosphere was significantly faster than N<sub>2</sub> in controlling adults of O. mercator and E. cautella.

### 3.5.3.2. Effect of Low O<sub>2</sub> Atmosphere

Bailey and Banks (1980) reported that at low O<sub>2</sub> concentrations (<1%), the proportion of CO<sub>2</sub> and N<sub>2</sub> in the atmosphere is not important for effective control of most stored-product insects. The mortality of T. castaneum adults increased with a decrease in O<sub>2</sub> concentration from 5 to 2% (Navarro, 1978). Shejbal et al. (1973) found an increase in the mortality of T. castaneum, Tribolium confusum J. du Val (Coleoptera: Tenebrionidae) and S. granarius as the O<sub>2</sub> was progressively reduced from 1 to 0.1%. Other researchers (Bailey and Banks, 1980; Navarro and Calderon, 1980) reported that the presence of CO<sub>2</sub> in a low O<sub>2</sub> atmosphere (<5%) is more lethal to insects than a low O<sub>2</sub> atmosphere itself. The lethal action of a low O<sub>2</sub> (<1%) atmosphere was found to be

dependent on temperature, exposure time (Storey, 1980a) and relative humidity (Navarro and Calderon, 1980) in the absence of CO<sub>2</sub>. The presence of CO<sub>2</sub> in a low O<sub>2</sub> atmosphere improved the efficacy more than the presence of N<sub>2</sub> in a low O<sub>2</sub> atmosphere. Calderon and Navarro (1979) reported that in an atmosphere of less than 5% O<sub>2</sub>, the mortality of T. castaneum adults was dependent on CO<sub>2</sub>. As CO<sub>2</sub> increased from 10 to 40%, the exposure time decreased from 5 to 1 day for a 5 to 2% reduction in O<sub>2</sub> to obtain 95% mortality of T. castaneum. When CO<sub>2</sub> is present, O<sub>2</sub> is used up more quickly and the insects die due to increased desiccation. Under depleted O<sub>2</sub> atmospheres, increased water loss from the body of the insect leads to mortality. Storey (1975a, 1975b) reported that in an atmosphere having less than 1% O<sub>2</sub>, at 27°C and 50% relative humidity, all life stages of P. interpunctella, A. transitella and adults of S. granarius, S. oryzae, T. castaneum, T. confusum and O. surinamensis were killed within an exposure of 24 h. An atmosphere having less than 2% O<sub>2</sub> and 5 to 20% CO<sub>2</sub> resulted in complete mortality of C. ferrugineus adults after 4 days of exposure (Krishnamurthy et al., 1986) at 27°C. When the O<sub>2</sub> level decreased to 0% at 25°C, exposure of 3 weeks reduced the population of C. ferrugineus adult to 2% of the original levels (Burrell, 1980). Annis (1987) reported that 95% or greater mortality of most stored-product pests occurred within 10 days in a less than 1% O<sub>2</sub> atmosphere, except those of Trogoderma granarium Everts (Coleoptera: Dermistidae) larvae, which required 12 days at 0.1% O<sub>2</sub> to achieve the same level of mortality.

### 3.5.3.3. Effect of CO<sub>2</sub> Atmospheres

Jay and Pearman (1971) reported that CO<sub>2</sub> is the most efficient gas among O<sub>2</sub>, N<sub>2</sub>, CO<sub>2</sub> and He in controlling insect population within a grain storage system. A controlled atmosphere was very effective for controlling insects in milled rice. There were no live insects after 8 months in a storage system covered with a plastic sheet and purged with CO<sub>2</sub> (Calverely, 1983). Mitsuda et al. (1973) found that it is feasible to store grain in laminated plastic bags purged with CO<sub>2</sub>. Adults, larvae and eggs of T. castaneum, P. interpunctella, Trogoderma variabile (L.) (Coleoptera: Dermestidae) and Lasioderma serricorne (F.) (Coleoptera: Anobiidae) could not survive in CO<sub>2</sub> purged food pouches after 12 weeks of storage (Daniel and Highland, 1978). Harein and Press (1968) reported that if the air in a confined storage was purged with N<sub>2</sub>, then O<sub>2</sub> should be reduced to 1% to produce a lethal atmosphere to T. castaneum at 15 to 27°C. On the other hand, if CO<sub>2</sub> was used, even the presence of 15% O<sub>2</sub> permitted the same lethal effect.

At 10°C, 94% CO<sub>2</sub> and 1% O<sub>2</sub>, 100% mortality of C. ferrugineus was obtained within the exposure of one week. Whereas at 20°C, complete mortality could be obtained at a CO<sub>2</sub> level of 59% and 9% O<sub>2</sub> within a week (White et al., 1988). At 27°C, Aliniabee (1971a) obtained complete mortality of T. confusum and T. castaneum in less than 1.5 days with 2% O<sub>2</sub> in CO<sub>2</sub> atmosphere, but it took 4 days when a similar atmosphere was created using N<sub>2</sub> instead of CO<sub>2</sub>. In situations where little or no attempts are made to seal the storage structure prior to the treatment,

elevated CO<sub>2</sub> (>60%) is more effective than depleted O<sub>2</sub> for controlling most stored-product pests (Jay, 1980; Bailey and Banks, 1980). Lindgren and Vincent (1970), however reported that 100% CO<sub>2</sub> is not as lethal as 60 to 80% CO<sub>2</sub>. Aliniabee (1971a) reported that in a high CO<sub>2</sub> atmosphere (90 to 100%), the effect of change in concentration of O<sub>2</sub> from 10 to 2% was negligible in increasing the mortality of five important stored-product insects.

Jay (1980) reported that to obtain 95% mortality of most stored-product pests, it took 4 days at high CO<sub>2</sub> (>60%) compared to 10 days at low O<sub>2</sub> (<1%) atmospheres. The data collected by Annis (1987) indicated that at 80% CO<sub>2</sub> it would take 16 days to obtain 95% mortality of most stored-product pests. If T. granarium is not present, exposure time can be reduced to 8.5 days and if Sitophilus species are also not present it would take only 5.5 days. At 60% CO<sub>2</sub>, if T. granarium was present, 25 days were needed to kill all insects. A high CO<sub>2</sub> (>70%) atmosphere was less dependent (Bailey and Banks, 1980; Harein and Press, 1968) on temperature and more dependent on relative humidity (Navarro and Calderon, 1980). The phenomenon of less temperature dependency of high CO<sub>2</sub> atmospheres was further proved by Zakladnoi (1976). However Aliniabee (1971a) found a positive effect of temperature on the lethal action of 100% CO<sub>2</sub> in controlling Tribolium species. In high CO<sub>2</sub> and high relative humidity (>70%) atmospheres, the mortality generally occurred due to the lethal action of CO<sub>2</sub> alone (Navarro and Calderon, 1980). An elevated CO<sub>2</sub> (>60%) and depleted O<sub>2</sub> (<10%) atmosphere was recommended by most of the researchers for controlling most stored-



product pests. Some of the insects were not controlled very well in this atmosphere because of the temperature and relative humidity combinations used in the studies.

#### 3.5.4. Effect of Time of Exposure on the Mortality of Insects

The effectiveness of controlled atmosphere storage is highly dependent on the exposure time of the insects. Annis (1987) recommended that CO<sub>2</sub> concentration of 45 to 60% should be maintained for 6 days at 27°C; 12 days at 21 to 26°C and 21 to 28 days at 16 to 20°C to obtain 95% mortality of most stored-product pests. Jay (1980) reported that it took only 4 days to kill most stored-product insects when the CO<sub>2</sub> concentration was maintained at 60%. Spratt et al. (1985) showed that exposure to 75% CO<sub>2</sub> for 6 days at 27°C or above may not be adequate if T. granarium is present, and they reported that larvae of T. granarium took 15 days to die at 30°C and 75% CO<sub>2</sub>. However, in all these studies, effect of relative humidity was not considered, which may influence the exposure time considerably. Storey (1975a) reported that the time required to kill 95% of adults of S. oryzae, S. granarius, R. dominica, T. castaneum and O. surinamensis varied from 3.8 to 296.7 h at temperatures of 15 to 32°C and 50% relative humidity in an atmosphere of <1% O<sub>2</sub> and 10% CO<sub>2</sub>. A long exposure time of 296.7 h was required to obtain 95% mortality of S. oryzae at 15°C, whereas O. surinamensis required only 3.8 h at 32°C. Storey (1975 b) reported that all the stages of P. interpunctella were killed in an exposure time of 48 h at 27°C and 50% relative humidity at less than 1% O<sub>2</sub> atmosphere. However

to kill all life stages of S. cerealella under the same atmosphere condition took 120 h.

### 3.5.5. Susceptibility of Species and Life Stages of Insects

Different insect species require different atmospheres for their control. Trogoderma granarium was the most tolerant species among identified stored-product pests and Sitophilus species were more tolerant than other species like Tribolium when exposed to 100% CO<sub>2</sub> (Annis, 1987; Spratt et al., 1985; Storey, 1975a). Cryptolestes ferrugineus has a high rate of survival compared to other stored-product pests such as Ahasverus advena (Waltl) (Coleoptera: Silvanidae), Typhaea stercorea (L.) (Coleoptera: Mycetophagidae) (Burrell, 1980) and O. surinamensis, T. castaneum and R. dominica in 10 to 30% CO<sub>2</sub> atmospheres (Krishnamurthy et al., 1986). Even within the insect species different strains or populations required different atmospheres for their control depending on their physiology and environmental temperature and relative humidities. For example, strains of C. ferrugineus survived (Sinha and Watters, 1985; Smith, 1968) sub-zero temperature in Canada but other strains could not survive at temperatures of 9.5 to 13.5°C for 13 weeks in Australia (Evans, 1987b).

Susceptibility of life stages in controlled atmospheres varied from insect to insect. However, in most of the studies, adults were the most susceptible and pupae were the most tolerant life stage. Aliniazev (1972) reported that adults of T. castaneum and T. confusum were the

most susceptible, followed by larva, egg and pupa in N<sub>2</sub> and He atmospheres. Lindgren and Vincent (1970) reported a similar susceptibility pattern for S. oryzae in CO<sub>2</sub>, N<sub>2</sub> or He atmospheres, whereas S. granarius followed the pattern of adults, larva, pupa and egg. The larva of Trogoderma glabrum (Herbst) (Coleoptera: Dermestidae) and S. oryzae survived for a longer exposure than pupae of S. oryzae and T. glabrum in trinary mixtures of CO<sub>2</sub>, O<sub>2</sub> and N<sub>2</sub> at 15 to 37°C. Storey (1975b) reported that the order of tolerance for S. cerealella was larva, pupa, egg and adult, whereas for Cadra (Ephestia) cautella, the order was, egg, pupa, larva and adult and for P. interpunctella, it was pupa, egg, adult and larva.

Barker (1981) reported that in a N<sub>2</sub> atmosphere of 95-100%, 90-95% of C. ferrugineus eggs survived at 25°C for an exposure of 7 to 10 days. When the same atmosphere was maintained for a period of 13 to 20 days, mortality of eggs increased up to 75% depending on the concentration of O<sub>2</sub> used in the mixture. However, 90% of adults survived for 13 days in the same atmosphere. In CO<sub>2</sub> atmospheres ranging from 10 to 87%, adults did not survive after 7 days of exposure, whereas 9 to 26% of the eggs survived. Results obtained after eight days of exposure showed that in 10 to 70% CO<sub>2</sub> atmospheres, only 10% of eggs survived, whereas at CO<sub>2</sub> levels greater than 70%, 21% of eggs survived (Barker, 1979). Storey (1975a) compared the tolerance of five stored-product insects in low O<sub>2</sub> atmospheres and reported that S. oryzae was the most tolerant largely because immatures develop inside cereal kernels, followed by S. granarius, R. dominica, T. castaneum and

O. surinamensis. Based on the data base, mortality response of pupa, larva and egg were studied in 33, 27 and 10% of controlled atmosphere studies. It was confirmed by most of the researchers that adults of most stored-product pests are more susceptible to elevated CO<sub>2</sub> (>60%) and depleted O<sub>2</sub> atmospheres than the other life stages.

### 3.5.6. Effect of Flow Rate on Mortality

In most of the controlled atmosphere studies, flow rate ranging from 20 to 200 cc/min was used. Press et al. (1967) conducted experiments with flow rates ranging from 50 to 200 cc/min at 95 to 99% N<sub>2</sub> and 90-95% CO<sub>2</sub> atmospheres to find the mortality rate of the CO<sub>2</sub>-tolerant stored-product insect T. granarium. They reported that the average mortality increased rapidly in the N<sub>2</sub> atmosphere with an increase in the flow rate. The influence of flow rate on mortality was less in CO<sub>2</sub> atmospheres of 90 to 95%. Shejbal et al. (1973) reported that as the flow rate increased, the mortality of insects decreased in low O<sub>2</sub> (<5%) atmospheres. Because of a lack of information available in the literature about the effect of flow rate on mortality at low O<sub>2</sub> or high CO<sub>2</sub> (about 60%) and at different temperatures and relative humidities, most researchers neglected this parameter and they did not even report it.

### 3.8. Advantages and Disadvantages of Controlled Atmosphere Storage of Grains

Controlled atmosphere storage does not leave any toxic chemical residue. In addition to effectively controlling stored-product pests,

controlled atmosphere storage maintains the quality of stored grain. Annis and Greve (1983) reported that coffee beans in CO<sub>2</sub> atmosphere were preserved better than in ambient air, the latter resulting in moisture damage and bad odor. Controlled atmosphere treatment inhibited aerobic fungi, which eliminated mycotoxin production (Busta et al. 1980).

The high operational cost of controlled atmospheres compared to the most commonly used fumigants like phosphine or methyl bromide, and unknown reliability of elevated CO<sub>2</sub> or N<sub>2</sub> levels under granary conditions are the main reasons for limited commercial acceptance of controlled atmosphere storage (Annis, 1987; Jay, 1983). As a result of the change in atmosphere and variation in temperature within a grain bulk, certain Tribolium species secrete a substance called benzoquinone, which may have an undesirable effect on the baking quality and taste of bread. Also Tribolium species, in CO<sub>2</sub> atmosphere, release a pungent volatile compound that irritates human nasal membranes and in conjunction with benzoquinones turn flour a pink colour. In concrete storage structures, uptake of CO<sub>2</sub> by concrete results in formation of carbonates, which can penetrate up to 75 mm into unprotected concrete. This carbonation front is sufficient to reach reinforced steel in large concrete granaries and may place them at risk of corrosion in the presence of free water and O<sub>2</sub> (Banks and Macabe, 1988). Stored-product insects have the genetic potential to develop resistance against controlled atmosphere treatments. Therefore, if insects are exposed to CO<sub>2</sub> atmospheres for many generations, the

insects may develop a potential resistance against controlled atmosphere treatments. Bond and Buckland (1979) reported that treatment of seven successive generations of S. granarius adults with 75% CO<sub>2</sub> at 25°C made them three times more tolerant to high CO<sub>2</sub> atmospheres.

### 3.7. Devices Used in Laboratory Studies for Controlling Stored-Product Insects using Controlled Atmospheres

#### 3.7.1. Anesthetizing Devices

Several methods have been used to anesthetize insects for a prolonged period without deleterious effect. Williams (1946) used low pressure, commercial CO<sub>2</sub> to anesthetize insects, whereas Caldwell (1956) maintained CO<sub>2</sub> atmospheres with a tray of dry ice suspended in a bucket. White and Paul (1961) developed a device to generate a CO<sub>2</sub> atmosphere. It consisted of a petri dish and a wooden deck, both equipped with wire mesh at the bottom, which were used to segregate insects. CO<sub>2</sub> flowed through the petri dish and wooden deck and finally collected in glass vials. The authors primarily used this device for anesthetization of minute insects of Aphytis species (Hymenoptera: Aphelinidae). Adkins (1968) developed a CO<sub>2</sub> anesthetization device to inactivate insects and permit sorting of the facefly, Musca autumnalis DeGeer (Diptera: Muscidae) by sex. The device was a plywood box (600 \* 450 mm) with a shallow metal sheet funnel and a floor of wire mesh fitted inside the box. A 7.6 mm diameter baffle was mounted at the centre of the funnel above the gas entry point. CO<sub>2</sub> was released in the area under the baffle through a hose connected to a pressure

reduction valve, which was attached to a CO<sub>2</sub> cylinder and was regulated by a foot activated valve.

### 3.7.2. Controlled Atmosphere Units

Harein and Press (1968) designed an apparatus to generate gas mixtures of CO<sub>2</sub> and N<sub>2</sub> ranging from 0 to 100% and O<sub>2</sub> ranging from 0 to 20%. Insect cages were suspended in glass exposure jars, which were partly submerged in water baths, maintained at 15.6, 26.7 and 37.8°C. Flow meters and reduction valves were used, however, little design detail was reported. Storey (1977, 1980a) used an exothermic inert atmosphere generator for modified atmosphere studies of mortality of several stored-product insects. The atmosphere unit consisted of a laboratory-scale generator, five metal cylindrical silos, two incubators and pneumatic grain-handling equipment for loading and unloading the silos. The generator was built by Gas Atmosphere Inc. (Strongsville, Ohio, U.S.A) and produced 2.7 m<sup>3</sup>/h of inert atmosphere composed of less than 1% O<sub>2</sub>, 8.5 to 11.5% CO<sub>2</sub> and a balance of N<sub>2</sub>. Navarro (1972) designed a unit for studying the effect of low pressure and gas composition on stored-product insects. A laboratory oil pump was operated by a motor to create low pressure in a vacuum reservoir. A vacuum controller regulated the operation of the motor by checking the level of pressure in the reservoir. When the pump stopped, a solenoid valve was activated to close the circuit, which prevented any further entry of air into the reservoir. Using a regulator and a needle valve, a desired pressure ranging from 3 to 14 kPa was maintained.

Spratt (1979) developed an apparatus to create desired atmospheres with mixtures of CO<sub>2</sub>, O<sub>2</sub> and N<sub>2</sub>. Three gas cylinders were used in the system. Reduction valves were used to reduce the pressure of gases to 840 kPa from initial cylinder pressures of 14 MPa. From the cylinder, gases passed through the flow meter and mixed in the blender. The blended gases passed into a reservoir tank, until pressure inside the reservoir reached 700 kPa, when the solenoid valve automatically cut off the flow. The flow was resumed by the solenoid valve when pressure dropped below 350 kPa. From the reservoir unit, gas flowed through a reduction valve set at 70 kPa into six lines with flow meters fixed in each line. The flow was regulated at 30 cc/min. The regulated gas mixture was humidified by passing it through saturated solutions of NaCl and KCl, which produced 71% relative humidity at 30°C. The humidified gas mixture was passed through an insect chamber, which consisted of circular perspex dishes (140 mm diameter and 60 mm height) and lids sealed with petroleum jelly. Navarro et al. (1985) developed a unit to regulate and mix CO<sub>2</sub>, O<sub>2</sub> and N<sub>2</sub> in the required proportion to produce desired atmospheres. Compressed gas from the cylinders passed through needle valves and flow meters and reached a reservoir. The gas mixture was humidified using a gas-washing bottle containing a saturated salt solution. Two narrow perspex plates containing insect samples were sandwiched between a glass slide and a screen, and the whole assembly was held in position by a metal clip. These assemblies were exposed to humidified gas mixture in the exposure units placed inside controlled temperature rooms of 15.6 and 26.7°C.



### 3.8. Summary of Literature Review

Everyone involved in the production, storage, handling, processing and consumption of various cereals, oilseeds and their derived products, suffer a significant monetary loss due to infestation by stored-product pests. These pests are generally controlled by chemical pesticides if infestations become detectable. The chemicals can leave toxic residues in the treated stored-products. A physical method, which can eliminate the problem of chemical residues is controlled atmosphere storage. The developed data base on controlled atmosphere storage revealed that more than 1000 different environmental combinations have been used to study the mortality response of various stored-product insects and their life stages. There is a potential for using the same or more environmental combinations in future studies on different stored-product pests in controlled atmospheres. The laboratory controlled atmosphere units developed by many researchers had their own limitations and produced limited and unique operating conditions used in the studies. A versatile controlled atmosphere unit capable of generating desired gaseous composition, a range of relative humidities and of handling four to six exposure times in any experiment for studying the mortality response of all life stages of important stored-product insects is needed.

Many researchers confirmed that elevated CO<sub>2</sub> (>60%) and depleted O<sub>2</sub> (<10%) atmospheres, at a temperature >27°C and relative humidity <50% were effective in controlling most of the stored-product insects. In elevated CO<sub>2</sub> atmosphere, the insects were controlled within four to

six days, whereas in depleted O<sub>2</sub> atmospheres, 10 days were required for controlling most of the stored-product insects. Not many controlled atmosphere studies were conducted on the mortality of different life stages of C. ferrugineus, which is one of the most economically important insect species infesting stored cereals in Canada. Cryptolestes ferrugineus does most damage to farm-stored wheat in Canada by consuming large quantities of germ of the seeds. The populations of the beetle produce high metabolic heat and elevated moisture, which lead to hot spots and microfloral spoilage of grains. The presence of one detected live stored-product insect in commercial grain necessitates fumigation of the grain because Canada has a legally defined zero tolerance for insects in export grain (Canada Grain Act, 1970; Canada Grain Regulations, 1975). Quality loss in grain by extensive infestations results in down-grading of the grain, usually to animal feed with significant financial losses to the producer.

## 4. MATERIALS AND METHODS

### 4.1. Components of the Controlled Atmosphere Unit

The components of the controlled atmosphere unit (Fig. 4.1) are compressed gas cylinders, pressure regulators, flow meters, a gas sampling port, a gas blender, relative humidity units with measuring ports, an insect chamber with exposure units and an exhaust assembly. The gases from individual cylinders flow sequentially through pressure regulators, flow meters, blender, relative humidity units, exposure units and an exhaust assembly.

#### 4.1.1. Gas Cylinder-Regulator Details

High pressure gas cylinders ( $\text{CO}_2$ : 5.8 MPa,  $\text{O}_2$  and  $\text{N}_2$ : 16.1 MPa) were placed in an equilateral triangular bottom stand with sides of 500 mm and attached to a central pole (40 mm diameter) by chains. These gas cylinders contained 99.5 to 99.95% pure gases, 50 to 120 ppm of water vapor and traces of some inert gases like helium, neon and argon. The pressure was reduced to 35 kPa (all pressures reported in this thesis are gage pressures except where mentioned otherwise) using pressure regulators. The pressure regulators used in the experiment had input gauge indicators with the pressure range of 0 to 28 MPa and output gauge indicators with the range of 0 to 700 kPa.

#### 4.1.2. Flow Meter-Calibration Details

A rotameter (Tube-cube model, Matheson Instruments, Ottawa,

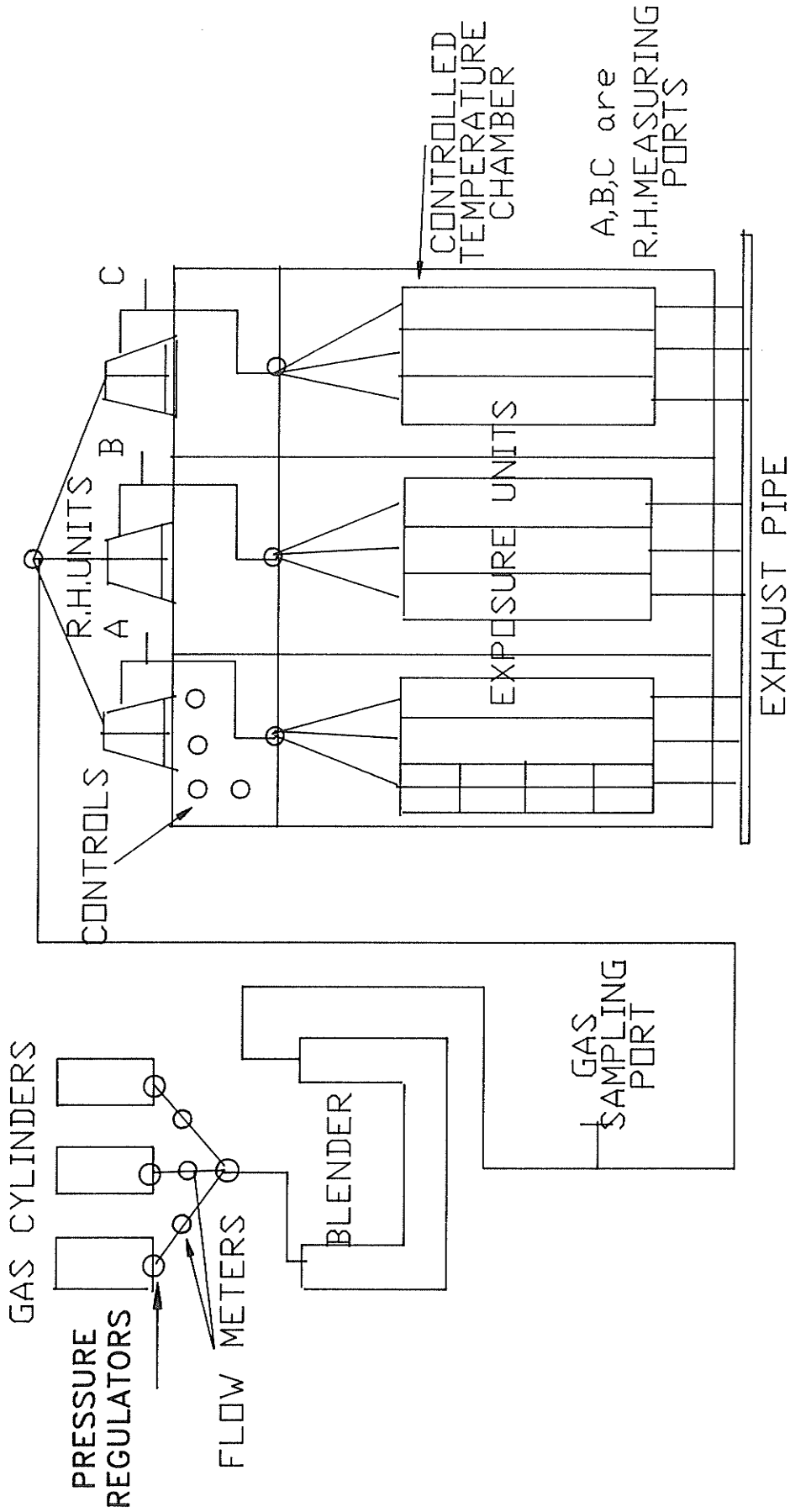


FIG. 4.1. SCHEMATIC DIAGRAM OF CONTROLLED ATMOSPHERE UNIT

Ontario, Canada) with a range of 0 to 3200 cc/min was used to measure CO<sub>2</sub> flow rate. Two other rotameters (Sho-rate model Brook's Instrument Division, Ontario, Canada) with a range of 0 to 1600 cc/min were used to measure N<sub>2</sub> and O<sub>2</sub> flow rates. All these rotameters were initially calibrated using a water displacement method. Two cylindrical tanks of equal volume (18.72 L) were used in the water displacement tests. The tanks were placed at the same elevation to avoid the problem of gravity flow. Each gas (CO<sub>2</sub>, O<sub>2</sub> and N<sub>2</sub>) at 35 kPa was passed through the rotameter to be calibrated and then into the top of tank 1 through 6.25 mm diameter polyvinyl tubing and a control valve. From the outlet of tank 1, the water flowed through another control valve into tank 2. Outside the tanks, marks were made to indicate the level of water in litres. The time taken for the displacement of water from level 1 (5 L mark) to level 2 (15 L mark) in tank 1 was noted. The volumetric flow rate indicated by the rotameter and the flow rate calculated using the water displacement method were compared.

Three trials were conducted at 160, 480, 800, 1120, 2080 and 3200 cc/min flow rates as indicated by the Matheson rotameter. The same procedure was repeated for Sho-rate rotameters at 160, 480, 800, 1120 and 1600 cc/min. The calibration of rotameters using the water displacement method was verified using a pitot tube digital meter. The pitot tube digital meter (Hand Digital Model, Air Neotronics, Oxford, England) gave a direct reading of gas velocity. From the velocity, the flow rate was calculated by multiplying the area of tube cross section. Three trials were conducted using all three rotameters at each level

of flow rate used in the water displacement calibration method. The results were compared with the water displacement values and it was concluded that the pitot tube gave better precision than the water displacement method.

#### 4.1.3. Blender-Design Details

The front view of the blender used to mix the gases uniformly is shown in Fig 4.2. To obtain efficient mixing, the length of flow was increased several times by placing baffles (Fig. 4.3) at approximately one half of the pipe diameter (75 mm) and forcing the gas mixtures through orifices of approximately 0.5% ( $30 \text{ mm}^2$ ) of the total area of the baffle. The baffles in the blender were arranged in such a way that adjacent baffles had orifices in the upper and lower half of the baffle. Many researchers (Beer and Chieger, 1972; Hartung and Hiby, 1972, cited in Ajinkya, 1984) recommended that concurrent and cross flow of gases in a swirling flow gave better mixing efficiency. Based on these recommendations, the opening area, position of the baffles and configuration of the blender were selected. The elbow portions of the blender were used as temporary reservoirs over the design range of flow rate used in the unit. The total length of the blender tubing was 916 mm and 25 baffles were used.

The baffle assembly consisted of a threaded rod (5 mm diameter), baffles and hexagonal nuts. Baffles were positioned on the threaded rod by hexagonal nuts. Three plastic lids, one at inlet (I), one at outlet (O) and the other one in between the inlet and outlet, at M (Fig. 4.2),

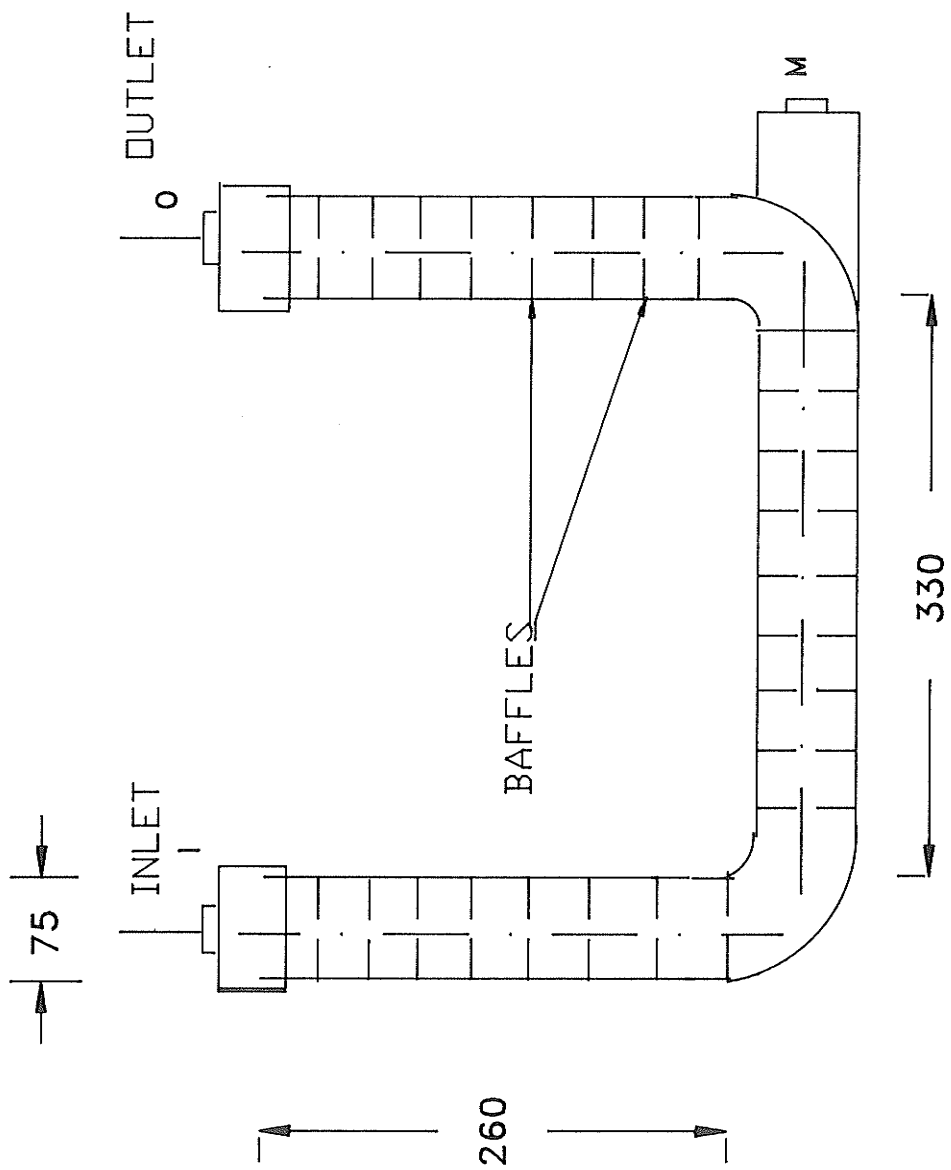


FIG. 4.2. DESIGN DETAILS OF BLENDER

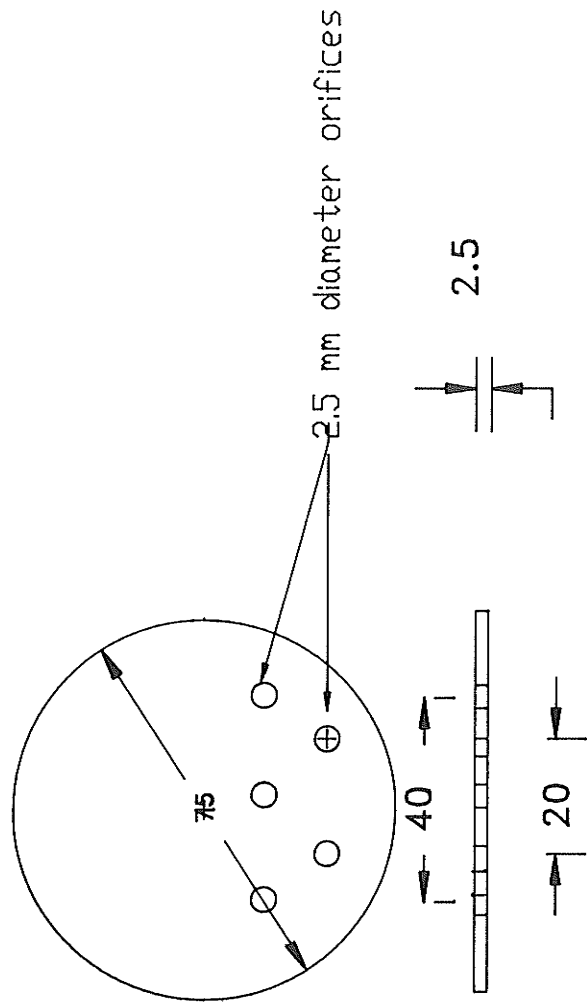


FIG. 4.3. DESIGN DEATILS OF A BAFFLLE USED IN BLENDER



were used for easy installation of blender assemblies and for adjustments of baffle spacing in an assembly.

#### 4.1.4. Gas Sampling Port - Gas Composition Analysis

A gas sampling port was placed between the blender and relative humidity units. It was a brass T section with a rubber septum fixed at the outlet of the T section. Gas samples were taken using gas-tight 10 cc syringes. The efficiency of gas mixing in the blender was determined by analyzing the samples taken from the sampling port. A gas chromatograph (Matheson, model: 8430, H.F. Instruments Ltd. Rexdale, Ontario, Canada) with a thermal conductivity detector was used to analyze gas composition in the mortality study of adults of C. ferrugineus. Helium was used as the carrier gas. The chromatograph was calibrated with commercially prepared standard gases ranging from 0 to 100% and charts relating chromatograph response to gas concentration were prepared for CO<sub>2</sub> and O<sub>2</sub>. The oven and detector temperatures were maintained at 45°C. A fixed-volume 1 cc injector loop and 2-m columns of porapak Q (CO<sub>2</sub>) or molecular sieve 5A (O<sub>2</sub>) were used. The attenuation used in the chromatograph was varied from 16 to 64 depending on the concentration of the mixture being analyzed. The peaks were recorded using a chart recorder.

Gas composition used in the mortality studies of eggs of C. ferrugineus was analyzed using a gas chromatograph (Helwett Packard, model:HP9850A, Avondale, Pennsylvania, USA). The chromatograph was calibrated using commercially prepared standard gas mixtures containing

gases ( $\text{CO}_2$ ,  $\text{O}_2$ ,  $\text{N}_2$ ) in the range of 0 to 100%. The mean area, retention time and area/amount relationship obtained from 10 replications for each gas in the gas mixture was stored in 3-level calibration files. The calibration files were stored in the random access memory of an integrator (Helwett Packard, model:HP3396A, Avondale, Pennsylvania, USA). The linear, non-linear and point to point calibration files were created for each gas as well as for the gas mixtures. Depending on the level of gas concentration used in the experiments, either linear or non-linear calibration files were retrieved every time for analysis of gases. The gas chromatograph had a fixed volume 0.5 cc sample injector loop. The oven temperature was maintained at 70°C for 2 min, increased to 90°C at the rate of 30°C/min and maintained at 90°C for 1 min. Helium was used as the carrier gas at 215 kPa. A thermal conductivity detector, porapak ( $\text{CO}_2$ ) and molecular sieve ( $\text{O}_2$ ) columns of 2 m long were used to detect the gas concentration in the samples.

#### 4.1.5. Relative Humidity Units

The gas mixture from the blender was distributed equally to three relative humidity units by a three-way divider. Each relative humidity unit consisted of a 500 ml Erlenmeyer flask with a rubber stopper having a hole of 5 mm diameter. Through the inlet hole, a 145 mm long tube was inserted, which reached 8 mm above the bottom of the flask. The desired relative humidities were generated by bubbling the gas mixture in saturated salt solutions. The relative humidities produced were measured using a Vaisala, humicap, HM 1698 probe equipped with a thin polymer capacitance sensor and HMI 31 digital meter (Helinski,

Finland). The probe was calibrated with standard salt solutions of LiCl, NaCl and K<sub>2</sub>SO<sub>4</sub> using standard procedures and a Vaisala HM 11 calibrator.

The relative humidity measuring ports were located between relative humidity units and the insect chamber. A polyvinyl T-joint, with a provision for the insertion of a relative humidity probe and a polyvinyl position control valve, was used as the measuring port. The humidified gas was tapped in the measuring port and exposed to the relative humidity probe. Exposure times of 15 to 20 min were used to bring the humidity sensor into equilibrium with the gas especially when the step change in the relative humidity measurement was around 20%. The humidified gas from each relative humidity unit was distributed equally into three parts by a three way divider. From each part of the divider it was further subdivided into two parts and was taken to the exposure units of the insect chamber. At each line, a flow regulator was used to regulate the gas flow into the exposure units.

#### 4.1.6. Insect Chamber-Details

The mixed, humidified gases were flushed continuously into the exposure units of the insect chamber. This continuous flushing prevented the formation of a gas composition different from the desired level due to metabolic activities of the insects. The plan and elevation of the insect chamber are shown in Fig. 4.4. Each exposure unit consisted of four insect boxes of 50 mm diameter and 50 mm high, with a screen of 80 mesh (110 micrometer opening) fixed at the bottom

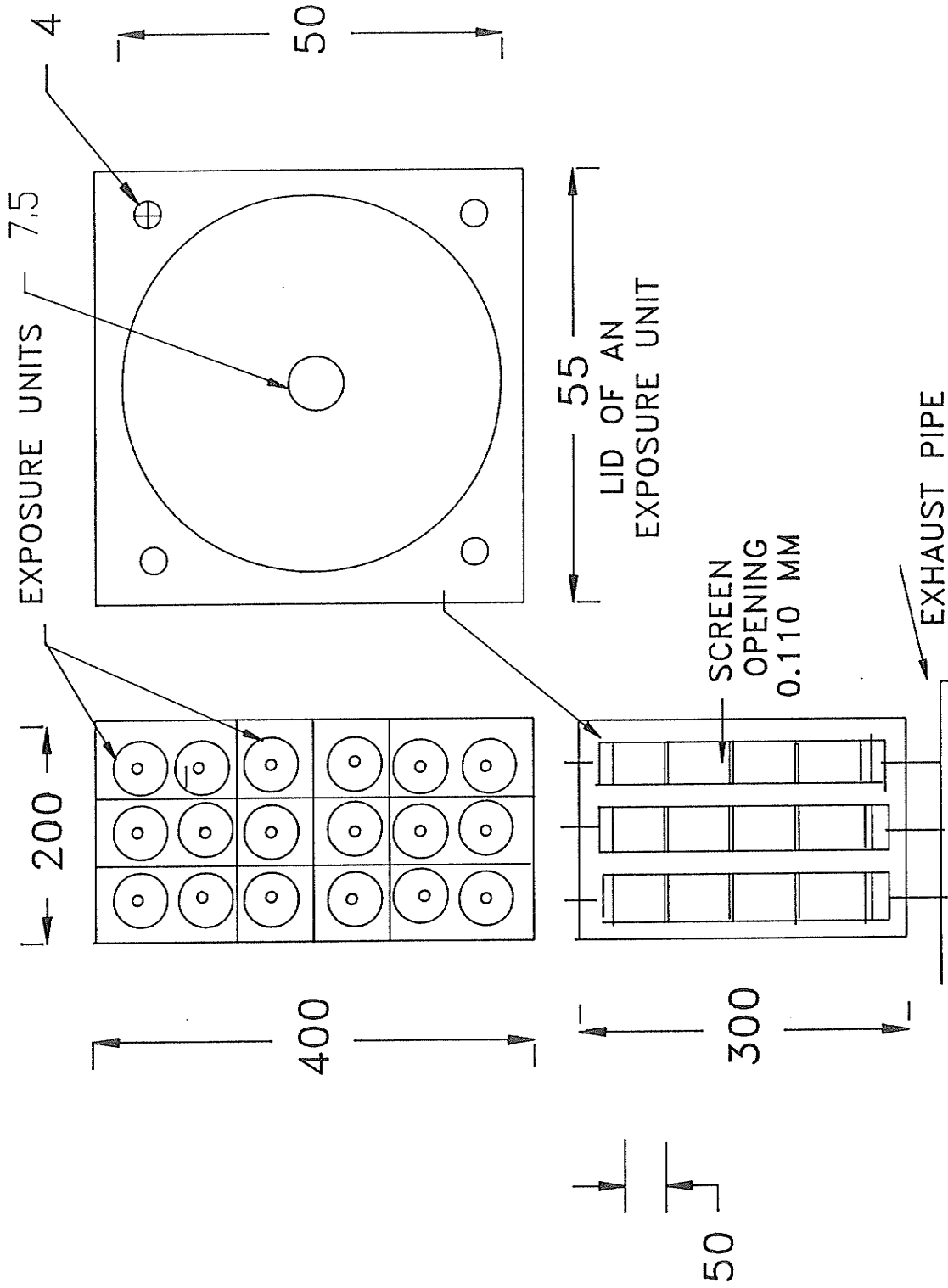


FIG. 4.4. DESIGN DETAILS OF INSECT CHAMBER

of each box. Insect boxes in an exposure unit were placed one over another and duct tape (aluminum coated) was used to keep them tightly sealed.

For the exposure unit, two, 55 x 55 x 6 mm glass plates were used as lids. As shown in the Fig. 4.4, four holes of 4 mm diameter were drilled, at a little offset (2 mm) from the circumference of the 50 mm diameter circle in the glass lids. The distance between the drilled holes in lids was  $46 \pm 2$  mm. Four threaded rods of 260 mm length and 4 mm diameter were inserted through the four drilled holes in both the lids, after inserting the exposure unit within the four threaded rods. Four hexagonal nuts were used on both the lids to keep the exposure unit tightly sealed. The input and output gas lines were connected to the exposure units through 7.5 mm diameter openings in the lids. Flow rates through inlet and outlet of all exposure units were measured. The insect chamber was capable of handling six exposure times and eighteen exposure units. The flow of gas into the exposure units from the relative humidity units was controlled by position control valves. Four controls (not exposed to the generated atmosphere of gas) of exactly the same dimension as the insect box were placed inside the controlled temperature chamber (Fig. 4.1)

#### 4.1.7. Exhaust assembly

The gases from the outlet of the exposure units were exhausted to the atmosphere through an exhaust assembly. The exhaust assembly consisted of nine exhaust inlets and one exhaust outlet. Two outlets

from exposure units were connected to one exhaust inlet by means of a Y polyvinyl coupler. The main exhaust tube was 10 mm in diameter and 7 m long. This main exhaust tube was connected to an exhaust pipe of 180 mm diameter, which was then connected to an existing exhaust system for safe disposal of gases. The controlled atmosphere unit was housed in a temperature-controlled chamber for studying the effect of temperature at 10, 15 and 20°C. The temperature was maintained within 0.9°C.

#### 4.2. Rearing of Adults and Eggs of C. ferrugineus

Adults of the rusty grain beetle were taken from laboratory cultures on wheat germ (5%) and whole wheat (95%) at 30°C and 70% relative humidity. The adult beetles used in the experiments were about 2 months old. Eggs of rusty grain beetle were reared by placing 250 adults in 100% wheat flour cultures. The cultures were maintained at 30°C and 70% relative humidity for 60 h and then they were sifted using sieves with openings of 0.425 and 0.112 mm to separate the beetles and flour from the eggs.

#### 4.3. Experimental Design

A 3 (CO<sub>2</sub>: 70, 80 and 90%) x 3 (O<sub>2</sub>: 0, 4 and 8%) x 3 (relative humidity: 65, 75 and 85%) x 3 (temperature: 10, 15 and 20°C) x 6 (exposure time: 24, 48, 60, 72, 84 and 96 h) factorial design was used to study the mortality of C. ferrugineus adults at a pressure of 35 kPa and a flow rate of 55 cc/min. A factorial design of 3 (CO<sub>2</sub>: 70, 80 and 90%) x 2 (O<sub>2</sub>: 0 and 4%) x 3 (relative humidity: 65, 75 and 85%) x 2 (temperature: 10 and 20°C) x 3 (exposure time: 24, 48 and 96 h) was

used for studying the mortality of eggs at the same pressure and flow rate. Four replicates were run at each condition.

#### 4.4. Experimental Methods

Twenty five adults and 1 g of wheat germ were placed in each insect box of the exposure units and the controls. Insect boxes were assembled into exposure units as described in section 4.1.6. The exposure units were assembled in the insect chamber. Inlets and outlets of the exposure units were connected to the gas lines from the relative humidity units and exhaust assembly, respectively. Flow meters were adjusted to set the proportion of individual gases ( $\text{CO}_2$ ,  $\text{O}_2$  and  $\text{N}_2$ ) for the gas mixture required in a given experiment. Saturated salt solutions of  $\text{NaNO}_2$ ,  $\text{NaCl}$  and  $\text{KCl}$  were prepared by dissolving 50 g of salts in 35 mL of distilled water in the relative humidity units for generation of 65, 75 and 85% relative humidity, respectively (Winston and Bates, 1960). Flow rate at the inlet and outlet of all the exposure units and relative humidity at each relative humidity port were measured. Electrical circuits of the temperature-controlled chamber were activated 60 min before starting each experiment to attain a required constant temperature within the chamber. Temperature of the environmental room was recorded continuously using a chart recorder. The recorded temperatures were verified using a mercury-in-glass thermometer at an interval of 24 h. The gas composition of samples was analyzed by injecting 5 cc of sample into the gas chromatographs (section 3.14) at an interval of 12 h. Relative humidity

was measured manually at an interval of 6 to 12 h as described in section 3.1.5.

After each exposure (mentioned in section 4.3. on Experimental Design), the position control valves of corresponding exposure units were closed and the units were removed and disassembled. The flow meters were adjusted to maintain the flow rate at 55 cc/min in the remaining exposure units. From the insect samples, wheat germ was sifted using a sieve with an opening of 1.19 mm. After sifting, the proportion of knocked down and active adults were recorded. Then all the adults and a fresh 1 g of wheat germ were placed in glass vials of 25 cc capacity with perforated lids. The glass vials were kept for 168 h at 30°C and 70% relative humidity for allowing the adult to recover. Wheat germ was sifted once again and number of mobile adults were recorded. The difference between the initial adult population (25) and mobile adults obtained after recovery was defined as dead adults and was expressed as mortality on a percent basis.

For mortality studies on eggs, experiments were conducted with five eggs placed on 0.5 g of wheat flour in each insect box of the exposure unit. Temperature, relative humidity and gas compositions were monitored at intervals of 24, 12 and 24 h, respectively. Immediately after the exposure, the eggs were sifted using a sieve of 0.110 mm opening and counted. Then they were placed on wheat flour at 30°C and 70% relative humidity for 4 days for larval emergence. The emerged larvae were counted and egg mortality, expressed on a percent



basis was calculated by subtracting the number of emerged larvae from initial egg numbers.

## 5. RESULTS AND DISCUSSION

### 5.1. Precision of the Controlled Atmosphere Unit

Fig. 5.1 to 5.3 represent the deviation of measured values of CO<sub>2</sub>, O<sub>2</sub> and relative humidity, respectively from the mean of measured values obtained in the mortality study of C. ferrugineus adults. The mean of each level of CO<sub>2</sub> and O<sub>2</sub> was obtained from nine tests (3 gas levels x 3 temperatures) and mean relative humidity was calculated from 27 tests (3 CO<sub>2</sub> x 3 O<sub>2</sub> x 3 temperatures). For each test, the gas levels and relative humidity were measured at each exposure time. Measured values of gas levels and relative humidity given in Fig. 5.1 to 5.3 are the averages of the measured values at the different exposure times.

At 90% CO<sub>2</sub>, the mean of CO<sub>2</sub> concentration was within 0.5% of the set level, whereas at 70 and 80%, it was within 1% (Fig. 5.1.). At all levels of CO<sub>2</sub>, the measured values were within a range of  $\pm 2\%$  from the mean. At 70 and 80% CO<sub>2</sub> levels, measured values had a standard deviation of 1%, whereas at 90%, the standard deviation was 1.2%. The mean O<sub>2</sub> concentrations were within 0.5% of the levels set at all O<sub>2</sub> levels (Fig. 5.2.). When the concentration of O<sub>2</sub> in the gas mixture increased, the capability of the unit to maintain O<sub>2</sub> decreased (e.g., the standard deviation of the measured values at 8% O<sub>2</sub> level was about 0.8% compared to 0.1% at 0% O<sub>2</sub>). At the 8% O<sub>2</sub> level, some of the measured values were within a range of 1.1% from the mean. The

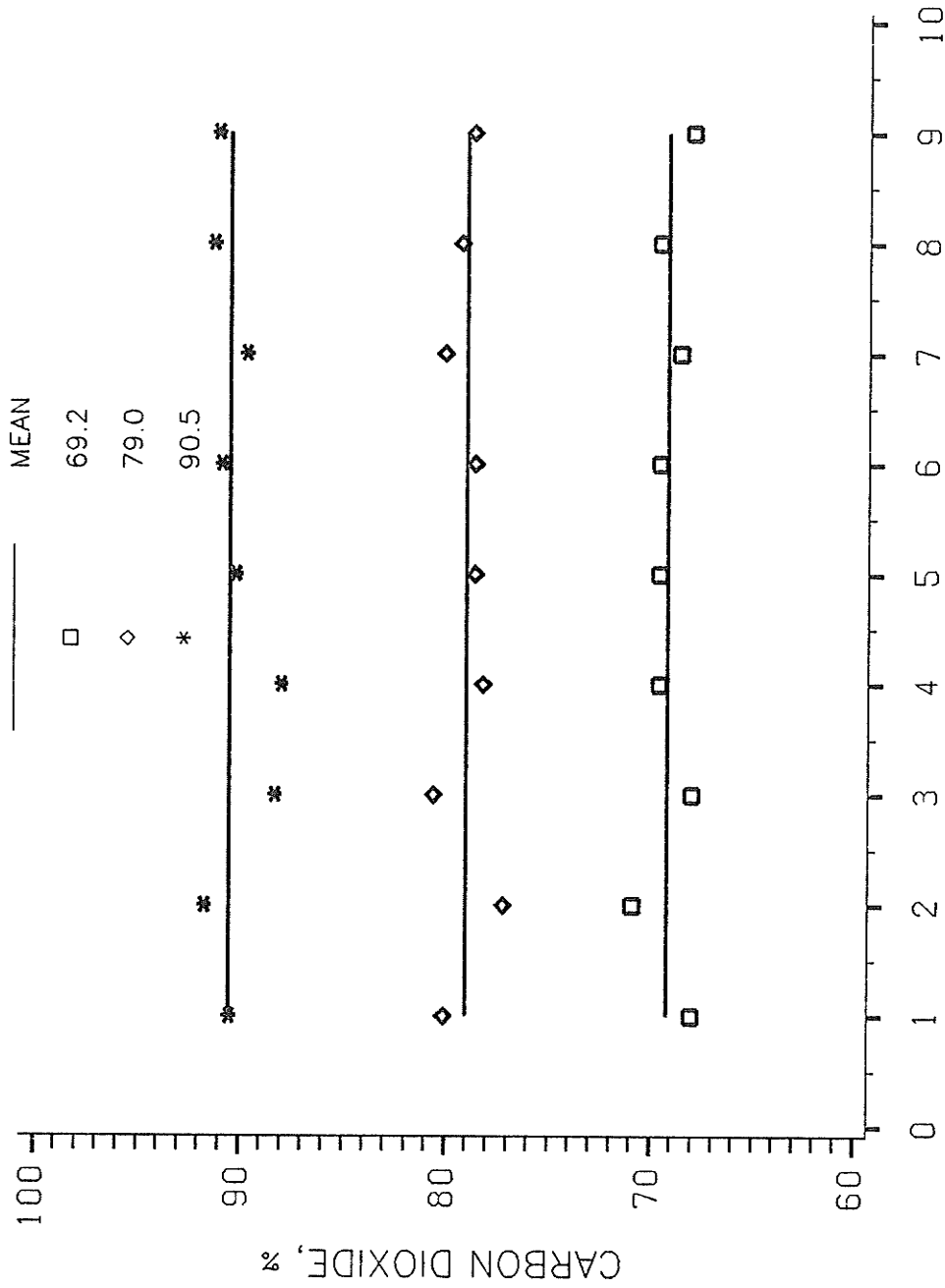
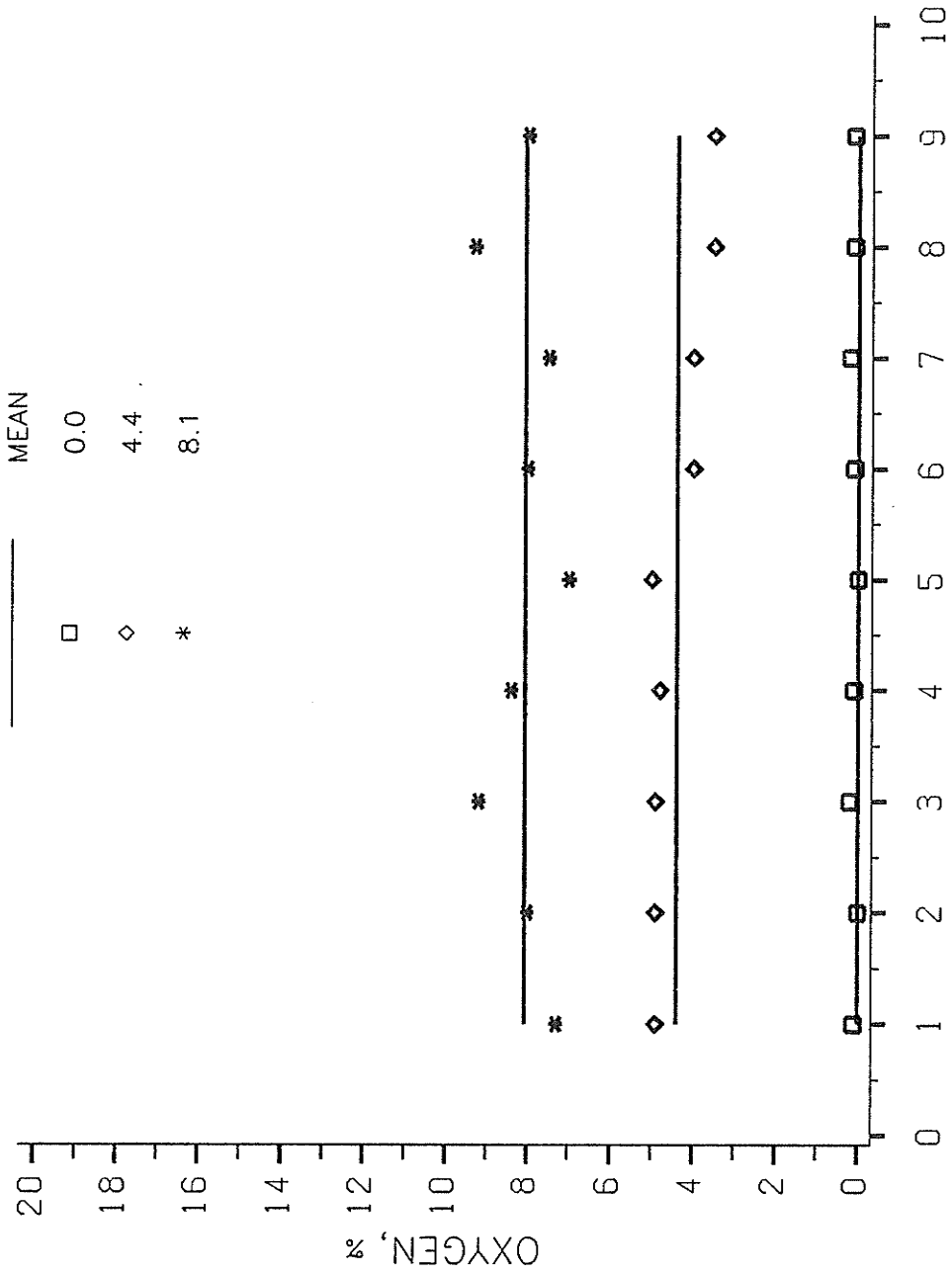
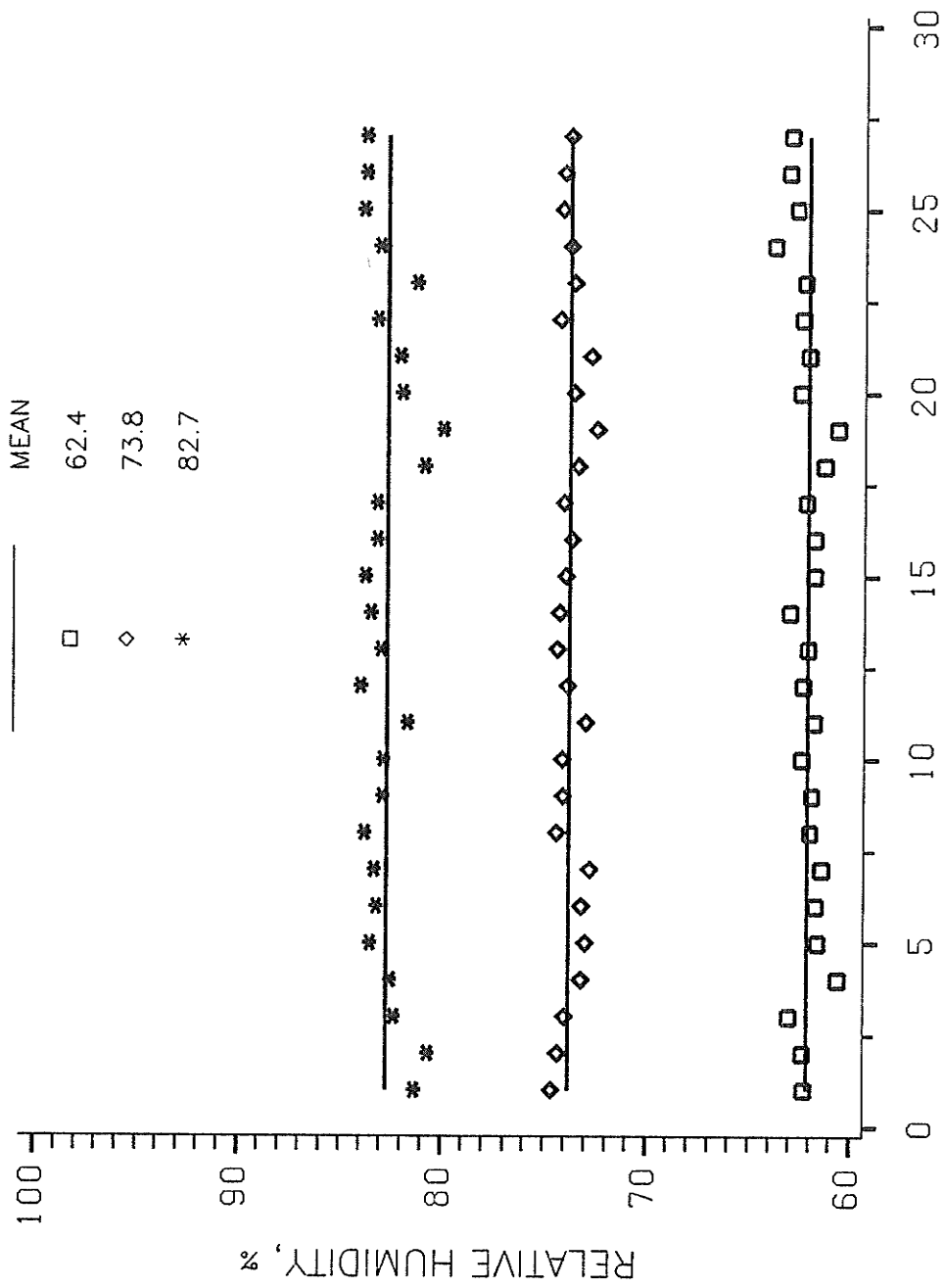


Fig. 5.1. Mean and measured values of carbon dioxide.



TESTS

Fig. 5.2. Mean and measured values of oxygen.



TESTS

Fig. 5.3. Mean and measured values of relative humidity.

rotameter had a wide range and therefore fine adjustments could not be made. This might have contributed to the variation in O<sub>2</sub> concentration. To solve this problem a high precision and low range flow meter could be used.

Mean of relative humidity were 2.3, 1.2 and 2.4% less than the set levels of 85, 75 and 65%, respectively. Although the measured relative humidity values at all three levels had a deviation ranging from 0 to 2.7% from the mean, the standard deviation at 75% relative humidity was only 0.6%, and 1.1% at 85% relative humidity. The regression fits using procedure GPLOT of SAS (SAS, 1985) indicated that at all CO<sub>2</sub> and relative humidity levels the measured values were well within the 95% confidence interval and only some of the measured O<sub>2</sub> concentrations at 4 and 8% O<sub>2</sub> levels were outside 95% confidence intervals.

Flow rates through the inlet and outlet of the exposure unit were measured. Since the difference between the mean values of measured inlet and outlet flow rates was almost zero, all the test insects in an exposure unit were equally and uniformly exposed to the generated atmosphere. Soap solution applied at all sealing points indicated no gas leakage. The range of measured flow rate values was from 53 to 57 cc/min. The pressure was monitored using the pressure gauge indicators attached to pressure regulators. When the pressure in the gas cylinders was more than 700 kPa, a constant pressure level of 35 kPa was maintained in the unit. When the pressure dropped below 700 kPa in the

gas cylinder, the regulator was adjusted frequently to set the pressure level at 35 kPa.

The tygon tubing used in the units was capable of withstanding a pressure of 250 kPa. If pressure greater than 250 kPa is planned, tubing with high bursting pressure should be selected and also high sealing requirements should be considered. As mentioned in the introduction, in most previous controlled atmosphere studies pressure data were not reported. When it was reported, pressure mainly ranged from 14 kPa (Navarro, 1972) to 70 kPa (Spratt, 1979). Based on this information it is felt that designs with greater than 250 kPa are unlikely to be used in controlled-atmosphere studies and therefore the unit designed in this study can be used for most experimental work.

## 5.2. Mortality of C. ferrugineus Adults

### 5.2.1. General Linear Model (GLM) and Statistical Analysis

The adult mortality data obtained from four replicates did not vary significantly at  $\alpha = 0.05$  [value of  $(1-2\alpha)$  is the confidence limit] in Duncan multiple comparison tests. Therefore, the data obtained from four replicates were summarized by calculating mean values. The standard deviations of mortality obtained at different replicates over the mean mortality of adults are presented in Table 1 of Appendix B. The mean mortality data were used in the GLM procedure of SAS (SAS, 1985) to find the effect of main variables and interactions among the variables on the mortality of C. ferrugineus adults. Interactions were limited to three factor levels. The output of

the GLM procedure showed that all the variables used in the study significantly influenced the mortality ( $P = 0.001$ ). The interactions between temperature and exposure time, exposure time and relative humidity,  $O_2$  and temperature, and temperature,  $CO_2$  and  $O_2$ , influenced the mortality ( $P = 0.001$ ).  $N_2$  and  $CO_2$ ,  $N_2$  and exposure time and  $CO_2$  and exposure time also influenced ( $0.01 < P < 0.10$ ) the efficacy of controlled atmospheres. The other interactions influenced the efficacy, however the magnitude was very small compared to above mentioned interactions.

The order of influence of operating conditions was identified by the sum of the squares of regression and F values. Exposure time was the major variable affecting insect mortality followed by relative humidity, temperature,  $CO_2$ ,  $O_2$  and  $N_2$  in descending order. This means that if all interactions were assumed to be negligible, the influence of  $CO_2$  and  $O_2$  levels used is less than the exposure time, relative humidity and temperature. But the data on the mortality response of controls, obtained at different exposure times (24 to 96 h), indicated that 99% of the adults survived at all temperatures (10 to 20°C).

Comparing results from control and treatments, humidified gas mixtures (relative humidity and gas composition) used in the treatment had more effect on the mortality than temperatures and exposure times. For all levels of gas compositions, exposure times and temperatures, the change in relative humidity from 60 to 84% showed a maximum decrease in mortality of 20-30%. Therefore the gas compositions used in the study influenced the mortality more than any other variable. The



analysis of data using procedures RSQUARE and forward STEPWISE regression of SAS (SAS, 1985) showed that mortality (M, %) of adults of C. ferrugineus can be explained as a function of CO<sub>2</sub> (%), O<sub>2</sub> (%), exposure time (E, h), relative humidity (r.h., %) and temperature (T, °C) with r<sup>2</sup> of 0.79 (Eq. 1.). If two factor and 3 factor interactions were included r<sup>2</sup> values increased up to 0.90.

$$M = -23.65 + 0.26 (CO_2) + 0.32 (O_2) + 0.85 (E) + 0.53 (T) - 0.44 (r.h.) \dots\dots\dots (1)$$

#### 5.2.2. Effect of Gas Compositions

Multiple comparison tests (Duncan) showed that all the CO<sub>2</sub> and O<sub>2</sub> levels significantly affected adult mortality ( $\alpha = 0.05$ ). However, comparisons done on N<sub>2</sub> levels indicated that N<sub>2</sub> treatments at 2 and 6% and also treatments ranging from 10 to 30% can be grouped together. Fig. 5.4 to 5.6 show the response of C. ferrugineus adults to CO<sub>2</sub> concentrations at 15°C and 74% relative humidity for different O<sub>2</sub> levels of 0, 4 and 8%, respectively. At all levels of CO<sub>2</sub> and O<sub>2</sub>, the mortality increased with an increase in the exposure time. For both 0 and 4% O<sub>2</sub>, the mortality was lower at 69.6% CO<sub>2</sub> especially after 48 h of exposure, than at the higher CO<sub>2</sub> levels. As the O<sub>2</sub> concentration increased the effect of CO<sub>2</sub> on the mortality gradually decreased. At 8% O<sub>2</sub>, the influence of change in CO<sub>2</sub> concentration from 69.6 to 90.9% on the mortality was almost non-existent. Whereas at 0% O<sub>2</sub>, the same change in CO<sub>2</sub> increased the mortality by 30 and 40% at 84 and 96 h, respectively. This means that at 15°C, an atmosphere with CO<sub>2</sub> concentration greater than 80% was lethal at low O<sub>2</sub> level.

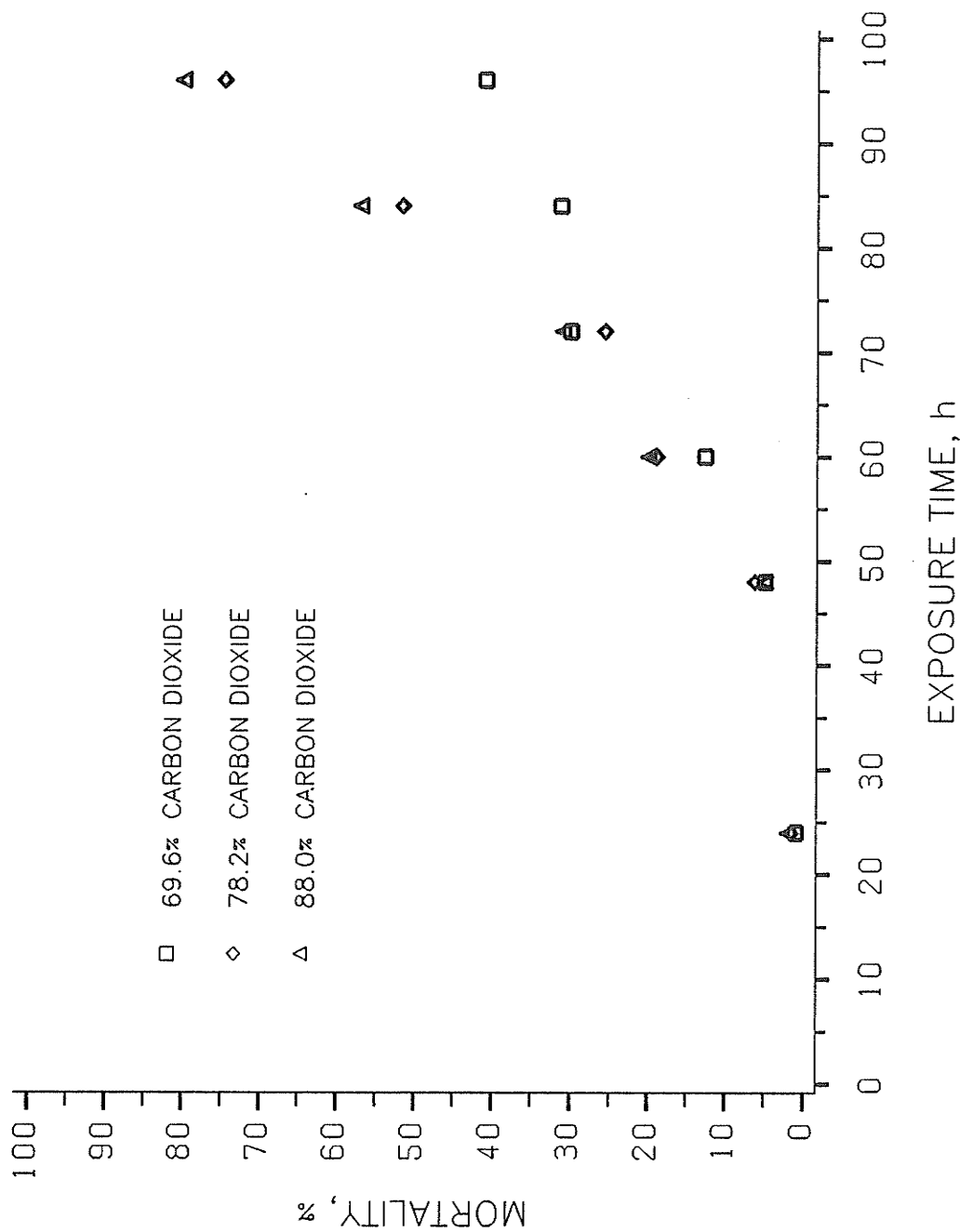


Fig. 5.4. Mortality of *C. ferrugineus* adults exposed to various carbon dioxide concentration at 15 C temperature, 0% oxygen and 74% relative humidity.

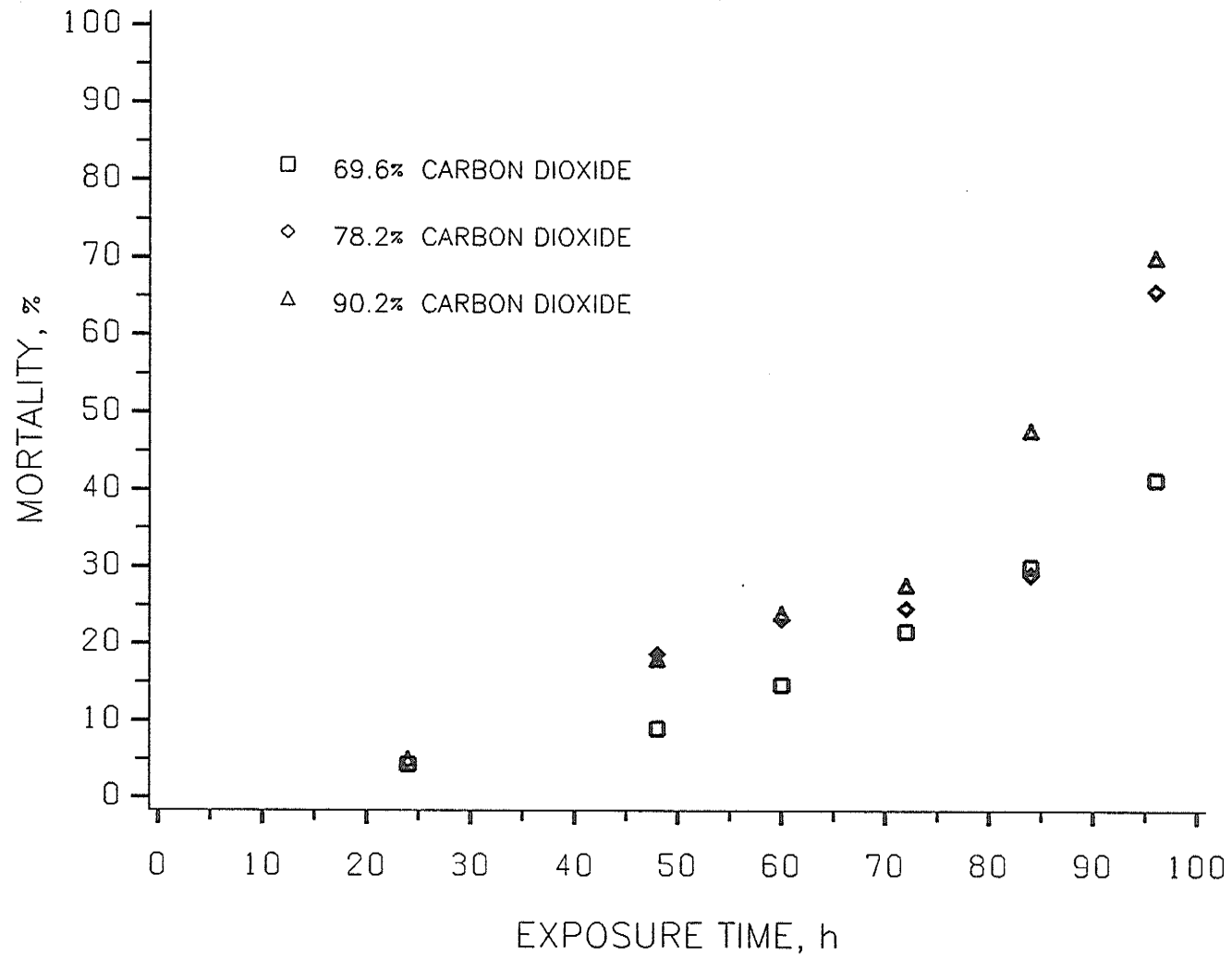


Fig. 5.5. Mortality of *C. ferrugineus* adults exposed to various carbon dioxide concentration at 15 C temperature, 4% oxygen and 74% relative humidity.

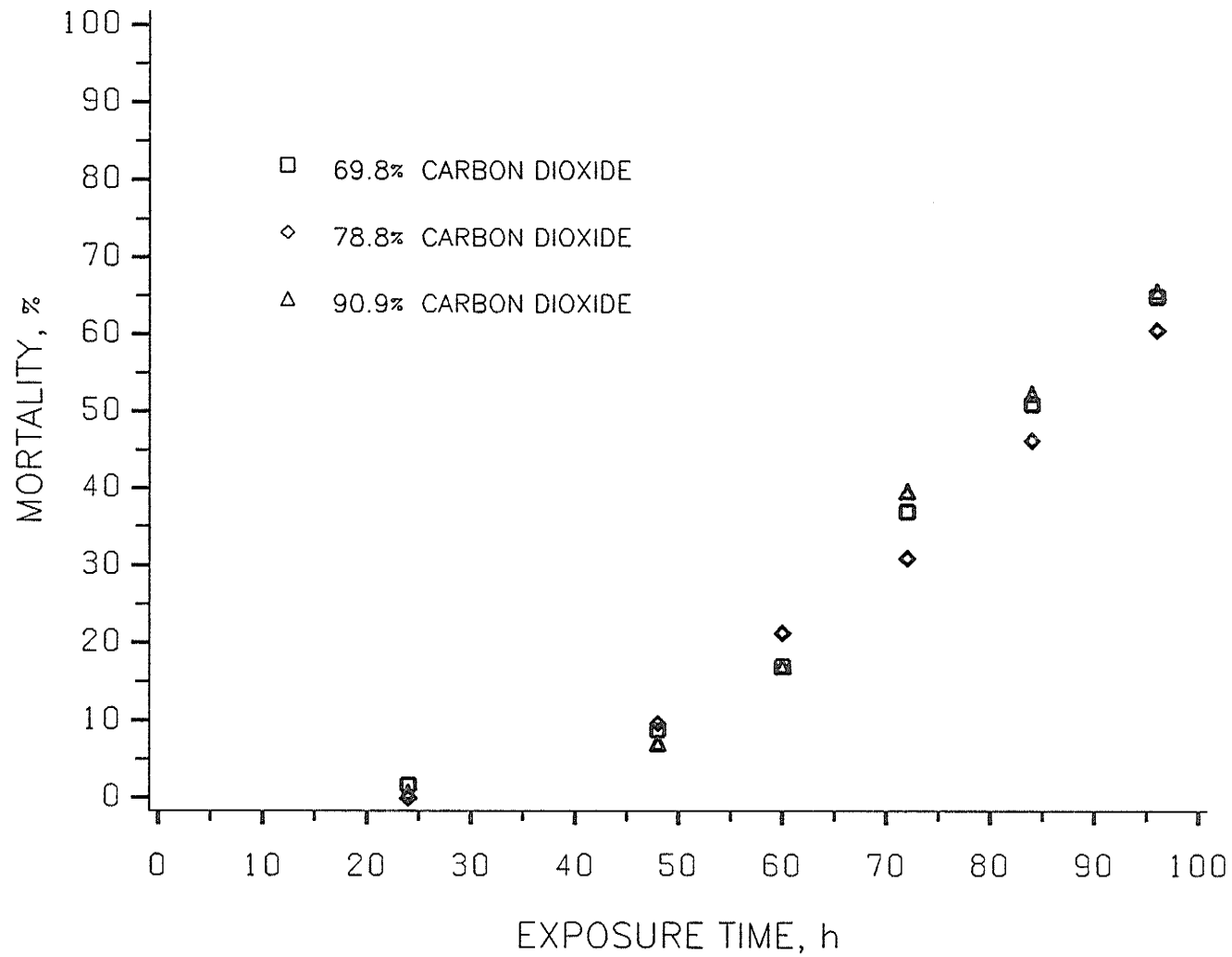


Fig. 5.6. Mortality of *C. ferrugineus* adults exposed to various carbon dioxide concentration at 15 C temperature, 8% oxygen and 74% relative humidity.

The response of adult beetles to various CO<sub>2</sub> and O<sub>2</sub> levels at 20°C and 74% relative humidity is represented in Fig. 5.7 to 5.9. The effect of CO<sub>2</sub> on the mortality of adult beetles at 20°C was more than that at 15°C. At 0% O<sub>2</sub> and at 84 h exposure time, the mortality was 50% higher at 89.7% CO<sub>2</sub> than that at 68.6% CO<sub>2</sub>. As the exposure time increased from 60 to 84 h, an increase of 40% mortality was obtained at both 80.6 and 89.7% CO<sub>2</sub>. For the same increase in exposure time at 68.6% CO<sub>2</sub>, mortality increased only by 15%. At the 8% O<sub>2</sub> level, an increase in CO<sub>2</sub> from 68.6 to 91.1% increased the mortality by 30% at 96 h of exposure, however the influence on mortality was less than 15% at other exposure times (24 to 72 h). The results obtained from 15 and 20°C showed an increasing effect of CO<sub>2</sub> with temperature in producing the mortality of C. ferrugineus adults.

The experiments conducted at all levels of CO<sub>2</sub> at 10°C, 0% O<sub>2</sub> and 74% relative humidity (Fig. 5.10) did not result in higher mortality at a given exposure time. Although the increase in CO<sub>2</sub> concentration from 68 to 91.7% increased the mortality by 10 to 15% at a given exposure time, both at 4 and 8% O<sub>2</sub> (Fig. 5.11, 5.12), it was less than 5% at 0% O<sub>2</sub>. The change in CO<sub>2</sub> concentration from 70 to 78% almost produced no difference in mortality of C. ferrugineus adults at 4% O<sub>2</sub> at given exposure times. There existed a strong interaction between CO<sub>2</sub> and O<sub>2</sub> concentration with temperature between 10 and 20°C. The GLM procedure also indicated the same strong interaction. The interaction between gas compositions and relative humidity is discussed in section 5.2.5..

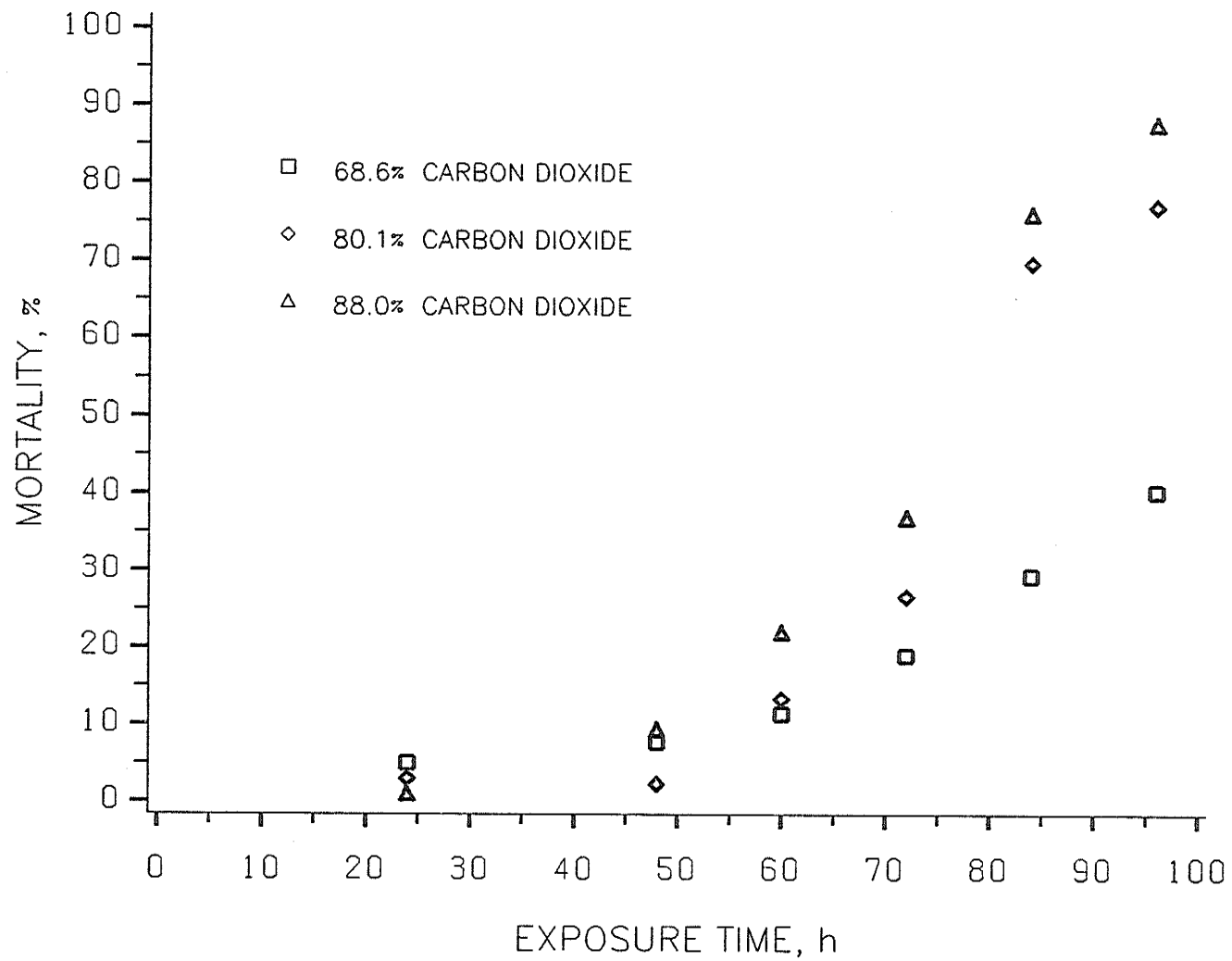


Fig. 5.7. Mortality of *C. ferrugineus* adults exposed to various carbon dioxide concentration at 20 C temperature, 0% oxygen and 74% relative humidity.

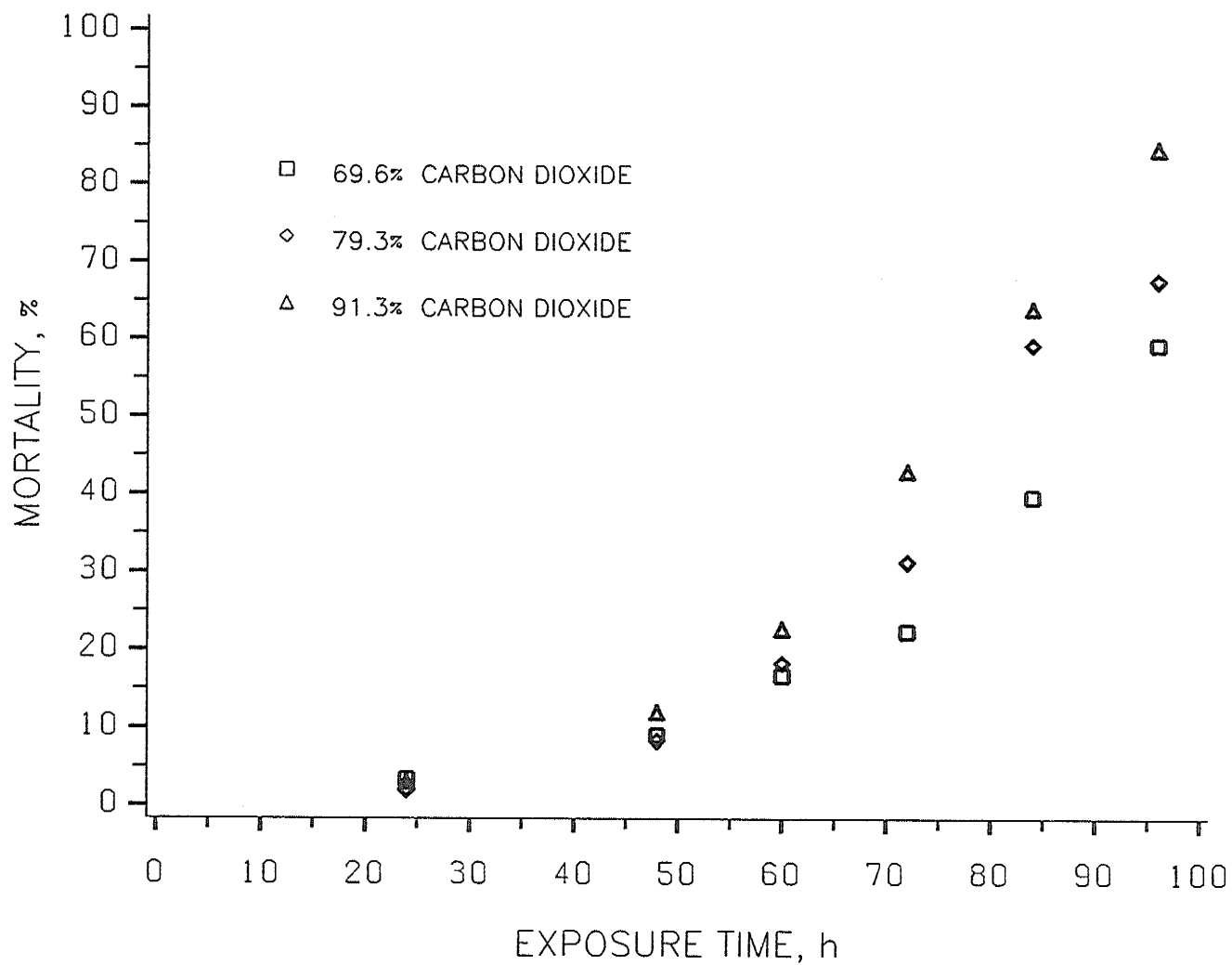


Fig. 5.8. Mortality of *C. ferrugineus* adults exposed to various carbon dioxide concentration at 20 C temperature, 4% oxygen and 74% relative humidity.

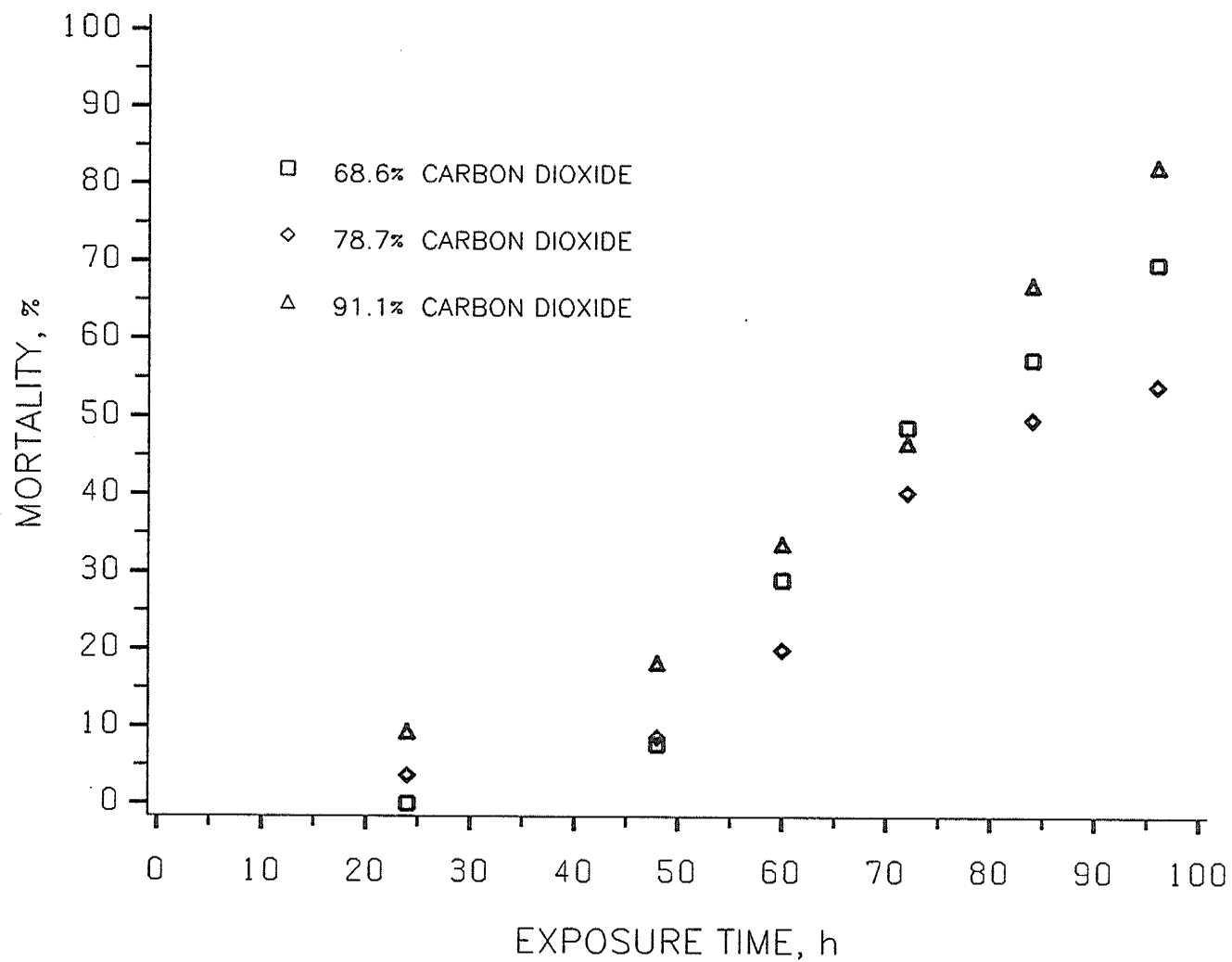


Fig. 5.9. Mortality of *C. ferrugineus* adults exposed to various carbon dioxide concentration at 20 C temperature, 8% oxygen and 74% relative humidity.



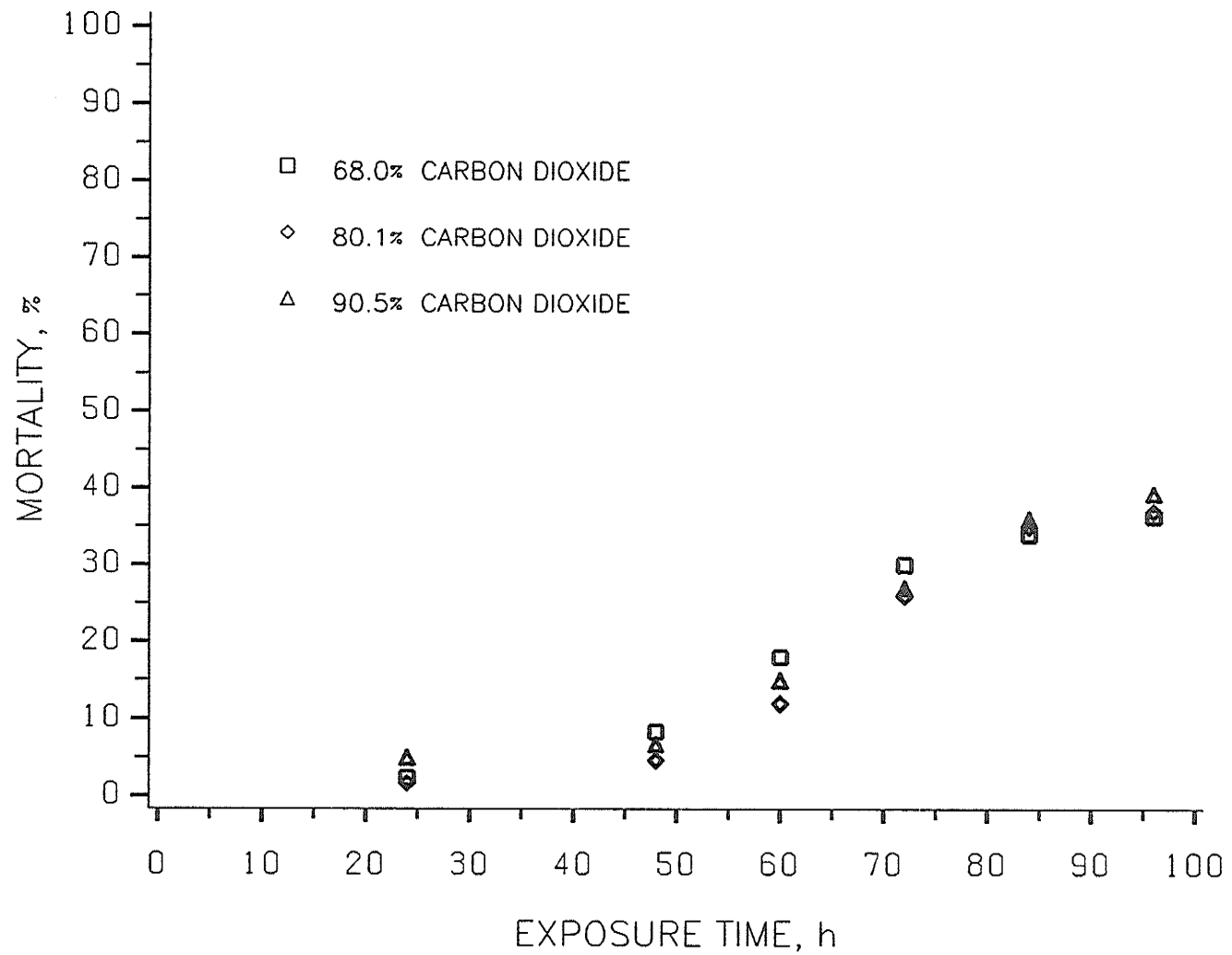


Fig. 5.10. Mortality of *C. ferrugineus* adults exposed to various carbon dioxide concentration at 10 C temperature, 0% oxygen and 74% relative humidity.

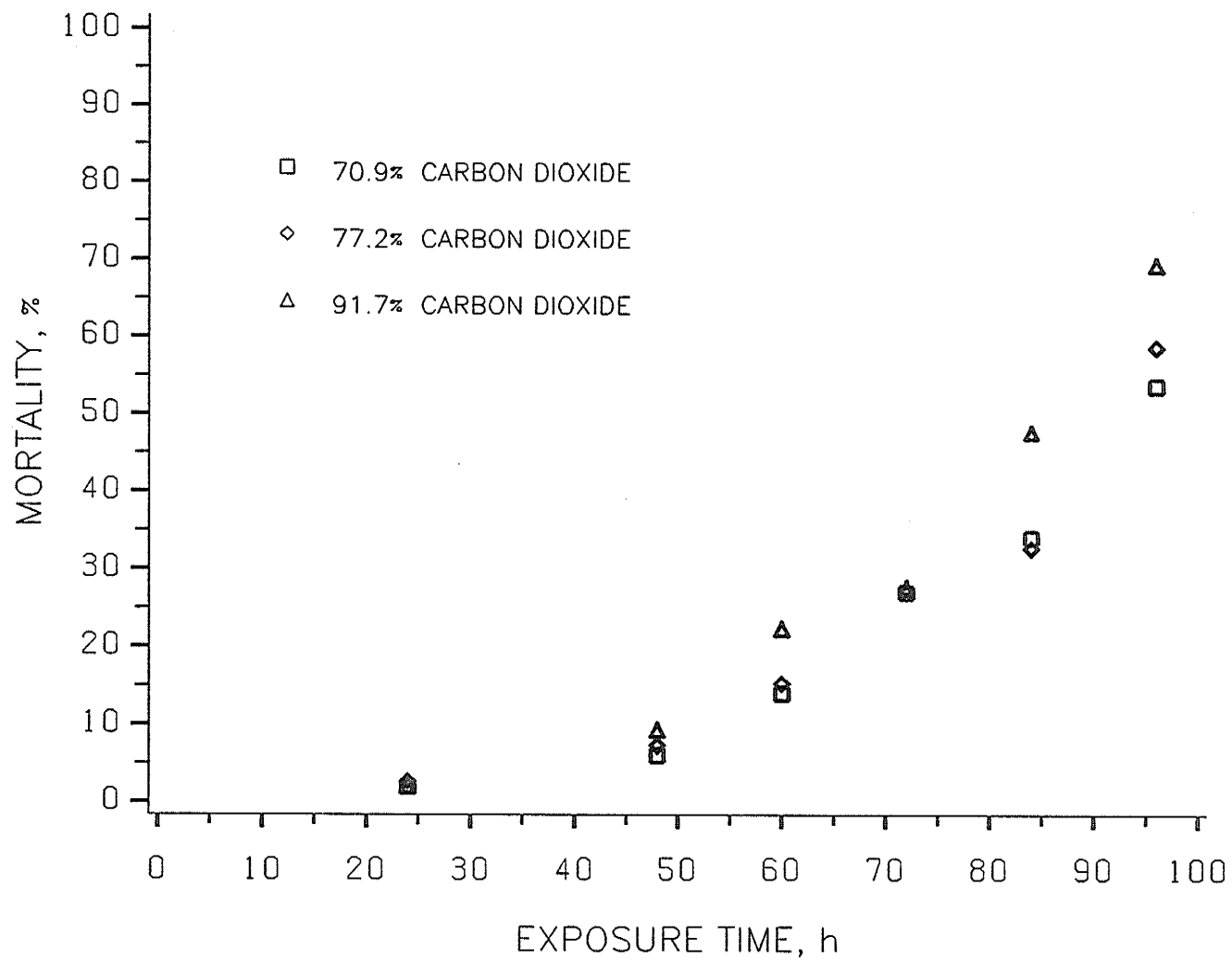


Fig. 5.11. Mortality of *C. ferrugineus* adults exposed to various carbon dioxide concentration at 10 C temperature, 4% oxygen and 74% relative humidity.

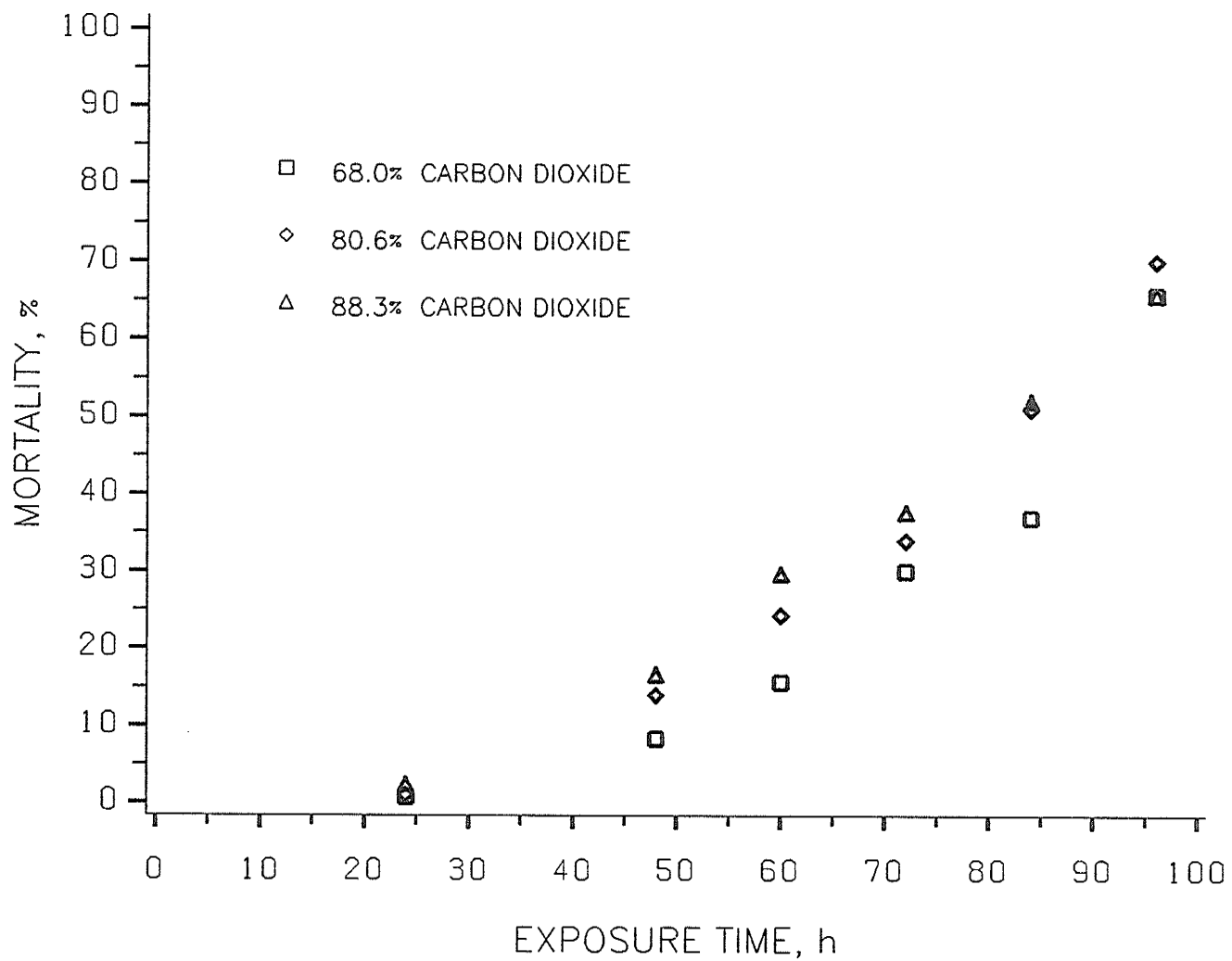


Fig. 5.12. Mortality of *C. ferrugineus* adults exposed to various carbon dioxide concentration at 10 C temperature, 8% oxygen and 74% relative humidity.

### 5.2.3. Effect of Temperature

As the temperature increased from 10 to 20°C, mortality of adults increased for 96 h exposure to most of the gas compositions at 74% relative humidity (Table 5.1.). Duncan multiple comparison tests for different temperatures (10, 15 and 20°C) indicated that mortality data at temperatures 10 and 15°C can be grouped together and mortality at 20°C is significantly different from the mortality obtained at 10 and 15°C. The data obtained from Smith (1965) indicated that mortality of C. ferrugineus during development increases as temperature decreases below an optimum of around 27 to 29°C in atmospheric air (Fig. 5.13.). Comparing the results of Smith (1965) with the results from this study, it is concluded that the effect of temperature in atmosphere having high CO<sub>2</sub> or low O<sub>2</sub> or combination of both may be different than the effect in atmospheric air on the mortality of immature of C. ferrugineus. White et al. (1988) also showed a similar trend of lower toxicity of CO<sub>2</sub> at lower temperatures on mortality of C. ferrugineus adults exposed to CO<sub>2</sub> concentrations greater than 60%.

### 5.2.4. Effect of Relative Humidity

In most of the experiments, the mortality of C. ferrugineus adults at 60 to 62% relative humidity was more than at 72 to 84% relative humidity (Table 5.2). Duncan multiple comparison tests showed that effect of relative humidity on the mortality of C. ferrugineus adults is significant ( $\alpha = 0.05$ ) for all the levels of gas compositions. At 10°C, a decrease in relative humidity from 82.4 to 61.6% increased the

Table 5.1. The mortality of *C. ferrugineus* adults exposed to different gas compositions at 74% relative humidity and two temperatures.

Gas composition, %			Temperature	Mortality, %
CO <sub>2</sub>	O <sub>2</sub>	N <sub>2</sub>	°C	
68.0	0.1	31.9	10	36
68.0	0.1	31.9	20	40
80.1	0.0	19.9	10	37
80.1	0.0	19.9	20	77
90.5	0.2	9.3	10	39
90.5	0.2	9.3	20	88
71.1	4.9	24.0	10	57
71.1	4.9	24.0	20	60
77.2	4.9	17.9	10	59
77.2	4.9	17.9	20	68
91.7	4.9	3.4	10	69
91.7	4.9	3.4	20	85
68.0	7.3	24.7	10	66
68.0	7.3	24.7	20	71
80.6	8.0	11.4	10	69
80.6	8.0	11.4	20	54
88.3	9.2	2.5	10	66
88.3	9.2	2.5	20	82

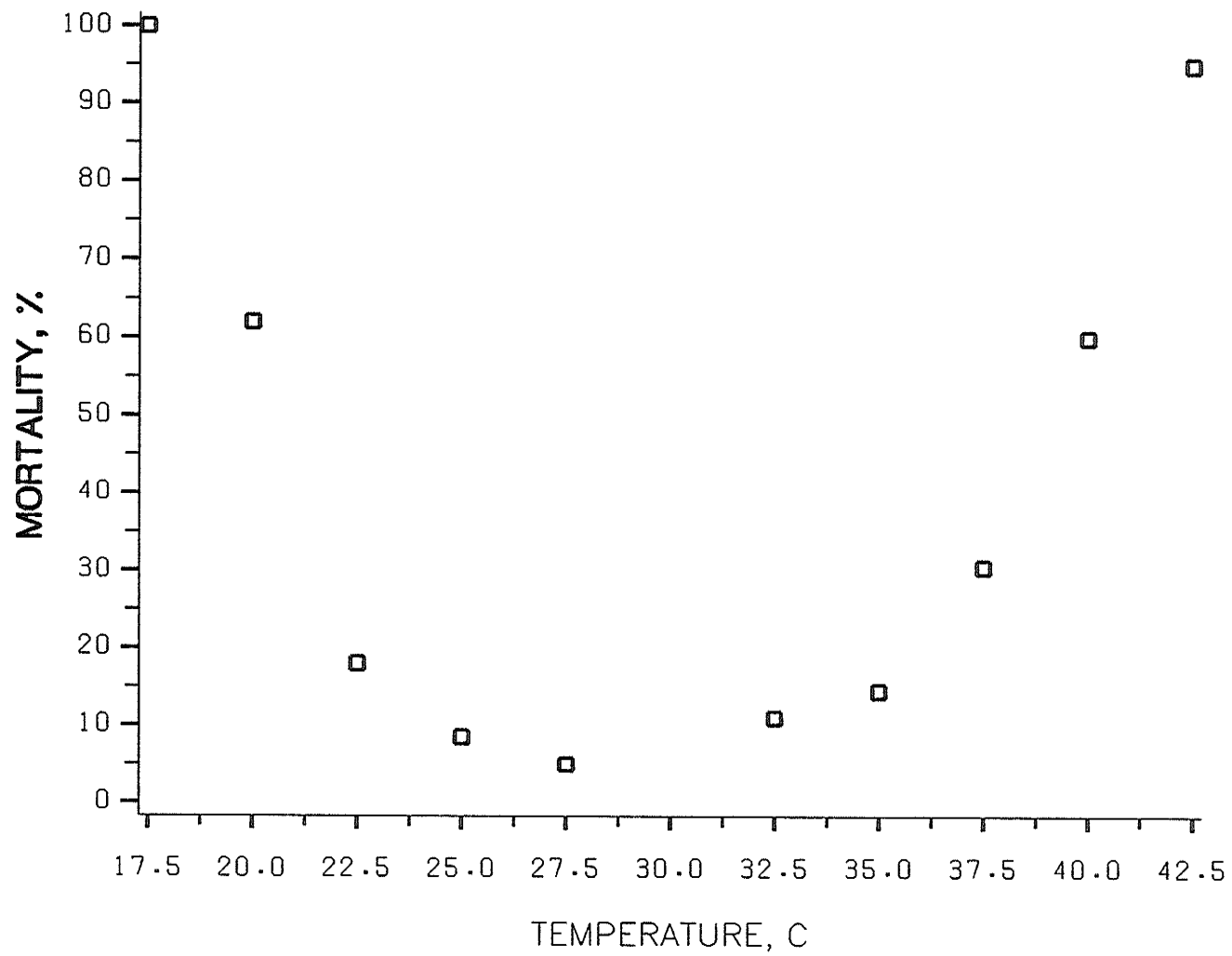


Fig. 5.13. Mortality of *C. ferrugineus* during the developmental period in atmospheric air (Smith, 1965)

Table 5.2. The mortality of C. ferrugineus adults exposed to different gas compositions at 10 and 20°C and three relative humidities.

Temperature °C	Gas compositions, %			Mortality at Relative Humidity, %		
	CO <sub>2</sub>	O <sub>2</sub>	N <sub>2</sub>	61.6	73.8	82.4
10	68.0	0.1	31.9	39	39	31
	80.1	0.1	19.8	52	35	25
	90.5	0.2	9.3	57	35	26
	71.1	4.9	24.0	58	63	50
	77.2	4.9	17.9	65	56	55
	91.7	4.9	3.4	84	65	59
	68.0	7.3	24.7	70	73	54
	80.6	8.0	14.4	77	70	61
	88.3	9.2	2.5	69	65	63
20	68.6	0.2	31.2	49	44	28
	80.1	0.2	19.7	77	79	75
	89.7	0.1	10.2	99	84	80
	69.6	4.0	26.4	73	48	57
	79.3	3.5	17.2	73	80	50
	91.3	3.5	5.2	97	80	77
	68.0	7.5	24.5	73	65	71
	78.7	9.3	12.0	60	53	49
	91.1	7.5	1.4	81	85	81

mortality of C. ferrugineus adults at 0 to 0.2% O<sub>2</sub> and at all levels of CO<sub>2</sub>. As the O<sub>2</sub> concentration increased to 4 and 8%, at about 70% CO<sub>2</sub>, the mortality obtained at 73.8% relative humidity was more than that at 61.6 and 82.4% relative humidity. But in 80 and 90% CO<sub>2</sub> atmospheres with 4 to 8% O<sub>2</sub>, as the relative humidity increased from 61.6 to 82.4%, the mortality decreased. At 20°C, at most of the gas compositions, more mortality was obtained at 61.6% relative humidity than at 73.8 and 82.4% relative humidity. The effect of relative humidity on mortality of C. ferrugineus adults in atmospheres with O<sub>2</sub> >4% and CO<sub>2</sub> at about 70% did not follow a specific trend. Whereas at all other gas compositions at 10 and 15°C, more mortality was obtained at a low relative humidity of 61.6% than other relative humidities. It can be generalized that the low relative humidity (about 61.6%) was not favorable for survival of C. ferrugineus adults in high CO<sub>2</sub> (>80%) and low O<sub>2</sub> (about 0%) atmospheres.

#### 5.2.5. Interactions Among Variables

Pearson co-efficients obtained from CORR procedure of SAS (SAS, 1985) indicated that interaction of relative humidity with O<sub>2</sub> is less than that with CO<sub>2</sub> or N<sub>2</sub>. Also the proportion of CO<sub>2</sub> and O<sub>2</sub>, O<sub>2</sub> and N<sub>2</sub> in the atmosphere affected the mortality of C. ferrugineus adults considerably (0.8 to 0.9 Pearson co-efficient). Insects in controls, which were exposed to atmospheric air consisting of approximately 79% N<sub>2</sub> and 20.9% O<sub>2</sub> had almost no mortality at all temperatures (10 to 20°C) and exposure times (24 to 96 h). Also the Duncan multiple



comparison tests indicated that treatments with N<sub>2</sub> ranging from 10 to 30% did not have any significant effect on the mortality. Increase in concentration of CO<sub>2</sub> and decrease in O<sub>2</sub> had a positive influence on the mortality of C. ferrugineus adults at all exposure times. An increase in CO<sub>2</sub> and decrease in O<sub>2</sub> concentrations increased the mortality of C. ferrugineus adults.

At low temperature (10°C), the mortality of C. ferrugineus adults was dependent on relative humidity only at low O<sub>2</sub> levels and as the temperature increased the dependency decreased. The effect of relative humidity on mortality was more dependent on CO<sub>2</sub> concentration than O<sub>2</sub> at all exposure times for 15 and 20°C. At 10°C, the interaction between O<sub>2</sub> and relative humidity was more than the interaction between CO<sub>2</sub> and relative humidity.

### 5.3. Mortality of C. ferrugineus eggs

The egg mortality obtained from replicates did not vary significantly at  $\alpha = 0.10$  in Duncan multiple comparison tests. Therefore, the mortality obtained from replicates were summarized by calculating mean values. The mean mortalities of eggs and standard deviations are presented in Table 2 of Appendix B. The sum of squares of regression and F values obtained from the GLM procedure showed that exposure time, O<sub>2</sub>, relative humidity, temperature and CO<sub>2</sub> significantly influenced the mortality of C. ferrugineus eggs in descending order. The interactions between temperature and O<sub>2</sub>, O<sub>2</sub> and relative humidity, and exposure time and relative humidity influenced

the mortality ( $P < 0.02$ ). Temperature with exposure time and relative humidity, and  $\text{CO}_2$  with exposure time interactions were also significant at  $P < 0.10$ . When all the two and three variable interactions are included in the GLM, the  $r^2$  was 0.95. The removal of interactions from the model resulted in an  $r^2$  of 0.87 (Eq. 2.). Duncan multiple comparisons tests done on mean values of replicates showed that all the ranges of the variables used in the study significantly influenced the mortality ( $\ell = 0.05$ ) except at 80 and 90%  $\text{CO}_2$ . Although at different  $\text{O}_2$  levels,  $\text{CO}_2$  influenced the mortality, the overall effect between 80 and 90%  $\text{CO}_2$  at 10 and  $20^\circ\text{C}$ , 60 to 85% relative humidity and 24 to 96 h was not significantly different ( $\ell = 0.05$ ). STEPWISE and RSQUARE procedures indicated that mortality (M, %) can be best explained as a function of exposure time (E, h),  $\text{O}_2$  (%), temperature (T,  $^\circ\text{C}$ ), relative humidity (r.h., %) and  $\text{CO}_2$  (%).

$$M = 8.84 + 0.26 (\text{CO}_2) - 3.53 (\text{O}_2) + 0.55 (\text{E}) + 0.62 (\text{T}) - 0.43 (\text{r.h.}) \dots\dots\dots (2)$$

### 5.3.1. Effect of Gas Compositions

Figures 5.14 and 5.15 show the mortality of C. ferrugineus eggs exposed to various  $\text{CO}_2$  concentrations with 4%  $\text{O}_2$  at 10 and  $20^\circ\text{C}$ . The comparison of experiments done at 10 and  $20^\circ\text{C}$  showed that the influence of  $\text{CO}_2$  on the egg mortality is a function of temperature and exposure time. At  $10^\circ\text{C}$ , as the exposure time increased, the mortality linearly increased. The increase in mortality due to  $\text{CO}_2$  (68.9 to 90.4%) was distinct at early stages of exposures (24 and 48 h) and as the exposure time increased to 96 h, the influence of  $\text{CO}_2$  gradually decreased. At

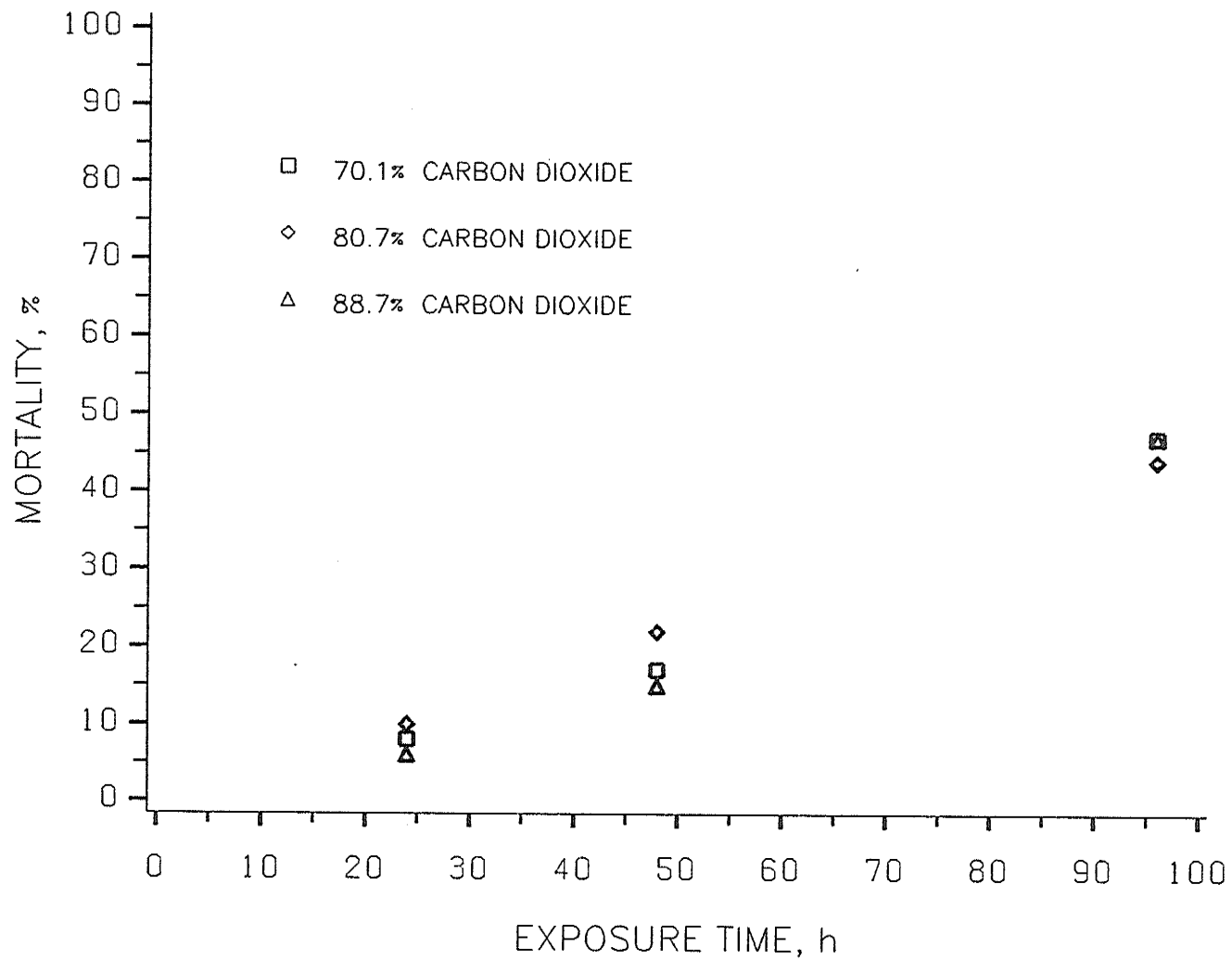


Fig. 5.14. Mortality of *C. ferrugineus* eggs exposed to various carbon dioxide concentration at 10 C temperature, 4% oxygen and 74% relative humidity.

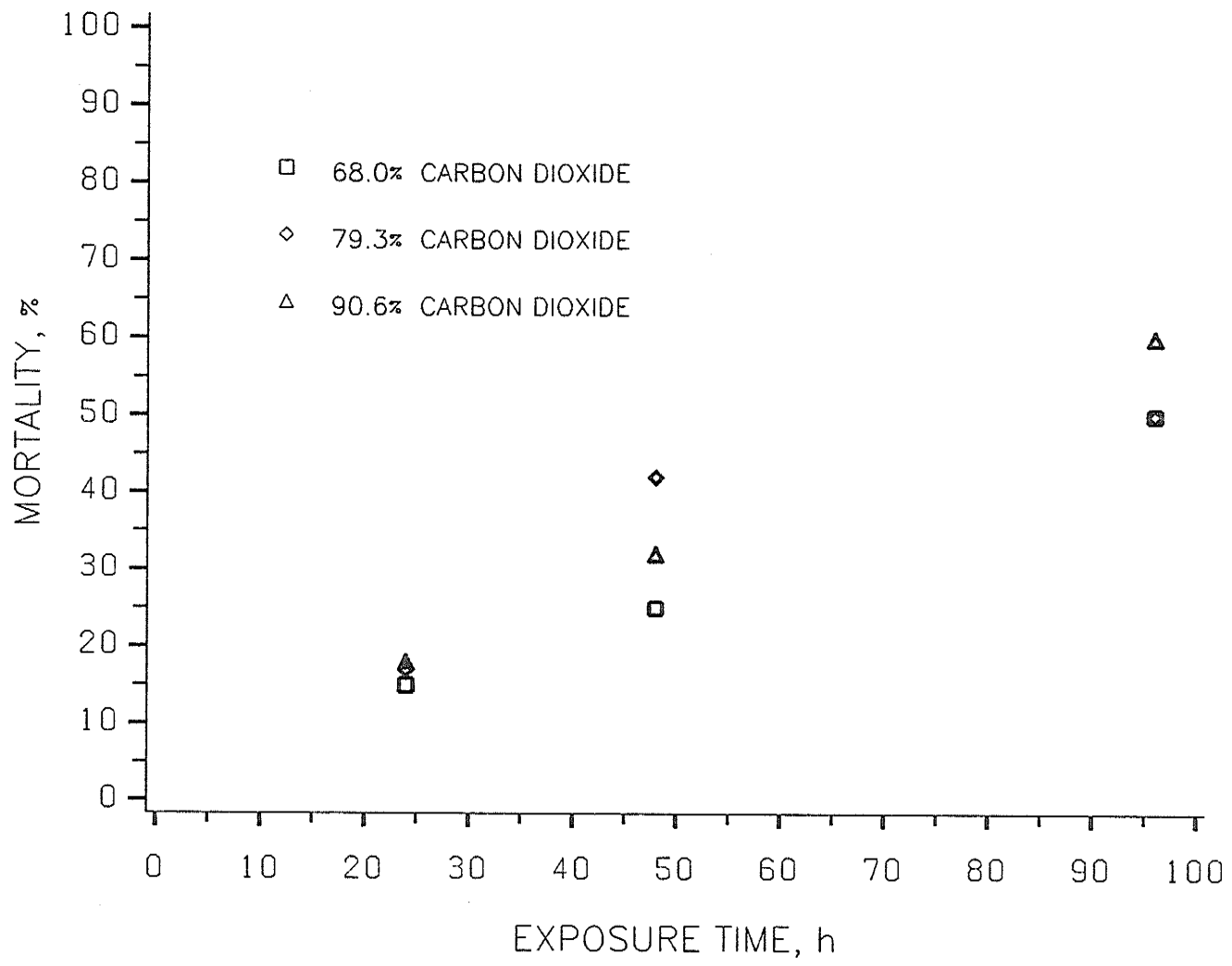


Fig. 5.15. Mortality of *C. ferrugineus* eggs exposed to various carbon dioxide concentration at 20 C temperature, 4% oxygen and 74% relative humidity.

20°C, the increase in mortality due to change in CO<sub>2</sub> from 70.9 to 90.7% at 96 h is greater than at 24 and 48 h.

At 0% O<sub>2</sub> (Fig. 5.16 and 5.17), the egg mortality linearly increased with an increase in exposure time at all CO<sub>2</sub> levels except at 79.30% CO<sub>2</sub> and 10°C. Although the effect of CO<sub>2</sub> (68.0 to 90.6%) on mortality of C. ferrugineus eggs at 0% O<sub>2</sub> was within 10 to 17%, it was distinguishable at all conditions except at 79.3% CO<sub>2</sub> and 10°C. At 96 h of exposure, the influence of CO<sub>2</sub> on the mortality of C. ferrugineus eggs was less at 10°C compared to 20°C. At both temperatures the influence of different levels of CO<sub>2</sub> was more at 48 h than at 24 or 96 h. The results obtained at 48 h exposure and 20°C showed that the change in O<sub>2</sub> concentration from 4 to 0% at 90.0% CO<sub>2</sub> increased the egg mortality by 30 to 35%, however at 96 h of exposure the same change resulted in only a 10% increase in mortality. At 10°C, change in O<sub>2</sub> concentration from 4 to 0% increased the mortality of C. ferrugineus eggs by 20 to 22% at 79.0 and 90.4% CO<sub>2</sub> at an exposure time of 48 h. Although the reduction in O<sub>2</sub> concentration increased the mortality at 24 and 96 h, the difference between CO<sub>2</sub> levels was small compared to 48 h of exposure.

Pearson correlation co-efficients obtained using the CORR procedure of SAS (1985) showed that CO<sub>2</sub> and O<sub>2</sub> were correlated with N<sub>2</sub> in causing the mortality at all experimental conditions. The other interaction co-efficients were less than 0.10. Based on the Pearson

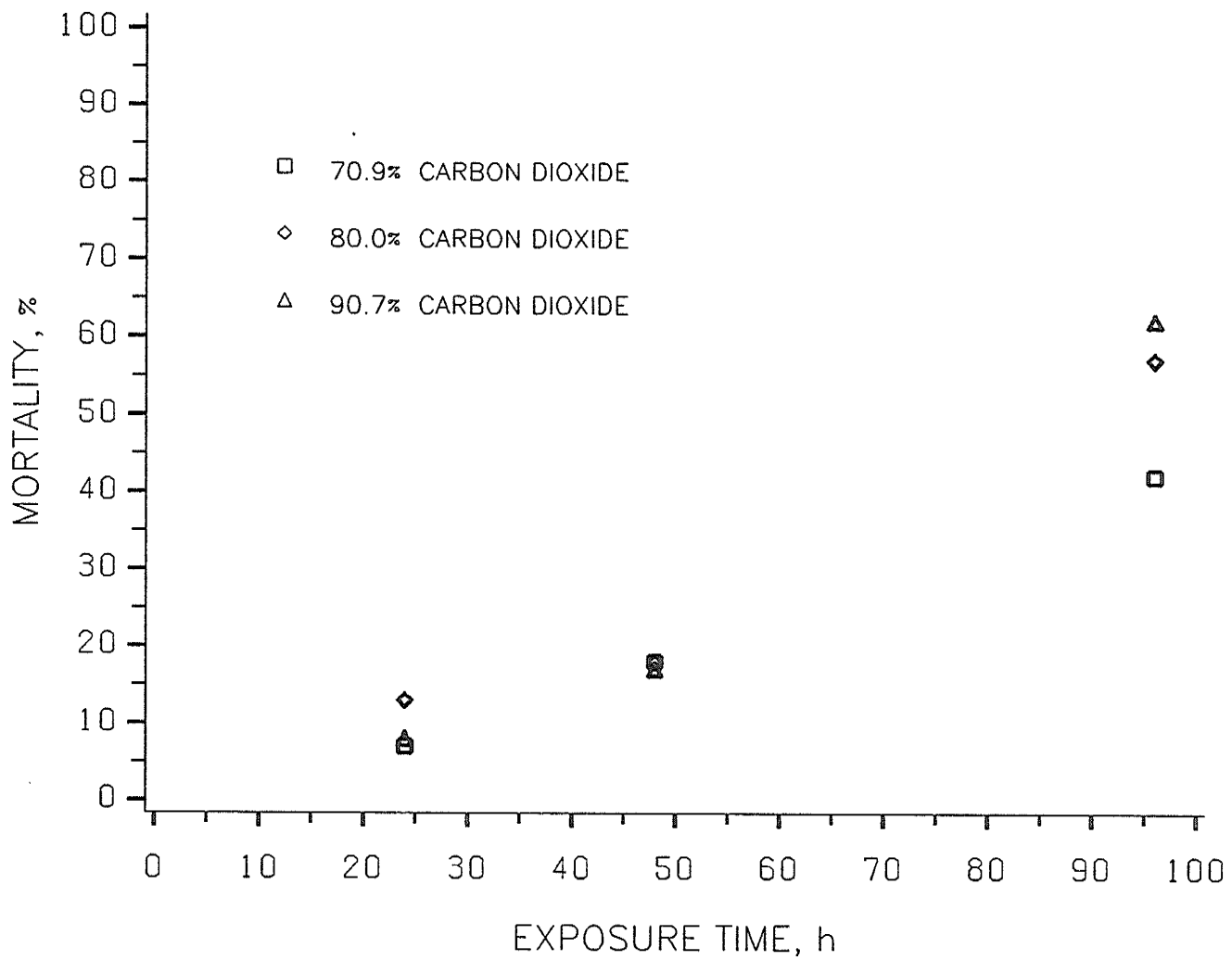


Fig. 5.16. Mortality of *C. ferrugineus* eggs exposed to various carbon dioxide concentration at 10 C temperature, 0% oxygen and 74% relative humidity.

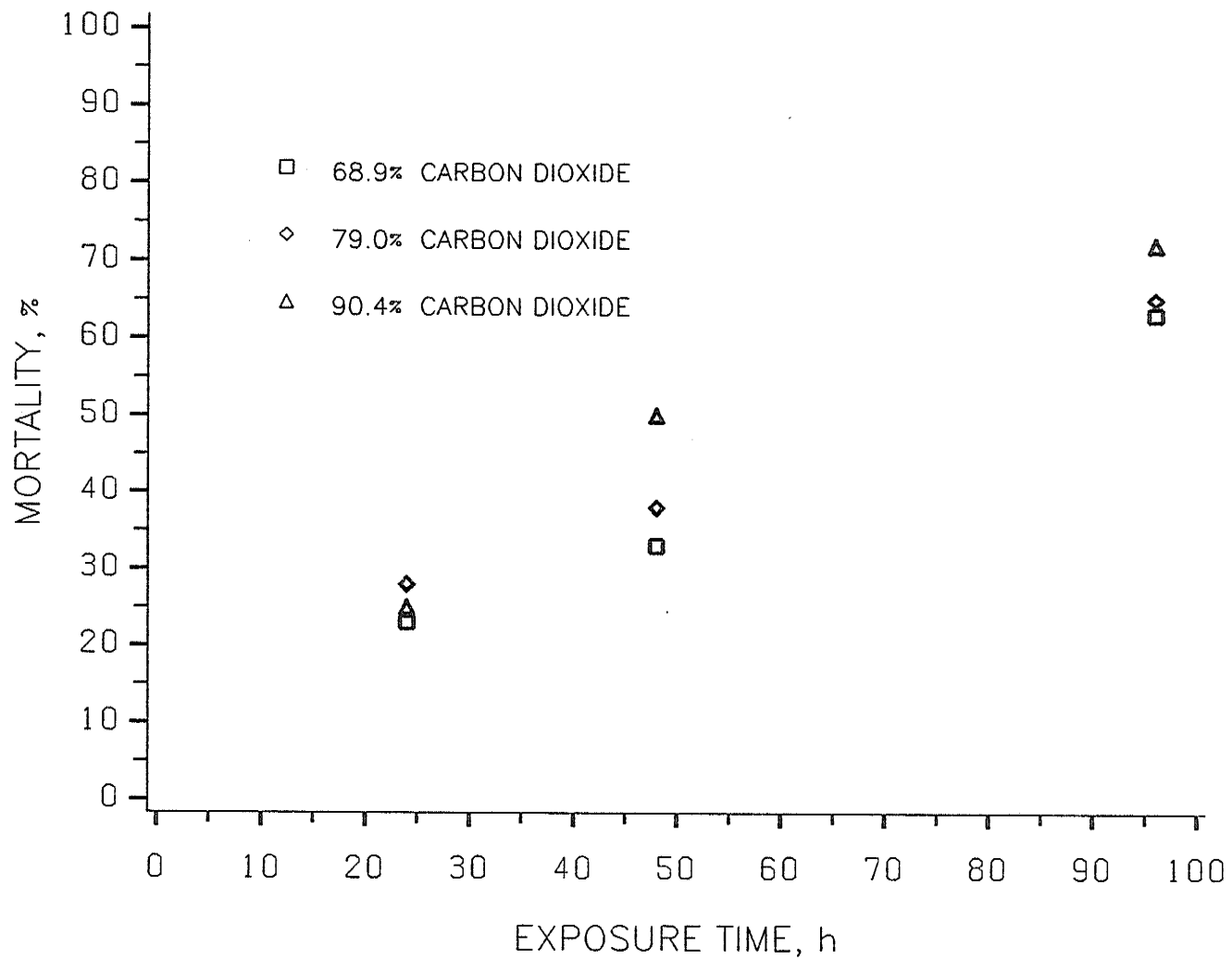


Fig. 5.17. Mortality of *C. ferrugineus* eggs exposed to various carbon dioxide concentration at 20 C temperature, 0% oxygen and 74% relative humidity.

correlation co-efficients, it was concluded that the gas compositions influenced mortality more than other variables. Results obtained from controls showed that only 5 to 10% mortality occurred due to the temperatures and exposure times. Based on results obtained from controls it was assumed that exposure time and temperature influences on the mortality of C. ferrugineus eggs were minimal. Also, at all experimental conditions, the CO<sub>2</sub> influence on the egg mortality was less than 17%. Therefore, O<sub>2</sub> and relative humidity should be considered as the major variables influencing the mortality of C. ferrugineus eggs.

### 5.3.2. Effect of Temperature and Relative Humidity

Irrespective of the gas compositions, the temperature of controlled atmospheres influenced the egg mortality. On the average, mortality at 20°C was 6.5% more than at 10°C. Compared to the influence of exposure time and O<sub>2</sub> on the mortality of C. ferrugineus eggs, the temperature influence was less. However Duncan comparison tests showed that mortalities at 10 and 20°C were significantly different. At less than 48 h exposure, the influence of change in relative humidity from 62 to 84% was not clear but the results obtained at 96 h showed an increase in mortality of 20 to 30% except at 20°C and 4% O<sub>2</sub>. Higher temperature of 20°C and lower relative humidity of 60 to 62% was more lethal than other temperatures (10 and 15°C) and relative humidity (74 and 83%). Although the nature of the effect of temperature and relative humidity on egg mortality was similar to



that on adult mortality, the magnitude of influence was less than that for adults.

## 6. CONCLUSIONS

1. The controlled atmosphere unit was capable of generating desired gaseous mixtures in the laboratory using three gases (CO<sub>2</sub>, O<sub>2</sub>, N<sub>2</sub>) in the range of 0 to 100% for each gas.
2. Any three relative humidity of gas mixtures can be generated depending on the salt solutions and temperatures and six exposure times can be handled using the unit to study the biological response of stored-product insects.
3. The unit can also maintain the pressure of gas mixtures at any level between 0 to 250 kPa and flow rate between 0 to 90 cc/min.
4. In the experiments conducted to study the mortality of C. ferrugineus adults and eggs, the unit maintained CO<sub>2</sub>, O<sub>2</sub> and relative humidity within 2, 1 and 3%, respectively at a constant pressure of 35 kPa and flow rate of 55±2 cc/min.
5. In general, adults were more susceptible than eggs to fairly high CO<sub>2</sub> (>68%) and low O<sub>2</sub> (<5%) atmospheres.
6. Increase in CO<sub>2</sub> from 68 to 91.7% increased the adult mortality more than the mortality of eggs. A decrease in O<sub>2</sub> from 5 to 0% increased the egg mortality more than the adult mortality.
7. In general, a decrease in relative humidity from 84 to 60% resulted in greater mortality of adults and eggs than an increase in temperature from 10 to 20°C.
8. The combination of 60 to 64% relative humidity and 20°C temperature was more lethal than any other combination of relative humidity and temperature used.

9. Although the mortality of adults and eggs almost linearly increased with exposure time in high CO<sub>2</sub> (>68%) and low O<sub>2</sub> (<9.2%) atmospheres, time had very little effect on controls.
10. Humidified gas mixtures used in the experiments had more influence on mortality of adults and eggs than other variables used.
12. High interactions between CO<sub>2</sub> and O<sub>2</sub> with temperature were related to adult mortality, whereas O<sub>2</sub> and relative humidity interaction was prominently related to the egg mortality.
13. Maximum mortality of 99% for adults and 85% for eggs was obtained at 20°C, 60 to 64% relative humidity, 0 to 0.5% O<sub>2</sub> and 88 to 91.7% CO<sub>2</sub> at 96 h of exposure.

## 7. RECOMMENDATION FOR FURTHER STUDIES

The developed unit can be used for studying the effectiveness of controlled atmospheres in controlling various life stages of the stored-product pests. In the literature, I did not find any data on the effect of controlled atmospheres on mortality of larvae and pupae of rusty grain beetles. Therefore, it is recommended that a detailed study with larvae and pupae of rusty grain beetles be done. I spent more than a month attempting to develop a technique to produce a desired number of pupae at a given time. No solution to rearing problems was found, however, ground wheat or wheat germ culture should be the right medium for producing pupae although it may be necessary to rear insects individually. A detailed controlled atmosphere study can be conducted with a mixture of late stage larvae and early stage of pupae. Considerable attention should be given for the selection of operating conditions in such a study because at 30°C and high relative humidity (>70%), the developmental time of pupae to adult is only 4 days. Data are available for the development and mortality of rusty grain beetle adults, eggs, larva and pre-adult stages at temperatures ranging from 22 to 37°C. Some data are available on effectiveness of controlled atmospheres for controlling eggs and adults of the rusty grain beetle. Based on these data, suitable operating conditions can be selected. High CO<sub>2</sub> atmospheres (>70%) with high temperature (>27°C), low relative humidity (<50%) and low O<sub>2</sub> (<5%) can be used, when the experiments are planned with all four life stages.

Little research has been conducted to study the effect of pressure and flow rate of gases on the mortality of stored-product pests in controlled atmosphere storage. Low pressures ranging from 13 to 52 kPa were found to be effective in controlling E. cautella. Shejbal et al.(1973) reported that as the flow rate of a low O<sub>2</sub> atmosphere increased, mortality increased. Therefore, studies can be conducted with the flow rates ranging from 10 to 100 cc/min and pressure from 0 to 70 kPa. Though the effect of relative humidity has been studied in conjunction with controlled atmosphere storage, the effect of relative humidity only on the mortality of stored-product pests has not been given attention. Hence it is suggested that a detailed study on the effect of relative humidity alone on mortality should be planned and conducted.

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## 9. Appendices

## Appendix A

## Summary of the Data Base:

## A. Stored-Product Insects

This data base contained information about 18 stored-product insects, whose Latin name are listed below.

1. Amyeolis transitella (Lepidoptera: Phycitidae)
2. Cadra cautella (almond moth) (Lepidoptera: Phycitidae)
3. Callosobruchus maculatus (Coleoptera : Bruchidae)
4. Cryptolestes ferrugineus (rusty grain beetle) (Coleoptera: Cucujidae)
5. Ephestia cautella (Lepidoptera: Phycitidae)
6. Ephestia kuhniella (Lepidoptera: Phycitidae)
7. Frankliniella occidentali (Thypanoptera: Thripidae)
8. Oryzaephilus surinamensis (sawtooth grain beetle) (Coleoptera: Cucujidae)
9. Plodia interpunctella (Indian meal moth) (Lepidoptera: Phycitidae)
10. Rhyzopertha dominica (lesser grain borer) (Coleoptera: Bostrichidae)
11. Sitophilus granarius (granary weevil) (Coleoptera: Curculionidae)
12. Sitophilus oryzae (rice weevil) (Coleoptera: Curculionidae)
13. Sitotroga cerealella (angoumois grain moth) (Lepidoptera: Gelichiidae)

14. Tribolium castaneum (red flour beetle) (Coleoptera: Tenebrionidae)
15. Tribolium confusum (confused flour beetle) (Coleoptera: Tenebrionidae)
16. Trogoderma variabile (warehouse beetle) (Coleoptera: Dermestidae)
17. Trogoderma glabrum (Coleoptera: Dermestidae)
18. Trogoderma granarium (khapra beetle) (Coleoptera: Dermestidae)

#### B. Life Stages of Insects

The database consisted of information about different life stages of insects namely adult, pupa, larva and egg. From the total of 1726 records, adults were reported in 1083. Larvae were used in 33.3% of the studies, whereas eggs were used only in 10% of the studies. Though in 27% of the studies pupae were used, fewer data were found on mortality of pupae. The problem of getting enough pupae in certain species of insect might be one of the reasons that not many controlled atmosphere studies on mortality of pupae were conducted. For example getting enough C. ferrugineus pupae in the laboratory at a given time was the biggest problem encountered by the author of this study. Similar conditions probably would be prevailing for other species of insects. It was confirmed by most of the researchers that adults of most of the stored-product insects are more susceptible than other life stages to controlled atmospheres with high CO<sub>2</sub> and low O<sub>2</sub>. Based on the information obtained from this database, it is suggested that future

research on controlled atmosphere storage should be concentrated mainly on immature stages.

### C. Temperature and Relative Humidity

In most of the controlled atmosphere studies, temperature in the range of 15 to 38°C was used. In 50% of the studies, temperature was only in the range of 20 to 30°C. Only three studies (White et al., 1988; Fredrick et al., 1970; Rameshbabu et al., 1989) used a temperature below 15°C in their studies. It is highly advisable to continue the research in the range of 20 to 30°C, because growth, development and reproduction of most of the insects occur at this range of temperatures. However more research should be conducted in future at temperatures lower than 10°C in high CO<sub>2</sub> and low O<sub>2</sub> atmospheres for better understanding of the mortality of insects over a wide range of temperatures.

Though relative humidity was reported in most of the studies, influence of relative humidity on mortality was studied only in 25% of the studies. Even though it was reported by many researchers that low humidity was highly unfavorable for survival of most of the insects, in 64% of the studies relative humidity of 50% or more was used. Data on the effect of relative humidity on the mortality of E. cautella (Navarro and Calderon, 1974, 1980), T. castaneum and O. surinamensis (Jay et al., 1971) are available for a wide range of relative humidity. The influence of relative humidity on mortality of C. ferrugineus was studied by Smith (1968) in the range of 40 to 60% in atmospheric air



and in the range of 60 to 84% by Rameshbabu et al., (1989) in high CO<sub>2</sub> and low O<sub>2</sub> atmospheres. Influence of relative humidity on mortality of some important insects like Sitophilus, Rhyzopertha, Sitotroga and other insects like Tribolium confusum should be given attention in future research.

#### D. Gas composition

From experiments conducted with different gas compositions, ranging from 0 to 100% of each gas (CO<sub>2</sub>, O<sub>2</sub>, N<sub>2</sub> or He), the combination of high CO<sub>2</sub> (>60%) and low O<sub>2</sub> (<10%) atmospheres was more lethal than other combinations in effective control of most stored-product insects. Therefore, future research for rapid insect control can be limited to this combination. However these conditions and problems associated with fabricating storage structures that are relatively air-tight involve high operating cost in real field situations.

#### E. Pressure and Flow rate

Calderon (1966), Navarro (1972) and Back and Cotton (1925) found that pressure influenced the mortality of some stored-product insects considerably. However, the data base showed that 90% of the studies did not report the pressure at which laboratory experiments were conducted. Flow rates were generally used in the range of 10 to 100 cc/min in 60% of the studies and in the remaining 40%, it was not reported. Shejbal et al. (1973) and Press et al. (1967) reported that flow rate considerably influenced the mortality. It is recommended that considerable research in controlled atmospheres should be conducted to

assess the exact influence of pressure and flow rate on the mortality of stored-product insects.

#### **F. Reference Details**

The references occupied 5 fields in the database namely, the author name, journal of publication, volume, year and page number. This information will expedite the searching process of the literature if the researcher is interested in knowing more than the operating conditions and insects used, and the mortality obtained in a particular study.

Appendix A2

## CONTROLLED ATMOSPHERE STORAGE DATA BASE

INSECT NAME	STAGE	TEMP C	R.H. %	CO2 %	O2 %	EXP h	MOR %	AUTHOR	YEAR
AMYEOLIS TRANSITELLA	LARVA	27.0	60.0	0.0	0.0	66	95	SODERSTORM ET AL.	1983
CRYPTOLESTES FERRUGINEUS	EGG	25.0	0.0	0.0	0.0	480	16	BARKER, PHILIP	1981
CRYPTOLESTES FERRUGINEUS	EGG	25.0	0.0	0.0	0.0	168	93	BARKER, PHILIP	1981
TRIBOLIUM CASTANEUM	ADULT	15.6	38.0	0.0	0.0	8	20	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	ADULT	15.6	38.0	0.0	0.0	12	99	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	ADULT	15.6	38.0	0.0	0.0	21	96	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	ADULT	15.6	38.0	0.0	0.0	15	99	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	ADULT	15.6	38.0	0.0	0.0	18	75	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	ADULT	15.6	38.0	0.0	0.0	12	15	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	ADULT	15.6	38.0	0.0	0.0	24	100	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	ADULT	15.6	38.0	0.0	0.0	15	55	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	ADULT	15.6	38.0	0.0	0.0	6	12	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	ADULT	15.6	38.0	0.0	0.0	30	100	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	ADULT	15.6	38.0	0.0	0.0	9	61	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	ADULT	15.6	38.0	0.0	0.0	10	82	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	ADULT	21.1	38.0	0.0	0.0	14	99	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	ADULT	21.1	38.0	0.0	0.0	6	2	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	ADULT	21.1	38.0	0.0	0.0	10	83	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	ADULT	21.1	38.0	0.0	0.0	10	100	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	ADULT	21.1	38.0	0.0	0.0	9	47	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	ADULT	21.1	38.0	0.0	0.0	15	100	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	ADULT	21.1	38.0	0.0	0.0	6	78	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	ADULT	21.1	38.0	0.0	0.0	3	7	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	ADULT	21.1	38.0	0.0	0.0	12	84	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	ADULT	21.1	38.0	0.0	0.0	9	100	ALINIAZEE T.	1972

CONTROLLED ATMOSPHERE STORAGE DATA BASE

INSECT NAME	STAGE	TEMP C	R.H. %	CO2 %	O2 %	EXP h	MOR %	AUTHOR	YEAR
TRIBOLIUM CASTANEUM	ADULT	21.1	38.0	0.0	0.0	8	95	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	ADULT	21.1	38.0	0.0	0.0	4	38	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	ADULT	26.7	38.0	0.0	0.0	5	92	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	ADULT	26.7	38.0	0.0	0.0	7	47	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	ADULT	26.7	38.0	0.0	0.0	3	12	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	ADULT	26.7	38.0	0.0	0.0	4	88	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	ADULT	26.7	38.0	0.0	0.0	15	100	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	ADULT	26.7	38.0	0.0	0.0	6	5	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	ADULT	26.7	38.0	0.0	0.0	12	100	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	ADULT	26.7	38.0	0.0	0.0	8	82	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	ADULT	26.7	38.0	0.0	0.0	6	100	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	ADULT	26.7	38.0	0.0	0.0	8	100	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	ADULT	26.7	38.0	0.0	0.0	4	79	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	ADULT	26.7	38.0	0.0	0.0	9	94	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	ADULT	26.7	100	0.0	0.0	18	86	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	ADULT	26.7	100	0.0	0.0	9	8	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	ADULT	26.7	100	0.0	0.0	15	76	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	ADULT	26.7	100	0.0	0.0	6	0	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	ADULT	26.7	100	0.0	0.0	15	89	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	ADULT	26.7	100	0.0	0.0	24	100	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	ADULT	26.7	100	0.0	0.0	18	97	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	ADULT	26.7	100	0.0	0.0	12	39	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	ADULT	26.7	100	0.0	0.0	24	100	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	ADULT	26.7	100	0.0	0.0	9	6	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	ADULT	26.7	100	0.0	0.0	12	30	ALINIAZEE T.	1972

CONTROLLED ATMOSPHERE STORAGE DATA BASE

INSECT NAME	STAGE	TEMP C	R.H. %	CO2 %	O2 %	EXP h	MOR %	AUTHOR	YEAR
TRIBOLIUM CASTANEUM	ADULT	26.7	100	0.0	0.0	6	0	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	LARVA	15.6	38.0	0.0	0.0	72	100	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	LARVA	15.6	38.0	0.0	0.0	30	82	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	LARVA	15.6	38.0	0.0	0.0	36	67	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	LARVA	15.6	38.0	0.0	0.0	18	6	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	LARVA	15.6	38.0	0.0	0.0	72	100	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	LARVA	15.6	38.0	0.0	0.0	848	85	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	LARVA	15.6	38.0	0.0	0.0	30	46	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	LARVA	15.6	38.0	0.0	0.0	48	97	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	LARVA	15.6	38.0	0.0	0.0	18	26	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	LARVA	15.6	38.0	0.0	0.0	36	83	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	LARVA	15.6	38.0	0.0	0.0	24	24	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	LARVA	15.6	38.0	0.0	0.0	24	61	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	LARVA	26.7	38.0	0.0	0.0	30	97	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	LARVA	26.7	38.0	0.0	0.0	42	100	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	LARVA	26.7	38.0	0.0	0.0	12	17	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	LARVA	26.7	38.0	0.0	0.0	18	94	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	LARVA	26.7	38.0	0.0	0.0	18	64	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	LARVA	26.7	38.0	0.0	0.0	42	100	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	LARVA	26.7	38.0	0.0	0.0	24	91	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	LARVA	26.7	38.0	0.0	0.0	6	4	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	LARVA	26.7	38.0	0.0	0.0	24	60	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	LARVA	26.7	38.0	0.0	0.0	6	10	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	LARVA	26.7	38.0	0.0	0.0	15	85	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	LARVA	26.7	38.0	0.0	0.0	30	99	ALINIAZEE T.	1972

## CONTROLLED ATMOSPHERE STORAGE DATA BASE

INSECT NAME	STAGE	TEMP C	R.H. %	CO2 %	O2 %	EXP h	MOR %	AUTHOR	YEAR
TRIBOLIUM CASTANEUM	PUPA	15.6	38.0	0.0	0.0	36	30	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	PUPA	15.6	38.0	0.0	0.0	120	100	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	PUPA	15.6	38.0	0.0	0.0	96	56	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	PUPA	15.6	38.0	0.0	0.0	60	60	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	PUPA	15.6	38.0	0.0	0.0	30	8	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	PUPA	15.6	38.0	0.0	0.0	84	76	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	PUPA	15.6	38.0	0.0	0.0	120	100	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	PUPA	15.6	38.0	0.0	0.0	42	16	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	PUPA	15.6	38.0	0.0	0.0	96	85	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	PUPA	15.6	38.0	0.0	0.0	60	27	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	PUPA	15.6	38.0	0.0	0.0	84	40	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	PUPA	15.6	38.0	0.0	0.0	30	8	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	PUPA	26.7	38.0	0.0	0.0	6	6	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	PUPA	26.7	38.0	0.0	0.0	12	20	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	PUPA	26.7	38.0	0.0	0.0	24	90	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	PUPA	26.7	38.0	0.0	0.0	42	82	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	PUPA	26.7	38.0	0.0	0.0	12	17	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	PUPA	26.7	38.0	0.0	0.0	60	100	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	PUPA	26.7	38.0	0.0	0.0	30	68	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	PUPA	26.7	38.0	0.0	0.0	72	100	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	PUPA	26.7	38.0	0.0	0.0	24	58	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	PUPA	26.7	38.0	0.0	0.0	42	93	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	PUPA	26.7	38.0	0.0	0.0	18	48	ALINIAZEE T.	1972
TRIBOLIUM CASTANEUM	PUPA	26.7	38.0	0.0	0.0	36	91	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM	ADULT	15.6	38.0	0.0	0.0	36	100	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM	ADULT	15.6	38.0	0.0	0.0	21	62	ALINIAZEE T.	1972

CONTROLLED ATMOSPHERE STORAGE DATA BASE

INSECT NAME	STAGE	TEMP	R.H.	CO2	O2	EXP	MOR	AUTHOR	YEAR
		C	%	%	%	h	%		
TRIBOLIUM CONFUSUM ADULT		15.6	38.0	0.0	0.0	15	10	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM ADULT		15.6	38.0	0.0	0.0	24	90	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM ADULT		15.6	38.0	0.0	0.0	9	24	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM ADULT		15.6	38.0	0.0	0.0	15	99	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM ADULT		15.6	38.0	0.0	0.0	15	99	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM ADULT		15.6	38.0	0.0	0.0	12	97	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM ADULT		15.6	38.0	0.0	0.0	15	99	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM ADULT		15.6	38.0	0.0	0.0	30	98	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM ADULT		15.6	38.0	0.0	0.0	10	57	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM ADULT		15.6	38.0	0.0	0.0	18	22	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM ADULT		21.1	38.0	0.0	0.0	6	28	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM ADULT		21.1	38.0	0.0	0.0	12	100	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM ADULT		21.1	38.0	0.0	0.0	10	44	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM ADULT		21.1	38.0	0.0	0.0	8	78	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM ADULT		21.1	38.0	0.0	0.0	15	100	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM ADULT		21.1	38.0	0.0	0.0	9	100	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM ADULT		21.1	38.0	0.0	0.0	18	100	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM ADULT		21.1	38.0	0.0	0.0	10	99	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM ADULT		21.1	38.0	0.0	0.0	9	13	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM ADULT		21.1	38.0	0.0	0.0	15	97	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM ADULT		21.1	38.0	0.0	0.0	14	95	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM ADULT		21.1	38.0	0.0	0.0	12	52	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM ADULT		26.7	38.0	0.0	0.0	5	97	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM ADULT		26.7	38.0	0.0	0.0	6	99	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM ADULT		26.7	38.0	0.0	0.0	18	86	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM ADULT		26.7	38.0	0.0	0.0	4	87	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM ADULT		26.7	38.0	0.0	0.0	8	100	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM ADULT		26.7	38.0	0.0	0.0	9	8	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM ADULT		26.7	38.0	0.0	0.0	6	0	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM ADULT		26.7	38.0	0.0	0.0	4	79	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM ADULT		26.7	38.0	0.0	0.0	3	24	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM ADULT		26.7	38.0	0.0	0.0	15	76	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM ADULT		26.7	38.0	0.0	0.0	24	100	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM ADULT		26.7	38.0	0.0	0.0	12	30	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM ADULT		26.7	100	0.0	0.0	18	95	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM ADULT		26.7	100	0.0	0.0	24	100	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM ADULT		26.7	100	0.0	0.0	12	55	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM ADULT		26.7	100	0.0	0.0	24	100	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM ADULT		26.7	100	0.0	0.0	15	46	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM ADULT		26.7	100	0.0	0.0	9	19	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM ADULT		26.7	100	0.0	0.0	18	91	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM ADULT		26.7	100	0.0	0.0	12	12	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM ADULT		26.7	100	0.0	0.0	6	0	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM ADULT		26.7	100	0.0	0.0	6	0	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM ADULT		26.7	100	0.0	0.0	15	89	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM ADULT		26.7	100	0.0	0.0	9	2	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM ADULT		27.0	0.0	0.0	0.0	122	100	KNIPLING ET AL.	1961
TRIBOLIUM CONFUSUM ADULT		27.6	0.0	0.0	0.0	36	50	KNIPLING ET AL.	1961



## CONTROLLED ATMOSPHERE STORAGE DATA BASE

INSECT NAME	STAGE	TEMP C	R.H. %	CO2 %	O2 %	EXP h	MOR %	AUTHOR	YEAR
TRIBOLIUM CONFUSUM	LARVA	15.6	38.0	0.0	0.0	36	88	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM	LARVA	15.6	38.0	0.0	0.0	18	28	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM	LARVA	15.6	38.0	0.0	0.0	36	88	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM	LARVA	15.6	38.0	0.0	0.0	24	20	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM	LARVA	15.6	38.0	0.0	0.0	60	100	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM	LARVA	15.6	38.0	0.0	0.0	42	56	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM	LARVA	15.6	38.0	0.0	0.0	18	9	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM	LARVA	15.6	38.0	0.0	0.0	30	46	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM	LARVA	15.6	38.0	0.0	0.0	24	61	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM	LARVA	15.6	38.0	0.0	0.0	30	77	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM	LARVA	15.6	38.0	0.0	0.0	42	92	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM	LARVA	15.6	38.0	0.0	0.0	72	99	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM	LARVA	15.6	38.0	0.0	0.0	60	83	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM	LARVA	26.0	38.0	0.0	0.0	18	96	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM	LARVA	26.7	38.0	0.0	0.0	12	59	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM	LARVA	26.7	38.0	0.0	0.0	15	83	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM	LARVA	26.7	38.0	0.0	0.0	6	4	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM	LARVA	26.7	38.0	0.0	0.0	30	99	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM	LARVA	26.7	38.0	0.0	0.0	24	97	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM	LARVA	26.7	38.0	0.0	0.0	42	100	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM	LARVA	26.7	38.0	0.0	0.0	18	64	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM	LARVA	26.7	38.0	0.0	0.0	6	4	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM	LARVA	26.7	38.0	0.0	0.0	12	20	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM	LARVA	26.7	38.0	0.0	0.0	24	94	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM	PUPA	15.6	38.0	0.0	0.0	42	27	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM	PUPA	15.6	38.0	0.0	0.0	96	72	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM	PUPA	15.6	38.0	0.0	0.0	96	93	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM	PUPA	15.6	38.0	0.0	0.0	46	60	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM	PUPA	15.6	38.0	0.0	0.0	72	56	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM	PUPA	15.6	38.0	0.0	0.0	36	32	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM	PUPA	15.6	38.0	0.0	0.0	48	56	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM	PUPA	15.6	38.0	0.0	0.0	48	100	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM	PUPA	15.6	38.0	0.0	0.0	72	82	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM	PUPA	15.6	38.0	0.0	0.0	30	5	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM	PUPA	15.6	38.0	0.0	0.0	120	100	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM	PUPA	15.6	38.0	0.0	0.0	30	10	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM	PUPA	15.6	38.0	0.0	0.0	120	100	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM	PUPA	26.0	38.0	0.0	0.0	24	84	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM	PUPA	26.7	38.0	0.0	0.0	42	88	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM	PUPA	26.7	38.0	0.0	0.0	6	1	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM	PUPA	26.7	38.0	0.0	0.0	24	69	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM	PUPA	26.7	38.0	0.0	0.0	18	64	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM	PUPA	26.7	38.0	0.0	0.0	72	100	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM	PUPA	26.7	38.0	0.0	0.0	48	93	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM	PUPA	26.7	38.0	0.0	0.0	6	4	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM	PUPA	26.7	38.0	0.0	0.0	12	16	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM	PUPA	26.7	38.0	0.0	0.0	12	24	ALINIAZEE T.	1972
TRIBOLIUM CONFUSUM	PUPA	26.7	38.0	0.0	0.0	36	92	ALINIAZEE T.	1972
TROGODERMA GLABARUM	LARVA	37.8	0.0	0.0	0.0	72	27	FREDRICK ET AL.	1970

## CONTROLLED ATMOSPHERE STORAGE DATA BASE

INSECT NAME	STAGE	TEMP C	R.H. %	CO2 %	O2 %	EXP h	MOR %	AUTHOR	YEAR
SITOPHILUS ZEAMAI	ADULT	26.5	0.0	0.0	0.1	72	100	WILLIAMS ET.AL	1980
SITOPHILUS ZEAMAI	EGG	26.5	0.0	0.0	0.1	96	100	WILLIAM ET.AL	1980
SITOPHILUS ZEAMAI	LARVA	26.5	0.0	0.0	0.1	80	100	WILLIAM ET.AL	1980
SITOPHILUS ZEAMAI	PUPA	26.5	0.0	0.0	0.1	192	100	WILLIAMS ET.AL	1980
TROGODERMA GRANARIUM	LARVA	26.5	0.0	0.0	0.1	120	100	WILLIAM ET.AL	1980
AMEYOLIS TRANSITELLA	ADULT	15.6	40.0	0.0	0.5	139	95	SODERSTOM ET.AL	1986
AMEYOLIS TRANSITELLA	ADULT	15.6	60.0	0.0	0.5	171	95	SODERSTOM ET.AL	1986
AMEYOLIS TRANSITELLA	ADULT	21.1	40.0	0.0	0.5	72	95	SODERSTOM ET.AL	1986
AMEYOLIS TRANSITELLA	ADULT	21.1	60.0	0.0	0.5	113	95	SODERSTOM ET.AL	1986
AMEYOLIS TRANSITELLA	ADULT	26.7	40.0	0.0	0.5	50	95	SODERSTOM ET.AL	1986
AMEYOLIS TRANSITELLA	ADULT	26.7	60.0	0.0	0.5	78	95	SODERSTOM ET.AL	1986
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	70.0	0.0	0.5	144	100	KRISNAMURTHY ET AL.	1986
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	70.0	0.0	0.5	72	56	KRISNAMURTHY ET AL.	1986
ORYZAEPHILUS SURINAMENSIS	ADULT	20.0	70.0	0.0	0.5	72	100	KRISNAMURTHY ET AL.	1986
PLODIA INTERPUNCTELLA	ADULT	15.6	40.0	0.0	0.5	122	95	SODERSTOM ET.AL	1986
PLODIA INTERPUNCTELLA	ADULT	15.6	60.0	0.0	0.5	138	95	SODERSTOM ET.AL	1986
PLODIA INTERPUNCTELLA	ADULT	21.1	40.0	0.0	0.5	53	95	SODERSTOM ET.AL	1986
PLODIA INTERPUNCTELLA	ADULT	21.1	60.0	0.0	0.5	58	95	SODERSTOM ET.AL	1986
PLODIA INTERPUNCTELLA	ADULT	26.7	40.0	0.0	0.5	36	95	SODERSTOM ET.AL	1986
PLODIA INTERPUNCTELLA	ADULT	26.7	60.0	0.0	0.5	41	95	SODERSTOM ET.AL	1986
SITOPHILUS GRANARIUS	ADULT	20.0	70.0	0.0	0.5	144	73	KRISNAMURTHY ET AL.	1986
SITOPHILUS GRANARIUS	ADULT	20.0	70.0	0.0	0.5	240	100	KRISNAMURTHY ET AL.	1986
SITOPHILUS GRANARIUS	ADULT	26.7	0.0	0.0	0.5	168	100	FREDRICK ET AL.	1970
SITOPHILUS GRANARIUS	ADULT	26.7	0.0	0.0	0.5	72	100	FREDRICK ET AL.	1970
SITOPHILUS GRANARIUS	ADULT	26.7	0.0	0.0	0.5	72	90	FREDRICK ET AL.	1970

## CONTROLLED ATMOSPHERE STORAGE DATA BASE

INSECT NAME	STAGE	TEMP C	R.H. %	CO2 %	O2 %	EXP h	MOR %	AUTHOR	YEAR
TRIBOLIUM CASTANEUM	ADULT	20.0	70.0	0.0	0.5	96	100	KRISNAMURTHY ET AL.	1986
TRIBOLIUM CASTANEUM	ADULT	20.0	70.0	0.0	0.5	72	100	KRISNAMURTHY ET AL.	1986
TRIBOLIUM CASTANEUM	ADULT	20.0	70.0	0.0	0.5	48	78	KRISNAMURTHY ET AL.	1986
TROGODERMA GLABARUM	ADULT	26.7	0.0	0.0	0.5	168	83	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	ADULT	26.7	0.0	0.0	0.5	72	23	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	ADULT	26.7	0.0	0.0	0.5	168	100	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	ADULT	26.7	0.0	0.0	0.5	72	100	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	LARVA	26.7	0.0	0.0	0.5	72	31	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	LARVA	26.7	0.0	0.0	0.5	72	100	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	LARVA	26.7	0.0	0.0	0.5	168	100	FREDRICK ET AL.	1970
SITOPHILUS GRANARIUS	ADULT	15.6	0.0	0.0	0.6	72	50	FREDRICK ET AL.	1970
SITOPHILUS GRANARIUS	ADULT	15.6	0.0	0.0	0.6	168	78	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	ADULT	15.6	0.0	0.0	0.6	168	97	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	ADULT	15.6	0.0	0.0	0.6	72	89	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	LARVA	15.6	0.0	0.0	0.6	168	57	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	LARVA	15.6	0.0	0.0	0.6	72	29	FREDRICK ET AL.	1970
ORYZAEPHILUS SURINAMENSIS	ADULT	27.6	9.0	0.0	1.0	24	44	STOREY C.L.	1971
ORYZAEPHILUS SURINAMENSIS	ADULT	27.6	33.3	0.0	1.0	24	30	STOREY C.L.	1971
ORYZAEPHILUS SURINAMENSIS	ADULT	27.6	54.0	0.0	1.0	24	18	STOREY C.L.	1971
ORYZAEPHILUS SURINAMENSIS	ADULT	27.6	68.0	0.0	1.0	24	5	STOREY C.L.	1971
PLODIA INTERPUNCTELLA	LARVA	16.0	67.5	0.0	1.0	168	82	HAREIN P.K. & A.F.PRESS	1968
PLODIA INTERPUNCTELLA	LARVA	16.0	67.5	0.0	1.0	336	99	HAREIN P.K. & A.F.PRESS	1968
PLODIA INTERPUNCTELLA	LARVA	38.2	62.0	0.0	1.0	336	100	HAREIN P.K. & A.F.PRESS	1968
PLODIA INTERPUNCTELLA	LARVA	38.2	62.0	0.0	1.0	168	100	HAREIN P.K. & A.F.PRESS	1968
SITOPHILUS ORYZAE	ADULT	15.0	50.0	0.0	1.0	298	95	BAILEY & BANKS	1971

CONTROLLED ATMOSPHERE STORAGE DATA BASE

INSECT NAME	STAGE	TEMP C	R.H. %	CO2 %	O2 %	EXP h	MOR %	AUTHOR	YEAR
SITOPHILUS ORYZAE	ADULT	32.0	50.0	0.0	1.0	20	95	BAILEY & BANKS	1975
SITOPHILUS ORYZAE	PUPA	21.0	50.0	0.0	1.0	648	95	STOREY C.L.	1975
TRIBOLIUM CASTANEUM	ADULT	16.0	67.5	0.0	1.0	168	69	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	ADULT	16.0	67.5	0.0	1.0	336	94	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	ADULT	27.6	9.0	0.0	1.0	24	99	JAY E.G.	1971
TRIBOLIUM CASTANEUM	ADULT	27.6	33.3	0.0	1.0	24	96	JAY E.G.	1971
TRIBOLIUM CASTANEUM	ADULT	27.6	54.0	0.0	1.0	24	79	JAY E.G.	1971
TRIBOLIUM CASTANEUM	ADULT	27.6	68.0	0.0	1.0	24	4	JAY E.G.	1971
TRIBOLIUM CASTANEUM	ADULT	38.2	62.0	0.0	1.0	168	100	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	ADULT	38.2	62.0	0.0	1.0	336	100	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	LARVA	16.0	67.5	0.0	1.0	168	14	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	LARVA	16.0	67.5	0.0	1.0	336	88	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	LARVA	38.2	62.0	0.0	1.0	168	100	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	LARVA	38.2	62.0	0.0	1.0	336	100	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CONFUSUM	ADULT	27.6	9.0	0.0	1.0	24	98	JAY E.G.	1971
TRIBOLIUM CONFUSUM	ADULT	27.6	33.3	0.0	1.0	24	96	JAY E.G.	1971
TRIBOLIUM CONFUSUM	ADULT	27.6	54.0	0.0	1.0	24	43	JAY E.G.	1971
TRIBOLIUM CONFUSUM	ADULT	27.6	68.0	0.0	1.0	24	8	JAY E.G.	1971
TROGODERMA GRANARIUM	ADULT	25.3	62.0	0.0	1.0	168	44	PRESS	1967
TROGODERMA GRANARIUM	ADULT	25.3	62.0	0.0	1.0	168	65	PRESS	1967
AMEYOLIS TRANSITELLA	ADULT	15.6	40.0	0.0	1.5	141	95	SODERSTOM ET.AL	1986
AMEYOLIS TRANSITELLA	ADULT	15.6	60.0	0.0	1.5	213	95	SODERSTOM ET.AL	1986
AMEYOLIS TRANSITELLA	ADULT	21.1	40.0	0.0	1.5	76	95	SODERSTOM ET.AL	1986
AMEYOLIS TRANSITELLA	ADULT	21.1	60.0	0.0	1.5	126	95	SODERSTOM ET.AL	1986
AMEYOLIS TRANSITELLA	ADULT	26.7	40.0	0.0	1.5	57	95	SODERSTOM ET.AL	1986
AMEYOLIS TRANSITELLA	ADULT	26.7	60.0	0.0	1.5	90	95	SODERSTOM ET.AL	1986
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	70.0	0.0	1.5	96	12	KRISNAMURTHY ET AL.	1986
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	70.0	0.0	1.5	192	60	KRISNAMURTHY ET AL.	1986

CONTROLLED ATMOSPHERE STORAGE DATA BASE

INSECT NAME	STAGE	TEMP C	R.H. %	CO2 %	O2 %	EXP h	MOR %	AUTHOR	YEAR
ORYZAEPHILUS SURINAMENSIS	ADULT	20.0	70.0	0.0	1.5	96	15	KRISNAMURTHY ET AL.	1986
ORYZAEPHILUS SURINAMENSIS	ADULT	20.0	70.0	0.0	1.5	240	100	KRISNAMURTHY ET AL.	1986
PLODIA INTERPUNCTELLA	ADULT	15.6	60.0	0.0	1.5	170	95	SODERSTOM ET.AL	1986
PLODIA INTERPUNCTELLA	ADULT	15.7	40.0	0.0	1.5	163	95	SODERSTOM ET.AL	1986
PLODIA INTERPUNCTELLA	ADULT	21.1	60.0	0.0	1.5	88	95	SODERSTOM ET.AL	1986
PLODIA INTERPUNCTELLA	ADULT	26.7	21.1	0.0	1.5	80	95	SODERSTOM ET.AL	1986
PLODIA INTERPUNCTELLA	ADULT	26.7	40.0	0.0	1.5	57	95	SODERSTOM ET.AL	1986
PLODIA INTERPUNCTELLA	ADULT	26.7	60.0	0.0	1.5	60	95	SODERSTOM ET.AL	1986
SITOPHILUS GRANARIUS	ADULT	20.0	70.0	0.0	1.5	96	8	KRISNAMURTHY ET AL.	1986
SITOPHILUS GRANARIUS	ADULT	20.0	70.0	0.0	1.5	192	57	KRISNAMURTHY ET AL.	1986
TRIBOLIUM CASTANEUM	ADULT	20.0	70.0	0.0	1.5	240	100	KRISNAMURTHY ET AL.	1986
TRIBOLIUM CASTANEUM	ADULT	20.0	70.0	0.0	1.5	48	7	KRISNAMURTHY ET AL.	1986
TRIBOLIUM CASTANEUM	ADULT	27.0	38.0	0.0	2.0	96	100	ALINIAZEE T.	1971
TRIBOLIUM CONFUSUM	ADULT	27.0	38.0	0.0	2.0	96	100	ALINIAZEE T.	1971
TROGODERMA GRANARIUM	ADULT	25.3	62.0	0.0	2.0	48	10	PRESS	1967
TROGODERMA GRANARIUM	ADULT	25.3	62.0	0.0	2.0	96	29	PRESS	1967
TROGODERMA GRANARIUM	ADULT	25.3	62.0	0.0	2.0	96	23	PRESS	1967
TROGODERMA GRANARIUM	ADULT	25.3	62.0	0.0	2.0	168	8	PRESS	1967
TROGODERMA GRANARIUM	ADULT	25.3	62.0	0.0	2.0	48	8	PRESS	1967
TROGODERMA GRANARIUM	ADULT	25.3	62.0	0.0	2.0	96	2	PRESS	1967
TROGODERMA GRANARIUM	ADULT	25.3	62.0	0.0	2.0	48	2	PRESS	1967
PLODIA INTERPUNCTELLA	LARVA	27.1	64.0	0.0	2.5	336	100	HAREIN P.K. & A.F.PRESS	1968
PLODIA INTERPUNCTELLA	LARVA	27.1	64.0	0.0	2.5	168	100	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	ADULT	27.1	64.0	0.0	2.5	168	100	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	LARVA	27.1	64.0	0.0	2.5	336	100	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	LARVA	27.1	64.0	0.0	2.5	168	97	HAREIN P.K. & A.F.PRESS	1968

## CONTROLLED ATMOSPHERE STORAGE DATA BASE

INSECT NAME	STAGE	TEMP C	R.H. %	CO2 %	O2 %	EXP h	MOR %	AUTHOR	YEAR
SITOPHILUS GRANARIUS	ADULT	4.4	0.0	0.0	3.4	72	1	FREDRICK ET AL.	1970
SITOPHILUS GRANARIUS	ADULT	4.4	0.0	0.0	3.4	168	32	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	ADULT	4.4	0.0	0.0	3.4	72	27	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	ADULT	4.4	0.0	0.0	3.4	168	9	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	LARVA	4.4	0.0	0.0	3.4	72	3	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	LARVA	4.4	0.0	0.0	3.4	168	17	FREDRICK ET AL.	1970
SITOPHILUS GRANARIUS	ADULT	26.7	0.0	0.0	3.5	168	90	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	LARVA	26.7	0.0	0.0	3.5	168	52	FREDRICK ET AL.	1970
PLODIA INTERPUNCTELLA	LARVA	16.0	67.5	0.0	4.0	168	24	HAREIN P.K. & A.F.PRESS	1968
PLODIA INTERPUNCTELLA	LARVA	16.0	67.5	0.0	4.0	336	81	HAREIN P.K. & A.F.PRESS	1968
PLODIA INTERPUNCTELLA	LARVA	38.2	62.0	0.0	4.0	336	100	HAREIN P.K. & A.F.PRESS	1968
PLODIA INTERPUNCTELLA	LARVA	38.2	62.0	0.0	4.0	336	100	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	ADULT	16.0	67.5	0.0	4.0	168	0	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	ADULT	16.0	67.5	0.0	4.0	336	2	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	ADULT	38.2	62.0	0.0	4.0	168	100	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	ADULT	38.2	62.0	0.0	4.0	336	100	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	LARVA	16.0	67.5	0.0	4.0	336	16	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	LARVA	16.0	67.5	0.0	4.0	168	6	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	LARVA	38.2	62.0	0.0	4.0	336	100	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	LARVA	38.2	62.0	0.0	4.0	168	100	HAREIN P.K. & A.F.PRESS	1968
AMEYOLIS TRANSITELLA	ADULT	15.6	60.0	0.0	5.0	242	95	SODERSTOM ET.AL	1986
AMEYOLIS TRANSITELLA	ADULT	21.1	60.0	0.0	5.0	166	95	SODERSTOM ET.AL	1986
AMEYOLIS TRANSITELLA	ADULT	21.1	60.0	0.0	5.0	166	95	SODERSTOM ET.AL	1986
AMEYOLIS TRANSITELLA	ADULT	26.7	40.0	0.0	5.0	68	95	SODERSTOM ET.AL	1986
AMEYOLIS TRANSITELLA	ADULT	26.7	40.0	0.0	5.0	68	95	SODERSTOM ET.AL	1986

CONTROLLED ATMOSPHERE STORAGE DATA BASE

INSECT NAME	STAGE	TEMP C	R.H. %	CO2 %	O2 %	EXP h	MOR %	AUTHOR	YEAR
AMEYOLIS TRANSITELLA	ADULT	26.7	60.0	0.0	5.0	150	95	SODERSTOM ET. AL	1986
PLODIA INTERPUNCTELLA	ADULT	15.6	40.0	0.0	5.0	319	95	SODERSTOM ET. AL	1986
PLODIA INTERPUNCTELLA	ADULT	15.6	60.0	0.0	5.0	491	95	SODERSTOM ET. AL	1986
PLODIA INTERPUNCTELLA	ADULT	21.1	40.0	0.0	5.0	401	95	SODERSTOM ET. AL	1986
PLODIA INTERPUNCTELLA	ADULT	21.1	60.0	0.0	5.0	166	95	SODERSTOM ET. AL	1986
PLODIA INTERPUNCTELLA	ADULT	26.7	40.0	0.0	5.0	128	95	SODERSTOM ET. AL	1986
PLODIA INTERPUNCTELLA	ADULT	26.7	60.0	0.0	5.0	290	95	SODERSTOM ET. AL	1986
SITOPHILUS GRANARIUS	ADULT	37.8	0.0	0.0	5.0	72	100	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	ADULT	37.8	0.0	0.0	5.0	72	100	FREDRICK ET AL.	1970
PLODIA INTERPUNCTELLA	LARVA	27.1	64.0	0.0	5.6	168	38	HAREIN P.K. & A.F.PRESS	1968
PLODIA INTERPUNCTELLA	LARVA	27.1	64.0	0.0	5.6	336	93	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	ADULT	27.1	64.0	0.0	5.6	336	22	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	ADULT	27.1	64.0	0.0	5.6	168	0	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	LARVA	27.1	64.0	0.0	5.6	168	2	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	LARVA	27.1	64.0	0.0	5.6	336	22	HAREIN P.K. & A.F.PRESS	1968
PLODIA INTERPUNCTELLA	LARVA	38.2	62.0	0.0	6.0	336	100	HAREIN P.K. & A.F.PRESS	1968
PLODIA INTERPUNCTELLA	LARVA	38.2	62.0	0.0	6.0	168	100	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	ADULT	38.2	62.0	0.0	6.0	168	100	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	ADULT	38.2	62.0	0.0	6.0	336	100	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	LARVA	38.2	62.0	0.0	6.0	336	100	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	LARVA	38.2	62.0	0.0	6.0	168	100	HAREIN P.K. & A.F.PRESS	1968
PLODIA INTERPUNCTELLA	LARVA	16.0	67.5	0.0	6.5	168	19	HAREIN P.K. & A.F.PRESS	1968
PLODIA INTERPUNCTELLA	LARVA	16.0	67.5	0.0	6.5	336	64	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	ADULT	16.0	67.5	0.0	6.5	168	0	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	ADULT	16.0	67.5	0.0	6.5	336	0	HAREIN P.K. & A.F.PRESS	1968

## CONTROLLED ATMOSPHERE STORAGE DATA BASE

INSECT NAME	STAGE	TEMP	R.H.	CO2	O2	EXP	MOR	AUTHOR	YEAR
		C	%	%	%	h	%		
TRIBOLIUM CASTANEUM	LARVA	16.0	67.5	0.0	6.5	336	12	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	LARVA	16.0	67.5	0.0	6.5	168	2	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	LARVA	27.1	64.0	0.0	10.0	336	4	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	LARVA	27.1	64.0	0.0	10.0	168	2	HAREIN P.K. & A.F.PRESS	1968
PLODIA INTERPUNCTELLA	LARVA	27.1	64.0	0.0	10.5	336	20	HAREIN P.K. & A.F.PRESS	1968
PLODIA INTERPUNCTELLA	LARVA	27.1	64.0	0.0	10.5	168	10	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	ADULT	27.1	64.0	0.0	10.5	168	0	HAREIN P.K. & A.F.PRESS	1968
PLODIA INTERPUNCTELLA	LARVA	38.2	62.0	0.0	11.0	168	100	HAREIN P.K. & A.F.PRESS	1968
PLODIA INTERPUNCTELLA	LARVA	38.2	62.0	0.0	11.0	336	100	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	ADULT	38.2	62.0	0.0	11.0	168	97	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	ADULT	38.2	62.0	0.0	11.0	336	100	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	LARVA	38.2	62.0	0.0	11.0	336	100	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	LARVA	38.2	62.0	0.0	11.0	168	44	HAREIN P.K. & A.F.PRESS	1968
PLODIA INTERPUNCTELLA	LARVA	16.0	67.5	0.0	12.0	336	31	HAREIN P.K. & A.F.PRESS	1968
PLODIA INTERPUNCTELLA	LARVA	16.0	67.5	0.0	12.0	168	14	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	ADULT	16.0	67.5	0.0	12.0	168	1	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	ADULT	16.0	67.5	0.0	12.0	336	0	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	LARVA	16.0	67.5	0.0	12.0	336	4	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	LARVA	16.0	67.5	0.0	12.0	168	4	HAREIN P.K. & A.F.PRESS	1968
PLODIA INTERPUNCTELLA	LARVA	16.0	67.5	0.0	21.0	336	26	HAREIN P.K. & A.F.PRESS	1968
PLODIA INTERPUNCTELLA	LARVA	16.0	67.5	0.0	21.0	168	6	HAREIN P.K. & A.F.PRESS	1968
PLODIA INTERPUNCTELLA	LARVA	27.1	64.0	0.0	21.0	336	8	HAREIN P.K. & A.F.PRESS	1968
PLODIA INTERPUNCTELLA	LARVA	27.1	64.0	0.0	21.0	168	9	HAREIN P.K. & A.F.PRESS	1968
PLODIA INTERPUNCTELLA	LARVA	38.2	62.0	0.0	21.0	336	100	HAREIN P.K. & A.F.PRESS	1968
PLODIA INTERPUNCTELLA	LARVA	38.2	62.0	0.0	21.0	168	99	HAREIN P.K. & A.F.PRESS	1968



## CONTROLLED ATMOSPHERE STORAGE DATA BASE

INSECT NAME	STAGE	TEMP C	R.H. %	CO2 %	O2 %	EXP h	MOR %	AUTHOR	YEAR
TRIBOLIUM CASTANEUM	ADULT	15.6	67.5	0.0	21.0	168	0	P.K.HAREIN & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	ADULT	16.0	67.5	0.0	21.0	336	1	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	ADULT	27.1	64.0	0.0	21.0	336	1	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	ADULT	27.1	64.0	0.0	21.0	168	0	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	ADULT	38.2	62.0	0.0	21.0	168	5	P.K.HAREIN & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	ADULT	38.2	62.0	0.0	21.0	336	99	P.K.HAREIN & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	LARVA	16.0	67.5	0.0	21.0	336	7	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	LARVA	16.0	67.5	0.0	21.0	168	4	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	LARVA	27.1	64.0	0.0	21.0	336	1	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	LARVA	27.1	64.0	0.0	21.0	168	0	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	LARVA	38.2	62.0	0.0	21.0	336	50	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	LARVA	38.2	62.0	0.0	21.0	168	5	HAREIN P.K. & A.F.PRESS	1968
FRANKLINIELLA OCCIDENTALI	ADULT	25.0	0.0	1.0	1.0	48	94	YAIR AKARONI ET.AL	1981
RHYZOPERTHA DOMINICA	EGG	26.0	57.0	5.0	2.0	96	90	CALDERON & NAVARRO	1980
TRIBOLIUM CASTANEUM	EGG	26.0	57.0	5.0	2.0	96	100	CALDERON & NAVARRO	1980
RHYZOPERTHA DOMINICA	EGG	26.0	57.0	7.5	4.0	96	85	CALDERON & NAVARRO	1980
SITOPHILUS ORYZAE	EGG	21.0	57.0	9.2	1.0	162	95	STOREY C.L.	1980
AMEYOLIS TRANSITELLA	ADULT	27.0	52.5	9.5	1.0	17	98	STOREY C.L.	1980
AMEYOLIS TRANSITELLA	EGG	27.0	52.5	9.5	1.0	28	98	STOREY C.L.	1980
AMEYOLIS TRANSITELLA	LARVA	27.0	52.5	9.5	1.0	27	98	STOREY C.L.	1980
AMEYOLIS TRANSITELLA	PUPA	27.0	52.5	9.5	1.0	38	98	STOREY C.L.	1980
CALLOSOBRUCHUS MACULTAUSE	EGG	27.0	52.5	9.5	1.0	96	98	STOREY C.L.	1980
CALLOSOBRUCHUS MACULTUS	LARVA	27.0	52.5	9.5	1.0	192	98	STOREY C.L.	1980
CALLOSOBRUCHUS MACULTUS	PUPA	27.0	52.5	9.5	1.0	192	98	STOREY C.L.	1980
CALLOSOBRUCHUS MACULTUS	ADULT	27.0	50.0	9.5	1.0	48	100	STOREY C.L.	1978
CALLOSOBRUCHUS MACULTUS	EGG	27.0	50.0	9.5	1.0	96	100	STOREY C.L.	1978

## CONTROLLED ATMOSPHERE STORAGE DATA BASE

INSECT NAME	STAGE	TEMP C	R.H. %	CO2 %	O2 %	EXP h	MOR %	AUTHOR	YEAR
CALLOSOBRUCHUS MACULUTUS	LARVA	27.0	50.0	9.5	1.0	120	100	STOREY C.L.	1978
CALLOSOBRUCHUS MACULUTUS	PUPA	27.0	50.0	9.5	1.0	192	100	STOREY C.L.	1978
CALLOSOBRUCHUS MACULTUS	ADULT	27.0	52.5	9.5	1.0	48	98	STOREY C.L.	1980
EPHESTIA CAUTELLA	ADULT	27.0	52.5	9.5	1.0	8	98	STOREY C.L.	1980
EPHESTIA CAUTELLA	EGG	27.0	52.5	9.5	1.0	48	98	STOREY C.L.	1980
EPHESTIA CAUTELLA	LARVA	27.0	52.5	9.5	1.0	8	98	STOREY C.L.	1980
EPHESTIA CAUTELLA	PUPA	27.0	52.5	9.5	1.0	24	98	STOREY C.L.	1980
ORYZAEPHILUS SURINAMENSIS	ADULT	15.0	57.0	9.5	1.0	47	95	STOREY C.L.	1980
ORYZAEPHILUS SURINAMENSIS	ADULT	21.0	57.0	9.5	1.0	18	95	STOREY C.L.	1980
ORYZAEPHILUS SURINAMENSIS	ADULT	27.0	57.0	9.5	1.0	11	95	STOREY C.L.	1980
ORYZAEPHILUS SURINAMENSIS	ADULT	32.0	57.0	9.5	1.0	4	95	STOREY C.L.	1980
PLODIA INTERPUNCTELLA	ADULT	27.0	52.5	9.5	1.0	8	98	STOREY C.L.	1980
PLODIA INTERPUNCTELLA	EGG	27.0	52.5	9.5	1.0	24	98	STOREY C.L.	1980
PLODIA INTERPUNCTELLA	LARVA	27.0	52.5	9.5	1.0	8	98	STOREY C.L.	1980
PLODIA INTERPUNCTELLA	PUPA	27.0	52.5	9.5	1.0	24	98	STOREY C.L.	1980
RHYZOPERTHA DOMINICA	ADULT	15.0	57.0	9.5	1.0	175	95	STOREY C.L.	1980
RHYZOPERTHA DOMINICA	ADULT	21.0	57.0	9.5	1.0	79	95	STOREY C.L.	1980
RHYZOPERTHA DOMINICA	ADULT	27.0	57.0	9.5	1.0	31	95	STOREY C.L.	1980
RHYZOPERTHA DOMINICA	ADULT	32.0	57.0	9.5	1.0	17	95	STOREY C.L.	1980
RHYZOPERTHA DOMINICA	EGG	27.0	52.5	9.5	1.0	72	98	STOREY C.L.	1980
RHYZOPERTHA DOMINICA	LARVA	27.0	52.5	9.5	1.0	192	98	STOREY C.L.	1980
RHYZOPERTHA DOMINICA	PUPA	27.0	52.5	9.5	1.0	216	98	STOREY C.L.	1980
SITOPHILUS GRANARIS	ADULT	15.0	57.0	9.5	1.0	228	95	STOREY C.L.	1980
SITOPHILUS GRANARIS	ADULT	21.0	57.0	9.5	1.0	145	95	STOREY C.L.	1980
SITOPHILUS GRANARIS	ADULT	27.0	57.0	9.5	1.0	55	95	STOREY C.L.	1980
SITOPHILUS GRANARIS	ADULT	32.0	57.0	9.5	1.0	20	95	STOREY C.L.	1980
SITOPHILUS GRANARIUS	EGG	27.0	52.5	9.5	1.0	85	98	STOREY C.L.	1980

CONTROLLED ATMOSPHERE STORAGE DATA BASE

INSECT NAME	STAGE	TEMP C	R.H. %	CO2 %	O2 %	EXP h	MOR %	AUTHOR	YEAR
SITOPHILUS GRANARIUS	LARVA	27.0	52.5	9.5	1.0	137	98	STOREY C.L.	1980
SITOPHILUS GRANARIUS	PUPA	27.0	52.5	9.5	1.0	148	98	STOREY C.L.	1980
SITOPHILUS ORYZAE	ADULT	15.0	57.0	9.5	1.0	297	95	STOREY C.L.	1980
SITOPHILUS ORYZAE	ADULT	21.0	57.0	9.5	1.0	200	95	STOREY C.L.	1980
SITOPHILUS ORYZAE	ADULT	27.0	57.0	9.5	1.0	48	95	STOREY C.L.	1980
SITOPHILUS ORYZAE	ADULT	32.0	57.0	9.5	1.0	19	95	STOREY C.L.	1980
SITOPHILUS ORYZAE	EGG	27.0	52.5	9.5	1.0	70	98	STOREY C.L.	1980
SITOPHILUS ORYZAE	LARVA	21.0	57.0	9.5	1.0	562	95	STOREY C.L.	1980
SITOPHILUS ORYZAE	LARVA	27.0	52.5	9.5	1.0	246	98	STOREY C.L.	1980
SITOPHILUS ORYZAE	PUPA	21.0	57.0	9.5	1.0	653	95	STOREY C.L.	1980
SITOPHILUS ORYZAE	PUPA	27.0	52.5	9.5	1.0	241	98	STOREY C.L.	1980
SITOTROGA CEREALELLA	ADULT	27.0	52.5	9.5	1.0	24	98	STOREY C.L.	1980
SITOTROGA CEREALELLA	LARVA	27.0	52.5	9.5	1.0	120	98	STOREY C.L.	1980
SITOTROGA CEREALELLA	PUPA	27.0	52.5	9.5	1.0	120	98	STOREY C.L.	1980
SITOTROGA CEREALELLA	EGG	27.0	52.5	9.5	1.0	48	98	STOREY C.L.	1980
TRIBOLIUM CASTANEUM	ADULT	15.0	57.0	9.5	1.0	67	95	STOREY C.L.	1980
TRIBOLIUM CASTANEUM	ADULT	21.0	57.0	9.5	1.0	32	95	STOREY C.L.	1980
TRIBOLIUM CASTANEUM	ADULT	27.0	57.0	9.5	1.0	17	95	STOREY C.L.	1980
TRIBOLIUM CASTANEUM	ADULT	32.0	57.0	9.5	1.0	8	95	STOREY C.L.	1980
TRIBOLIUM CASTANEUM	EGG	27.0	52.5	9.5	1.0	40	98	STOREY C.L.	1980
TRIBOLIUM CASTANEUM	LARVA	27.0	52.5	9.5	1.0	23	98	STOREY C.L.	1980
TRIBOLIUM CASTANEUM	PUPA	27.0	52.5	9.5	1.0	47	97	STOREY C.L.	1980
TRIBOLIUM CONFUSUM	EGG	27.0	52.5	9.5	1.0	40	975	STOREY C.L.	1980
TRIBOLIUM CONFUSUM	LARVA	27.0	52.5	9.5	1.0	20	98	STOREY C.L.	1980
TRIBOLIUM CONFUSUM	PUPA	27.0	52.5	9.5	1.0	53	98	STOREY C.L.	1980
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	70.0	10	0.5	144	100	KRISNAMURTHY ET AL.	1986
ORYZAEPHILUS SURINAMENSIS	ADULT	20.0	70.0	10	0.5	72	100	KRISNAMURTHY ET AL.	1986
SITOPHILUS GRANARIUS	ADULT	20.0	70.0	10	0.5	192	100	KRISNAMURTHY ET AL.	1986
TRIBOLIUM CASTANEUM	ADULT	20.0	70.0	10	0.5	48	100	KRISNAMURTHY ET AL.	1986
AMEYOLIS TRANSITELLA	LARVA	27.0	60.0	10	1.0	88	95	BRANDL ET.AL	1983
CADRA CAUTELLA	ADULT	27.0	50.0	10	1.0	8	100	STOREY C.L.	1975
CADRA CAUTELLA	EGG	27.0	50.0	10	1.0	48	100	STOREY C.L.	1975

CONTROLLED ATMOSPHERE STORAGE DATA BASE

INSECT NAME	STAGE	TEMP C	R.H. %	CO2 %	O2 %	EXP h	MOR %	AUTHOR	YEAR
CADRA CAUTELLA	LARVA	27.0	50.0	10	1.0	8	100	STOREY C.L.	1975
CADRA CAUTELLA	PUPA	27.0	50.0	10	1.0	24	100	STOREY C.L.	1975
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	70.0	10	1.0	144	100	KRISNAMURTHY ET AL.	1986
ORYZAEPHILUS SURINAMENSIS	ADULT	15.0	50.0	10	1.0	47	96	STOREY C.L.	1975
ORYZAEPHILUS SURINAMENSIS	ADULT	21.0	50.0	10	1.0	18	95	STOREY C.L.	1975
ORYZAEPHILUS SURINAMENSIS	ADULT	27.0	50.0	10	1.0	11	95	STOREY C.L.	1975
ORYZAEPHILUS SURINAMENSIS	ADULT	32.0	50.0	10	1.0	4	95	STOREY C.L.	1975
PLODIA INTERPUNCTELLA	ADULT	27.0	50.0	10	1.0	8	100	STOREY C.L.	1975
PLODIA INTERPUNCTELLA	EGG	27.0	50.0	10	1.0	24	96	STOREY C.L.	1975
PLODIA INTERPUNCTELLA	LARVA	27.0	50.0	10	1.0	8	100	STOREY C.L.	1975
PLODIA INTERPUNCTELLA	PUPA	27.0	50.0	10	1.0	24	100	STOREY C.L.	1975
RHYZOPERTHA DOMINICA	ADULT	15.0	50.0	10	1.0	175	96	STOREY C.L.	1975
RHYZOPERTHA DOMINICA	ADULT	21.0	50.0	10	1.0	80	95	STOREY C.L.	1975
RHYZOPERTHA DOMINICA	ADULT	27.0	50.0	10	1.0	31	95	STOREY C.L.	1975
RHYZOPERTHA DOMINICA	ADULT	32.0	50.0	10	1.0	17	95	STOREY C.L.	1975
SITOPHILUS GRANARIS	ADULT	27.0	53.0	10	1.0	55	98	STOREY C.L.	1980
SITOPHILUS GRANARIS	EGG	27.0	53.0	10	1.0	85	98	STOREY C.L.	1980
SITOPHILUS GRANARIS	LARVA	27.0	53.0	10	1.0	138	98	STOREY C.L.	1980
SITOPHILUS GRANARIS	PUPA	27.0	53.0	10	1.0	148	98	STOREY C.L.	1980
SITOPHILUS GRANARIUS	ADULT	15.0	50.0	10	1.0	228	96	STOREY C.L.	1975
SITOPHILUS GRANARIUS	ADULT	20.0	70.0	10	1.0	144	100	KRISNAMURTHY ET AL.	1986
SITOPHILUS GRANARIUS	ADULT	21.0	50.0	10	1.0	145	95	STOREY C.L.	1975
SITOPHILUS GRANARIUS	ADULT	27.0	50.0	10	1.0	55	95	STOREY C.L.	1975
SITOPHILUS GRANARIUS	ADULT	27.0	52.5	10	1.0	56	95	STOREY C.L.	1975
SITOPHILUS GRANARIUS	ADULT	32.0	50.0	10	1.0	20	95	STOREY C.L.	1975
SITOPHILUS GRANARIUS	EGG	28.0	52.5	10	1.0	86	95	STOREY C.L.	1975

CONTROLLED ATMOSPHERE STORAGE DATA BASE

INSECT NAME	STAGE	TEMP C	R.H. %	CO2 %	O2 %	EXP h	MOR %	AUTHOR	YEAR
SITOPHILUS GRANARIUS	LARVA	28.0	52.5	10	1.0	137	95	STOREY C.L.	1975
SITOPHILUS GRANARIUS	PUPA	27.0	52.5	10	1.0	156	95	STOREY C.L.	1975
SITOPHILUS ORYZAE	ADULT	15.0	50.0	10	1.0	297	96	STOREY C.L.	1975
SITOPHILUS ORYZAE	ADULT	21.0	50.0	10	1.0	200	95	STOREY C.L.	1975
SITOPHILUS ORYZAE	ADULT	22.0	52.5	10	1.0	140	50	STOREY C.L.	1975
SITOPHILUS ORYZAE	ADULT	22.0	52.5	10	1.0	200	95	STOREY C.L.	1975
SITOPHILUS ORYZAE	ADULT	27.0	50.0	10	1.0	48	95	STOREY C.L.	1975
SITOPHILUS ORYZAE	ADULT	27.0	52.5	10	1.0	30	50	STOREY C.L.	1975
SITOPHILUS ORYZAE	ADULT	27.0	52.5	10	1.0	48	95	STOREY C.L.	1975
SITOPHILUS ORYZAE	ADULT	27.0	53.0	10	1.0	48	98	STOREY C.L.	1980
SITOPHILUS ORYZAE	ADULT	32.0	50.0	10	1.0	19	95	STOREY C.L.	1975
SITOPHILUS ORYZAE	EGG	22.0	52.5	10	1.0	162	95	STOREY C.L.	1975
SITOPHILUS ORYZAE	EGG	22.0	52.5	10	1.0	102	50	STOREY C.L.	1975
SITOPHILUS ORYZAE	EGG	27.0	52.5	10	1.0	70	95	STOREY C.L.	1975
SITOPHILUS ORYZAE	EGG	27.0	52.5	10	1.0	2	50	STOREY C.L.	1975
SITOPHILUS ORYZAE	EGG	27.0	53.0	10	1.0	70	98	STOREY C.L.	1980
SITOPHILUS ORYZAE	LARVA	22.0	52.5	10	1.0	328	50	STOREY C.L.	1975
SITOPHILUS ORYZAE	LARVA	22.0	52.5	10	1.0	562	95	STOREY C.L.	1975
SITOPHILUS ORYZAE	LARVA	27.0	52.5	10	1.0	247	95	STOREY C.L.	1975
SITOPHILUS ORYZAE	LARVA	27.0	52.5	10	1.0	167	50	STOREY C.L.	1975
SITOPHILUS ORYZAE	LARVA	27.0	53.0	10	1.0	246	98	STOREY C.L.	1980
SITOPHILUS ORYZAE	PUPA	22.0	52.5	10	1.0	390	95	STOREY C.L.	1975
SITOPHILUS ORYZAE	PUPA	22.0	52.5	10	1.0	653	95	STOREY C.L.	1975
SITOPHILUS ORYZAE	PUPA	27.0	52.5	10	1.0	167	50	STOREY C.L.	1975
SITOPHILUS ORYZAE	PUPA	27.0	52.5	10	1.0	245	95	STOREY C.L.	1975
SITOPHILUS ORYZAE	PUPA	27.0	53.0	10	1.0	241	98	STOREY C.L.	1980
SITOTROGA CEREATELLA	EGG	27.0	50.0	10	1.0	48	100	STOREY C.L.	1975
SITOTROGA CEREATELLA	LARVA	27.0	50.0	10	1.0	120	100	STOREY C.L.	1975
SITOTROGA CEREATELLA	PUPA	27.0	50.0	10	1.0	120	100	STOREY C.L.	1975
TRIBOLIUM CASTANEUM	ADULT	15.0	50.0	10	1.0	67	96	STOREY C.L.	1975
TRIBOLIUM CASTANEUM	ADULT	18.0	50.0	10	1.0	39	95	STOREY C.L.	1977
TRIBOLIUM CASTANEUM	ADULT	20.0	70.0	10	1.0	144	100	KRISNAMURTHY ET AL.	1986
TRIBOLIUM CASTANEUM	ADULT	20.0	70.0	10	1.0	96	100	KRISNAMURTHY ET AL.	1986
TRIBOLIUM CASTANEUM	ADULT	21.0	50.0	10	1.0	32	95	STOREY C.L.	1975
TRIBOLIUM CASTANEUM	ADULT	27.0	50.0	10	1.0	17	95	STOREY C.L.	1975
TRIBOLIUM CASTANEUM	ADULT	27.0	50.0	10	1.0	14	95	STOREY C.L.	1977
TRIBOLIUM CASTANEUM	ADULT	27.0	50.0	10	1.0	14	95	STOREY C.L.	1977

CONTROLLED ATMOSPHERE STORAGE DATA BASE

INSECT NAME	STAGE	TEMP C	R.H. %	CO2 %	O2 %	EXP h	MOR %	AUTHOR	YEAR
TRIBOLIUM CASTANEUM	ADULT	32.0	50.0	10	1.0	8	95	STOREY C.L.	1975
TRIBOLIUM CASTANEUM	EGG	18.0	50.0	10	1.0	55	95	STOREY C.L.	1977
TRIBOLIUM CASTANEUM	EGG	27.0	50.0	10	1.0	22	95	STOREY C.L.	1977
TRIBOLIUM CASTANEUM	LARVA	18.0	50.0	10	1.0	50	95	STOREY C.L.	1977
TRIBOLIUM CASTANEUM	LARVA	27.0	50.0	10	1.0	15	95	STOREY C.L.	1977
TRIBOLIUM CASTANEUM	PUPA	27.0	50.0	10	1.0	46	95	STOREY C.L.	1977
TRIBOLIUM CONFUSUM	ADULT	18.0	50.0	10	1.0	38	95	STOREY C.L.	1977
TRIBOLIUM CONFUSUM	ADULT	27.0	50.0	10	1.0	12	95	STOREY C.L.	1977
TRIBOLIUM CONFUSUM	EGG	18.0	50.0	10	1.0	200	95	STOREY C.L.	1977
TRIBOLIUM CONFUSUM	EGG	27.0	50.0	10	1.0	31	95	STOREY C.L.	1977
TRIBOLIUM CONFUSUM	LARVA	18.0	50.0	10	1.0	41	95	STOREY C.L.	1977
TRIBOLIUM CONFUSUM	LARVA	27.0	50.0	10	1.0	15	95	STOREY C.L.	1977
TRIBOLIUM CONFUSUM	PUPA	27.0	50.0	10	1.0	53	95	STOREY C.L.	1977
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	70.0	10	1.2	72	50	KRISNAMURTHY ET AL.	1986
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	70.0	10	1.2	168	100	KRISNAMURTHY ET AL.	1986
ORYZAEPHILUS SURINAMENSIS	ADULT	20.0	70.0	10	1.2	72	83	KRISNAMURTHY ET AL.	1986
ORYZAEPHILUS SURINAMENSIS	ADULT	20.0	70.0	10	1.2	120	99	KRISNAMURTHY ET AL.	1986
SITOPHILUS GRANARIUS	ADULT	20.0	70.0	10	1.2	144	100	KRISNAMURTHY ET AL.	1986
SITOPHILUS GRANARIUS	ADULT	20.0	70.0	10	1.2	96	57	KRISNAMURTHY ET AL.	1986
TRIBOLIUM CASTANEUM	ADULT	20.0	70.0	10	1.2	48	40	KRISNAMURTHY ET AL.	1986
TRIBOLIUM CASTANEUM	ADULT	20.0	70.0	10	1.2	96	100	KRISNAMURTHY ET AL.	1986
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	70.0	10	1.5	168	100	KRISNAMURTHY ET AL.	1986
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	70.0	10	1.5	96	80	KRISNAMURTHY ET AL.	1986
ORYZAEPHILUS SURINAMENSIS	ADULT	20.0	70.0	10	1.5	48	44	KRISNAMURTHY ET AL.	1986
ORYZAEPHILUS SURINAMENSIS	ADULT	20.0	70.0	10	1.5	96	98	KRISNAMURTHY ET AL.	1986
SITOPHILUS GRANARIUS	ADULT	20.0	70.0	10	1.5	144	100	KRISNAMURTHY ET AL.	1986
SITOPHILUS GRANARIUS	ADULT	20.0	70.0	10	1.5	96	86	KRISNAMURTHY ET AL.	1986
TRIBOLIUM CASTANEUM	ADULT	20.0	70.0	10	1.5	48	7	KRISNAMURTHY ET AL.	1986
TRIBOLIUM CASTANEUM	ADULT	20.0	70.0	10	1.5	96	100	KRISNAMURTHY ET AL.	1986

## CONTROLLED ATMOSPHERE STORAGE DATA BASE

INSECT NAME	STAGE	TEMP C	R.H. %	CO2 %	O2 %	EXP h	MOR %	AUTHOR	YEAR
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	70.0	10	2.0	48	0	KRISNAMURTHY ET AL.	1986
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	70.0	10	2.0	192	16	KRISNAMURTHY ET AL.	1986
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	70.0	10	2.0	288	50	KRISNAMURTHY ET AL.	1986
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	70.0	10	2.0	144	10	KRISNAMURTHY ET AL.	1986
ORYZAEPHILUS SURINAMENSIS	ADULT	20.0	70.0	10	2.0	96	46	KRISNAMURTHY ET AL.	1986
ORYZAEPHILUS SURINAMENSIS	ADULT	20.0	70.0	10	2.0	264	100	KRISNAMURTHY ET AL.	1986
ORYZAEPHILUS SURINAMENSIS	ADULT	20.0	70.0	10	2.0	192	83	KRISNAMURTHY ET AL.	1986
ORYZAEPHILUS SURINAMENSIS	ADULT	20.0	70.0	10	2.0	48	3	KRISNAMURTHY ET AL.	1986
RHYZOPERTHA DOMINICA	ADULT	26.0	57.0	10	2.0	96	100	CALDERON & NAVARRO	1980
SITOPHILUS GRANARIUS	ADULT	20.0	70.0	10	2.0	96	13	KRISNAMURTHY ET AL.	1986
SITOPHILUS GRANARIUS	ADULT	20.0	70.0	10	2.0	192	49	KRISNAMURTHY ET AL.	1986
SITOPHILUS GRANARIUS	ADULT	20.0	70.0	10	2.0	144	26	KRISNAMURTHY ET AL.	1986
SITOPHILUS GRANARIUS	ADULT	20.0	70.0	10	2.0	240	96	KRISNAMURTHY ET AL.	1986
TRIBOLIUM CASTANEUM	ADULT	20.0	70.0	10	2.0	48	40	KRISNAMURTHY ET AL.	1986
TRIBOLIUM CASTANEUM	ADULT	20.0	70.0	10	2.0	192	98	KRISNAMURTHY ET AL.	1986
TRIBOLIUM CASTANEUM	ADULT	20.0	70.0	10	2.0	264	100	KRISNAMURTHY ET AL.	1986
TRIBOLIUM CASTANEUM	ADULT	20.0	70.0	10	2.0	96	87	KRISNAMURTHY ET AL.	1986
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	70.0	10	2.3	192	68	KRISNAMURTHY ET AL.	1986
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	70.0	10	2.3	72	0	KRISNAMURTHY ET AL.	1986
ORYZAEPHILUS SURINAMENSIS	ADULT	20.0	70.0	10	2.3	72	10	KRISNAMURTHY ET AL.	1986
ORYZAEPHILUS SURINAMENSIS	ADULT	20.0	70.0	10	2.3	216	100	KRISNAMURTHY ET AL.	1986
SITOPHILUS GRANARIUS	ADULT	20.0	70.0	10	2.3	216	77	KRISNAMURTHY ET AL.	1986
SITOPHILUS GRANARIUS	ADULT	20.0	70.0	10	2.3	120	26	KRISNAMURTHY ET AL.	1986
TRIBOLIUM CASTANEUM	ADULT	20.0	70.0	10	2.3	72	36	KRISNAMURTHY ET AL.	1986
TRIBOLIUM CASTANEUM	ADULT	20.0	70.0	10	2.3	144	100	KRISNAMURTHY ET AL.	1986

## CONTROLLED ATMOSPHERE STORAGE DATA BASE

INSECT NAME	STAGE	TEMP C	R.H. %	CO2 %	O2 %	EXP h	MOR %	AUTHOR	YEAR
TRIBOLIUM CASTANEUM	EGG	26.0	57.0	10	6.0	96	100	CALDERON & NAVARRO	1980
AMEYOLIS TRANSITELLA	LARVA	27.0	60.0	11	0.0	57	100	BRANDL ET.AL	1983
AMEYOLIS TRANSITELLA	LARVA	27.0	60.0	11	0.3	57	95	BRANDL ET.AL	1983
TRIBOLIUM CASTANEUM	ADULT	26.0	57.0	12	2.0	96	98	CALDERON &NAVARRO	1980
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	70.0	15	0.5	96	99	KRISNAMURTHY ET AL.	1986
ORYZAEPHILUS SURINAMENSIS	ADULT	20.0	70.0	15	0.5	48	99	KRISNAMURTHY ET AL.	1986
SITOPHILUS GRANARIUS	ADULT	20.0	70.0	15	0.5	192	100	KRISNAMURTHY ET AL.	1986
TRIBOLIUM CASTANEUM	ADULT	20.0	70.0	15	0.5	48	100	KRISNAMURTHY ET AL.	1986
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	70.0	15	1.0	96	100	KRISNAMURTHY ET AL.	1986
ORYZAEPHILUS SURINAMENSIS	ADULT	20.0	70.0	15	1.0	96	100	KRISNAMURTHY ET AL.	1986
SITOPHILUS GRANARIUS	ADULT	20.0	70.0	15	1.0	144	100	KRISNAMURTHY ET AL.	1986
TRIBOLIUM CASTANEUM	ADULT	20.0	70.0	15	1.0	72	100	KRISNAMURTHY ET AL.	1986
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	70.0	15	1.2	96	75	KRISNAMURTHY ET AL.	1986
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	70.0	15	1.2	144	98	KRISNAMURTHY ET AL.	1986
ORYZAEPHILUS SURINAMENSIS	ADULT	20.0	70.0	15	1.2	96	100	KRISNAMURTHY ET AL.	1986
ORYZAEPHILUS SURINAMENSIS	ADULT	20.0	70.0	15	1.2	48	23	KRISNAMURTHY ET AL.	1986
SITOPHILUS GRANARIUS	ADULT	20.0	70.0	15	1.2	144	100	KRISNAMURTHY ET AL.	1986
SITOPHILUS GRANARIUS	ADULT	20.0	70.0	15	1.2	96	85	KRISNAMURTHY ET AL.	1986
TRIBOLIUM CASTANEUM	ADULT	20.0	70.0	15	1.2	48	50	KRISNAMURTHY ET AL.	1986
TRIBOLIUM CASTANEUM	ADULT	20.0	70.0	15	1.2	96	100	KRISNAMURTHY ET AL.	1986
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	70.0	15	1.5	96	87	KRISNAMURTHY ET AL.	1986
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	70.0	15	1.5	168	100	KRISNAMURTHY ET AL.	1986
ORYZAEPHILUS SURINAMENSIS	ADULT	20.0	70.0	15	1.5	120	100	KRISNAMURTHY ET AL.	1986
SITOPHILUS GRANARIUS	ADULT	20.0	70.0	15	1.5	144	100	KRISNAMURTHY ET AL.	1986
SITOPHILUS GRANARIUS	ADULT	20.0	70.0	15	1.5	72	56	KRISNAMURTHY ET AL.	1986



Page No. 22  
08/18/89

## CONTROLLED ATMOSPHERE STORAGE DATA BASE

INSECT NAME	STAGE	TEMP C	R.H. %	CO2 %	O2 %	EXP h	MOR %	AUTHOR	YEAR
TRIBOLIUM CASTANEUM	ADULT	20.0	70.0	15	1.5	72	100	KRISNAMURTHY ET AL.	1986
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	70.0	15	2.0	288	97	KRISNAMURTHY ET AL.	1986
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	70.0	15	2.0	144	66	KRISNAMURTHY ET AL.	1986
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	70.0	15	2.0	192	79	KRISNAMURTHY ET AL.	1986
ORYZAEPHILUS SURINAMENSIS	ADULT	20.0	70.0	15	2.0	144	100	KRISNAMURTHY ET AL.	1986
ORYZAEPHILUS SURINAMENSIS	ADULT	20.0	70.0	15	2.0	48	28	KRISNAMURTHY ET AL.	1986
ORYZAEPHILUS SURINAMENSIS	ADULT	20.0	70.0	15	2.0	96	86	KRISNAMURTHY ET AL.	1986
SITOPHILUS GRANARIUS	ADULT	20.0	70.0	15	2.0	144	89	KRISNAMURTHY ET AL.	1986
SITOPHILUS GRANARIUS	ADULT	20.0	70.0	15	2.0	192	92	KRISNAMURTHY ET AL.	1986
SITOPHILUS GRANARIUS	ADULT	20.0	70.0	15	2.0	240	100	KRISNAMURTHY ET AL.	1986
TRIBOLIUM CASTANEUM	ADULT	20.0	70.0	15	2.0	96	92	KRISNAMURTHY ET AL.	1986
TRIBOLIUM CASTANEUM	ADULT	20.0	70.0	15	2.0	48	40	KRISNAMURTHY ET AL.	1986
TRIBOLIUM CASTANEUM	ADULT	20.0	70.0	15	2.0	144	100	KRISNAMURTHY ET AL.	1986
RHYZOPERTHA DOMINICA	ADULT	26.0	57.0	15	4.0	96	65	CALDERON & NAVARRO	1980
RHYZOPERTHA DOMINICA	EGG	26.0	57.0	15	6.0	96	70	CALDERON & NAVARRO	1980
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	70.0	20	0.5	96	100	KRISNAMURTHY ET AL.	1986
ORYZAEPHILUS SURINAMENSIS	ADULT	20.0	70.0	20	0.5	48	100	KRISNAMURTHY ET AL.	1986
SITOPHILUS GRANARIUS	ADULT	20.0	70.0	20	0.5	192	93	KRISNAMURTHY ET AL.	1986
TRIBOLIUM CASTANEUM	ADULT	20.0	70.0	20	0.5	48	100	KRISNAMURTHY ET AL.	1986
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	70.0	20	1.0	144	100	KRISNAMURTHY ET AL.	1986
ORYZAEPHILUS SURINAMENSIS	ADULT	20.0	70.0	20	1.0	48	100	KRISNAMURTHY ET AL.	1986
SITOPHILUS GRANARIUS	ADULT	20.0	70.0	20	1.0	120	100	KRISNAMURTHY ET AL.	1986
TRIBOLIUM CASTANEUM	ADULT	20.0	70.0	20	1.0	72	100	KRISNAMURTHY ET AL.	1986
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	70.0	20	1.5	168	100	KRISNAMURTHY ET AL.	1986
ORYZAEPHILUS SURINAMENSIS	ADULT	20.0	70.0	20	1.5	120	100	KRISNAMURTHY ET AL.	1986

## CONTROLLED ATMOSPHERE STORAGE DATA BASE

INSECT NAME	STAGE	TEMP	R.H.	CO2	O2	EXP	MOR	AUTHOR	YEAR
		C	%	%	%	h	%		
SITOPHILUS GRANARIUS	ADULT	20.0	70.0	20	1.5	96	100	KRISNAMURTHY ET AL.	1986
TRIBOLIUM CASTANEUM	ADULT	20.0	70.0	20	1.5	72	100	KRISNAMURTHY ET AL.	1986
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	70.0	20	2.0	144	85	KRISNAMURTHY ET AL.	1986
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	70.0	20	2.0	96	66	KRISNAMURTHY ET AL.	1986
ORYZAEPHILUS SURINAMENSIS	ADULT	20.0	70.0	20	2.0	48	16	KRISNAMURTHY ET AL.	1986
ORYZAEPHILUS SURINAMENSIS	ADULT	20.0	70.0	20	2.0	288	95	KRISNAMURTHY ET AL.	1986
ORYZAEPHILUS SURINAMENSIS	ADULT	20.0	70.0	20	2.0	96	36	KRISNAMURTHY ET AL.	1986
ORYZAEPHILUS SURINAMENSIS	ADULT	20.0	70.0	20	2.0	144	100	KRISNAMURTHY ET AL.	1986
SITOPHILUS GRANARIUS	ADULT	20.0	70.0	20	2.0	72	30	KRISNAMURTHY ET AL.	1986
SITOPHILUS GRANARIUS	ADULT	20.0	70.0	20	2.0	192	100	KRISNAMURTHY ET AL.	1986
SITOPHILUS GRANARIUS	ADULT	20.0	70.0	20	2.0	144	93	KRISNAMURTHY ET AL.	1986
TRIBOLIUM CASTANEUM	ADULT	20.0	70.0	20	2.0	96	92	KRISNAMURTHY ET AL.	1986
TRIBOLIUM CASTANEUM	ADULT	20.0	70.0	20	2.0	48	40	KRISNAMURTHY ET AL.	1986
TRIBOLIUM CASTANEUM	ADULT	20.0	70.0	20	2.0	144	100	KRISNAMURTHY ET AL.	1986
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	70.0	20	2.6	48	9	KRISHNAMURTH Y ET.AL	1986
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	70.0	20	2.6	288	50	KRISNAMURTHY ET AL.	1986
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	70.0	20	2.6	96	7	KRISNAMURTHY ET AL.	1986
ORYZAEPHILUS SURINAMENSIS	ADULT	20.0	70.0	20	2.6	48	69	KRISHNAMURTH Y ET.AL	1986
ORYZAEPHILUS SURINAMENSIS	ADULT	20.0	70.0	20	2.6	192	100	KRISNAMURTHY ET AL.	1986
ORYZAEPHILUS SURINAMENSIS	ADULT	20.0	70.0	20	2.6	96	72	KRISNAMURTHY ET AL.	1986
SITOPHILUS GRANARIUS	ADULT	20.0	70.0	20	2.6	96	29	KRISHNAMURTH Y ET.AL	1986
SITOPHILUS GRANARIUS	ADULT	20.0	70.0	20	2.6	144	75	KRISNAMURTHY ET AL.	1986
SITOPHILUS GRANARIUS	ADULT	20.0	70.0	20	2.6	240	100	KRISNAMURTHY ET AL.	1986
TRIBOLIUM CASTANEUM	ADULT	20.0	70.0	20	2.6	48	75	KRISHNAMURTH Y ET.AL	1986
TRIBOLIUM CASTANEUM	ADULT	20.0	70.0	20	2.6	96	98	KRISNAMURTHY ET AL.	1986

## CONTROLLED ATMOSPHERE STORAGE DATA BASE

INSECT NAME	STAGE	TEMP C	R.H. %	CO2 %	O2 %	EXP h	MOR %	AUTHOR	YEAR
TRIBOLIUM CASTANEUM	ADULT	20.0	70.0	20	2.6	144	100	KRISNAMURTHY ET AL.	1986
RHYZOPERTHA DOMINICA	EGG	26.0	57.0	20	8.0	96	30	CALDERON & NAVARRO	1980
SITOPHILUS GRANARIS	ADULT	20.0	0.0	20	10.0	468	100	STOREY C.L.	1976
RHYZOPERTHA DOMINICA	ADULT	26.0	57.0	25	4.0	96	100	CALDERON & NAVARRO	1980
RHYZOPERTHA DOMINICA	ADULT	26.0	57.0	25	4.0	96	100	CALDERON & NAVARRO	1980
SITOPHILUS GRANARIS	PUPA	19.0	70.0	25	5.0	217	50	DESMARCHELIE R ET AL	1983
TRIBOLIUM CASTANEUM	ADULT	26.0	57.0	28	4.0	96	98	CALDERON & NAVARRO	1980
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	70.0	30	2.3	120	80	KRISNAMURTHY ET AL.	1986
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	70.0	30	2.3	288	91	KRISNAMURTHY ET AL.	1986
ORYZAEPHILUS SURINAMENSIS	ADULT	20.0	70.0	30	2.3	120	100	KRISNAMURTHY ET AL.	1986
ORYZAEPHILUS SURINAMENSIS	ADULT	20.0	70.0	30	2.3	72	48	KRISNAMURTHY ET AL.	1986
SITOPHILUS GRANARIUS	ADULT	20.0	70.0	30	2.3	48	4	KRISNAMURTHY ET AL.	1986
SITOPHILUS GRANARIUS	ADULT	20.0	70.0	30	2.3	144	100	KRISNAMURTHY ET AL.	1986
TRIBOLIUM CASTANEUM	ADULT	20.0	70.0	30	2.3	72	85	KRISNAMURTHY ET AL.	1986
TRIBOLIUM CASTANEUM	ADULT	20.0	70.0	30	2.3	120	100	KRISNAMURTHY ET AL.	1986
RHYZOPERTHA DOMINICA	ADULT	26.0	57.0	30	8.0	96	100	CALDERON AND NAVARRO	1980
TRIBOLIUM CASTANEUM	EGG	26.0	57.0	30	8.0	96	100	CALDERON & NAVARRO	1980
TRIBOLIUM CASTANEUM	SATGE	26.0	57.0	30	8.0	96	40	CALDERON & NAVARRO	1980
SITOPHILUS GRANARIUS	ADULT	15.6	0.0	34	15.4	168	100	FREDRICK ET AL.	1970
SITOPHILUS GRANARIUS	ADULT	15.6	0.0	34	15.4	72	100	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	ADULT	15.6	0.0	34	15.4	168	97	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	ADULT	15.6	0.0	34	15.4	72	93	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	LARVA	15.6	0.0	34	15.4	72	4	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	LARVA	15.6	0.0	34	15.4	168	5	FREDRICK ET AL.	1970
BLATELLA GERMANICA	ADULT	32.0	0.0	35	13.0	8	100	CANTWELL & NEIDHART	1976

## CONTROLLED ATMOSPHERE STORAGE DATA BASE

INSECT NAME	STAGE	TEMP C	R.H. %	CO2 %	O2 %	EXP h	MOR %	AUTHOR	YEAR
PLODIA INTERPUNCTELLA	LARVA	16.0	67.5	36	15.0	336	100	HAREIN P.K. & A.F.PRESS	1968
PLODIA INTERPUNCTELLA	LARVA	16.0	67.5	36	15.0	168	100	HAREIN P.K. & A.F.PRESS	1968
PLODIA INTERPUNCTELLA	LARVA	16.0	67.5	36	15.0	336	100	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	ADULT	16.0	67.5	36	15.0	168	78	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	ADULT	16.0	67.5	36	15.0	336	99	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	LARVA	16.0	67.5	36	15.0	336	93	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	LARVA	16.0	67.5	36	15.0	168	26	HAREIN P.K. & A.F.PRESS	1968
PLODIA INTERPUNCTELLA	LARVA	27.1	64.0	37	14.8	336	100	HAREIN P.K. & A.F.PRESS	1968
PLODIA INTERPUNCTELLA	LARVA	27.1	64.0	37	14.8	168	100	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	ADULT	27.1	64.5	37	14.8	336	91	P.K.HAREIN & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	ADULT	27.1	64.5	37	14.8	168	37	P.K.HAREIN & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	LARVA	27.1	64.0	37	14.8	168	37	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	LARVA	27.1	64.0	37	14.8	336	86	HAREIN P.K. & A.F.PRESS	1968
ORYZAEPHILUS SURINAMENSIS	ADULT	27.6	7.0	38	13.1	72	96	STOREY C.L.	1971
ORYZAEPHILUS SURINAMENSIS	ADULT	27.6	30.0	38	13.1	72	88	STOREY C.L.	1971
ORYZAEPHILUS SURINAMENSIS	ADULT	27.6	53.0	38	13.1	72	61	STOREY C.L.	1971
ORYZAEPHILUS SURINAMENSIS	ADULT	27.6	72.0	38	13.1	72	18	STOREY C.L.	1971
TRIBOLIUM CASTANEUM	ADULT	27.6	7.0	38	13.1	72	69	JAY E.G.	1971
TRIBOLIUM CASTANEUM	ADULT	27.6	30.0	38	13.1	72	46	JAY E.G.	1971
TRIBOLIUM CASTANEUM	ADULT	27.6	53.0	38	13.1	72	21	JAY E.G.	1971
TRIBOLIUM CASTANEUM	ADULT	27.6	72.0	38	13.1	72	4	JAY E.G.	1971
TRIBOLIUM CONFUSUM	ADULT	27.6	7.0	38	13.1	72	44	JAY E.G.	1971
TRIBOLIUM CONFUSUM	ADULT	27.6	30.0	38	13.1	72	30	JAY E.G.	1971
TRIBOLIUM CONFUSUM	ADULT	27.6	53.0	38	13.1	72	8	JAY E.G.	1971
TRIBOLIUM CONFUSUM	ADULT	27.6	72.0	38	13.1	72	1	JAY E.G.	1971
SITOPHILUS GRANARIUS	ADULT	4.4	0.0	38	15.7	168	96	FREDRICK ET AL.	1970
SITOPHILUS GRANARIUS	ADULT	4.4	0.0	38	15.7	72	42	FREDRICK ET AL.	1970

## CONTROLLED ATMOSPHERE STORAGE DATA BASE

INSECT NAME	STAGE	TEMP C	R.H. %	CO2 %	O2 %	EXP h	MOR %	AUTHOR	YEAR
TROGODERMA GLABARUM	ADULT	4.4	0.0	38	15.7	168	98	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	ADULT	4.4	0.0	38	15.7	72	46	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	LARVA	4.4	0.0	38	15.7	168	54	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	LARVA	4.4	0.0	38	15.7	72	3	FREDRICK ET AL.	1970
PLODIA INTERPUNCTELLA	LARVA	38.2	62.0	38	15.0	168	100	HAREIN P.K. & A.F.PRESS	1968
PLODIA INTERPUNCTELLA	LARVA	38.2	62.0	38	15.0	336	100	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	ADULT	38.2	62.0	38	15.0	336	100	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	ADULT	38.2	62.0	38	15.0	168	76	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	LARVA	38.2	62.0	38	15.0	336	100	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	LARVA	38.2	62.0	38	15.0	168	52	HAREIN P.K. & A.F.PRESS	1968
SITOPHILUS GRANARIUS	ADULT	26.7	0.0	39	16.0	168	100	FREDRICK ET AL.	1970
SITOPHILUS GRANARIUS	ADULT	26.7	0.0	39	16.0	72	100	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	ADULT	26.7	0.0	39	16.0	168	100	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	ADULT	26.7	0.0	39	16.0	72	100	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	LARVA	26.7	0.0	39	16.0	72	14	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	LARVA	26.7	0.0	39	16.0	168	14	FREDRICK ET AL.	1970
SITOPHILUS GRANARIS	ADULT	26.6	0.0	40	47.0	360	95	LINDGREN & VINCENT	1970
SITPHILUS ORYZAE	ADULT	26.6	0.0	40	47.0	72	95	LINDGREN & VINCENT	1970
EPHESTIA KUHENILLA	EGG	15.0	0.0	40	48.0	120	90	BELL C.H.	1983
SITOPHILUS GRANARIUS	ADULT	25.0	100	42	12.0	300	99	BOND E.J & BUCKLAND C.T.	1979
PLODIA INTERPUNCTELLA	LARVA	38.2	62.0	42	13.0	336	100	HAREIN P.K. & A.F.PRESS	1968
PLODIA INTERPUNCTELLA	LARVA	38.2	62.0	42	13.0	168	100	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	ADULT	38.2	62.0	42	13.0	336	100	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	ADULT	38.2	62.0	42	13.0	168	100	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	LARVA	38.2	62.0	42	13.0	336	100	HAREIN P.K. & A.F.PRESS	1968

## CONTROLLED ATMOSPHERE STORAGE DATA BASE

INSECT NAME	STAGE	TEMP C	R.H. %	CO2 %	O2 %	EXP h	MOR %	AUTHOR	YEAR
TRIBOLIUM CASTANEUM	LARVA	38.2	62.0	42	13.0	168	89	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	ADULT	26.7	41.0	45	11.0	192	95	ALINIAZEE T.	1971
TRIBOLIUM CONFUSUM	ADULT	26.7	41.0	45	11.0	271	95	ALINIAZEE T.	1971
SITOPHILUS GRANARIUS	ADULT	26.7	0.0	48	13.5	72	100	FREDRICK ET AL.	1970
SITOPHILUS GRANARIUS	ADULT	26.7	0.0	48	13.5	168	100	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	ADULT	26.7	0.0	48	13.5	168	100	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	ADULT	26.7	0.0	48	13.5	72	100	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	LARVA	26.7	0.0	48	13.5	72	35	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	LARVA	26.7	0.0	48	13.5	168	55	FREDRICK ET AL.	1970
SITOPHILUS GRANARIUS	ADULT	15.6	0.0	48	12.7	72	100	FREDRICK ET AL.	1970
SITOPHILUS GRANARIUS	ADULT	15.6	0.0	48	12.7	168	100	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	ADULT	15.6	0.0	48	12.7	72	99	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	ADULT	15.6	0.0	48	12.7	168	100	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	LARVA	15.6	0.0	48	12.7	72	12	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	LARVA	15.6	0.0	48	12.7	168	23	FREDRICK ET AL.	1970
PLODIA INTERPUNCTELLA	LARVA	16.0	67.5	48	13.5	168	100	HAREIN P.K. & A.F.PRESS	1968
PLODIA INTERPUNCTELLA	LARVA	16.0	67.5	48	13.5	336	100	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	ADULT	16.0	67.5	48	13.5	336	100	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	ADULT	16.0	67.5	48	13.5	168	92	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	LARVA	16.0	67.5	48	13.5	336	100	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	LARVA	16.0	67.5	48	13.5	168	67	HAREIN P.K. & A.F.PRESS	1968
PLODIA INTERPUNCTELLA	LARVA	27.1	64.0	50	12.7	168	100	HAREIN P.K. & A.F.PRESS	1968
PLODIA INTERPUNCTELLA	LARVA	27.1	64.0	50	12.7	336	100	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	LARVA	27.1	64.0	50	12.7	336	98	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	LARVA	27.1	64.0	50	12.7	168	80	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	ADULT	27.1	64.0	50	12.9	336	100	HAREIN P.K. & A.F.PRESS	1968

## CONTROLLED ATMOSPHERE STORAGE DATA BASE

INSECT NAME	STAGE	TEMP C	R.H. %	CO2 %	O2 %	EXP h	MOR %	AUTHOR	YEAR
TRIBOLIUM CASTANEUM	ADULT	27.1	64.0	50	12.9	168	100	HAREIN P.K. & A.F.PRESS	1968
SITOPHILUS GRANARIS	ADULT	26.6	0.0	50	40.0	192	95	LINDGREN & VINCENT	1970
SITPHILUS ORYZAE	ADULT	26.6	0.0	50	40.0	44	95	LINDGREN & VINCENT	1970
SITOPHILUS GRANARIUS	ADULT	4.4	0.0	53	12.5	168	96	FREDRICK ET AL.	1970
SITOPHILUS GRANARIUS	ADULT	4.4	0.0	53	12.5	72	46	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	ADULT	4.4	0.0	53	12.5	72	38	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	ADULT	4.4	0.0	53	12.5	168	98	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	LARVA	4.4	0.0	53	12.5	72	7	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	LARVA	4.4	0.0	53	12.5	168	61	FREDRICK ET AL.	1970
CRYPTOLESTES FERRUGINEUS	ADULT	2.5	60.0	54	15.5	168	66	WHITE ET AL.	1987
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	60.0	56	14.0	168	64	WHITE ET AL.	1987
SITOPHILUS GRANARIUS	ADULT	4.4	0.0	57	7.8	168	100	FREDRICK ET AL.	1970
SITOPHILUS GRANARIUS	ADULT	4.4	0.0	57	7.8	72	67	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	ADULT	4.4	0.0	57	7.8	72	22	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	ADULT	4.4	0.0	57	7.8	168	100	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	LARVA	4.4	0.0	57	7.8	72	25	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	LARVA	4.4	0.0	57	7.8	168	61	FREDRICK ET AL.	1970
TRIBOLIUM CASTANEUM	ADULT	27.0	50.0	58	8.0	24	28	JAY E.G.	1983
TRIBOLIUM CASTANEUM	ADULT	27.6	9.3	60	9.8	72	100	JAY E.G.	1971
TRIBOLIUM CASTANEUM	ADULT	27.6	33.3	60	9.8	72	100	JAY E.G.	1971
TRIBOLIUM CASTANEUM	ADULT	27.6	60.0	60	9.8	72	99	STOREY C.L.	1971
TRIBOLIUM CASTANEUM	ADULT	27.6	73.0	60	9.8	72	99	JAY E.G.	1971
TRIBOLIUM CONFUSUM	ADULT	27.6	9.3	60	9.8	72	100	JAY E.G.	1971
TRIBOLIUM CONFUSUM	ADULT	27.6	33.0	60	9.8	72	100	STOREY C.L.	1971
TRIBOLIUM CONFUSUM	ADULT	27.6	60.0	60	9.8	72	95	JAY E.G.	1971
TRIBOLIUM CONFUSUM	ADULT	27.6	73.0	60	9.8	72	92	JAY E.G.	1971
TRIBOLIUM CASTANEUM	ADULT	27.0	50.0	60	8.0	48	96	JAY E.G.	1981

Page No. 29  
08/18/89

## CONTROLLED ATMOSPHERE STORAGE DATA BASE

INSECT NAME	STAGE	TEMP C	R.H. %	CO2 %	O2 %	EXP h	MOR %	AUTHOR	YEAR
TRIBOLIUM CASTANEUM	ADULT	27.0	50.0	60	8.0	72	99	JAY E.G.	1981
TRIBOLIUM CASTANEUM	ADULT	27.0	66.0	60	8.0	72	98	JAY E.G.	1981
TRIBOLIUM CASTANEUM	ADULT	27.0	66.0	60	8.0	48	94	JAY E.G.	1983
TRIBOLIUM CASTANEUM	LARVA	27.0	50.0	60	8.0	72	80	JAY E.G.	1981
TRIBOLIUM CASTANEUM	LARVA	27.0	50.0	60	8.0	48	48	JAY E.G.	1981
TRIBOLIUM CASTANEUM	LARVA	27.0	66.0	60	8.0	48	20	JAY E.G.	1983
TRIBOLIUM CASTANEUM	LARVA	27.0	66.0	60	8.0	72	53	JAY E.G.	1983
TRIBOLIUM CASTANEUM	PUPA	27.0	50.0	60	8.0	72	99	JAY E.G.	1981
TRIBOLIUM CASTANEUM	PUPA	27.0	50.0	60	8.0	48	89	JAY E.G.	1981
TRIBOLIUM CASTANEUM	PUPA	27.0	66.0	60	8.0	48	46	JAY E.G.	1983
TRIBOLIUM CASTANEUM	PUPA	27.0	66.0	60	8.0	72	81	JAY E.G.	1983
TRIBOLIUM GRANARIUM	ADULT	20.0	60.0	60	8.0	144	100	SPRATT	1985
TRIBOLIUM GRANARIUM	EGG	20.0	60.0	60	8.0	144	100	SPRATT	1985
TRIBOLIUM GRANARIUM	PUPA	20.0	60.0	60	8.0	144	100	SPRATT	1985
TRIBOLIUM GRANARIUM	PUPA	30.0	60.0	60	8.0	144	100	SPRATT	1985
CRPTOLESTES FERRUGINEUS	ADULT	20.0	0.0	60	13.5	168	100	WHITE ET.AL	1988
EPHESTIA CAUTELLA	EGG	25.0	0.0	60	20.0	18	100	BELL C.H	1983
EPHESTIA CAUTELLA	EGG	25.0	0.0	60	20.0	24	100	BELL C.H.	1983
EPHESTIA KUEHNIELLA	EGG	25.0	0.0	60	20.0	18	100	BELL C.H.	1983
EPHESTIA KUEHNIELLA	EGG	25.0	0.0	60	20.0	24	100	BELL C.H.	1983
SITOPHILUS GRANARIS	ADULT	26.6	0.0	60	31.0	74	95	LINDGREN & VINCENT	1970
SITPHILUS ORYZAE	ADULT	26.6	0.0	60	31.0	40	95	LINDGREN & VINCENT	1970
SITOPHILUS GRANARIUS	ADULT	15.6	0.0	61	7.3	72	100	FREDRICK ET AL.	1970
SITOPHILUS GRANARIUS	ADULT	15.6	0.0	61	7.3	168	100	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	ADULT	15.6	0.0	61	7.3	72	100	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	ADULT	15.6	0.0	61	7.3	168	100	FREDRICK ET AL.	1970



## CONTROLLED ATMOSPHERE STORAGE DATA BASE

INSECT NAME	STAGE	TEMP C	R.H. %	CO2 %	O2 %	EXP h	MOR %	AUTHOR	YEAR
TROGODERMA GLABARUM	LARVA	15.6	0.0	61	7.3	168	98	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	LARVA	15.6	0.0	61	7.3	72	63	FREDRICK ET AL.	1970
TRIBOLIUM GRANARIUM	LARVA	33.0	50.0	61	5.0	48	25	JAY E.G.	1983
TRIBOLIUM GRANARIUM	LARVA	33.0	50.0	61	5.0	24	22	JAY E.G.	1983
TRIBOLIUM GRANARIUM	LARVA	33.0	50.0	61	5.0	48	32	JAY E.G.	1983
TRIBOLIUM GRANARIUM	LARVA	38.0	50.0	61	5.0	24	21	JAY E.G.	1983
TRIBOLIUM VARIABILIE	LARVA	33.0	50.0	61	5.0	48	15	JAY E.G.	1983
TRIBOLIUM VARIABILIE	LARVA	38.0	50.0	61	5.0	48	31	JAY E.G.	1983
TRIBOLIUM GRANARIUM	LARVA	3.0	50.0	61	8.0	24	21	JAY E.G.	1983
TRIBOLIUM GRANARIUM	PUPA	36.0	50.0	61	8.0	24	44	JAY E.G.	1983
TRIBOLIUM VARIABILIE	LARVA	36.0	50.0	61	8.0	24	16	JAY E.G.	1983
TRIBOLIUM VARIABILIE	PUPA	36.0	50.0	61	8.0	24	31	JAY E.G.	1983
TRIBOLIUM CASTANEUM	ADULT	26.7	41.0	62	7.6	60	95	ALINIAZEE T.	1971
TRIBOLIUM CONFUSUM	ADULT	26.7	41.0	62	7.6	58	95	ALINIAZEE T.	1971
ORYZAEPHILUS SURINAMENSIS	PUPA	16.0	50.0	62	8.0	240	100	JAY E.G.	1983
ORYZAEPHILUS SURINAMENSIS	PUPA	16.0	50.0	62	8.0	240	100	JAY E.G.	1983
ORYZAEPHILUS SURINAMENSIS	PUPA	27.0	50.0	62	8.0	96	100	JAY E.G.	1983
ORYZAEPHILUS SURINAMENSIS	PUPA	32.0	50.0	62	8.0	96	100	JAY E.G.	1983
CRYPTOLESTES FERRUGINEUS	ADULT	2.5	60.0	62	16.0	24	10	WHITE ET AL.	1987
SITOPHILUS GRANARIUS	ADULT	26.7	0.0	62	7.0	168	100	FREDRICK ET AL.	1970
SITOPHILUS GRANARIUS	ADULT	26.7	0.0	62	7.0	72	100	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	ADULT	26.7	0.0	62	7.0	168	100	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	ADULT	26.7	0.0	62	7.0	72	100	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	LARVA	26.7	0.0	62	7.0	72	64	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	LARVA	26.7	0.0	62	7.0	168	96	FREDRICK ET AL.	1970
PLODIA INTERPUNCTELLA	LARVA	16.0	67.5	63	7.5	168	100	HAREIN P.K. & A.F.PRESS	1968

Page No. 31  
08/18/89

## CONTROLLED ATMOSPHERE STORAGE DATA BASE

INSECT NAME	STAGE	TEMP C	R.H. %	CO2 %	O2 %	EXP h	MOR %	AUTHOR	YEAR
PLODIA INTERPUNCTELLA	LARVA	16.0	67.5	63	7.5	336	100	HAREIN P.K. & A.F.PRESS	1968
PLODIA INTERPUNCTELLA	LARVA	16.0	67.5	63	7.5	336	100	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	ADULT	16.0	67.5	63	7.5	336	100	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	ADULT	16.0	67.5	63	7.5	168	100	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	LARVA	16.0	67.5	63	7.5	336	100	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	LARVA	16.0	67.5	63	7.5	168	89	HAREIN P.K. & A.F.PRESS	1968
EPHESTIA CAUTELLA	ADULT	27.0	6.0	63	8.0	48	100	JAY E.G.	1983
EPHESTIA CAUTELLA	EGG	27.0	66.6	63	8.0	48	100	JAY E.G.	1983
EPHESTIA CAUTELLA	LARVA	27.0	66.0	63	8.0	120	100	JAY E.G.	1983
EPHESTIA CAUTELLA	PUPA	27.0	66.0	63	8.0	72	100	JAY E.G.	1983
TRIBOLIUM CASTANEUM	ADULT	27.0	66.0	63	8.0	96	100	JAY E.G.	1983
TRIBOLIUM CASTANEUM	EGG	27.0	66.0	63	8.0	48	100	JAY E.G.	1983
TRIBOLIUM CASTANEUM	LARVA	27.0	66.0	63	8.0	150	100	JAY E.G.	1983
TRIBOLIUM CASTANEUM	PUPA	27.0	66.0	63	8.0	120	100	JAY E.G.	1983
TRIBOLIUM GRANARIUM	PUPA	33.0	50.0	63	8.0	48	96	JAY E.G.	1983
TRIBOLIUM GRANARIUM	PUPA	33.0	50.0	63	8.0	24	30	JAY E.G.	1983
TRIBOLIUM GRANARIUM	PUPA	38.0	50.0	63	8.0	24	44	JAY E.G.	1983
TRIBOLIUM GRANARIUM	PUPA	38.0	50.0	63	8.0	16	13	JAY E.G.	1983
TRIBOLIUM VARIABILIE	PUPA	33.0	50.0	63	8.0	48	64	JAY E.G.	1983
TRIBOLIUM VARIABILIE	PUPA	33.0	50.0	63	8.0	24	22	JAY E.G.	1983
TRIBOLIUM VARIABILIE	PUPA	38.0	50.0	63	8.0	24	31	JAY E.G.	1983
TRIBOLIUM VARIABILIE	PUPA	38.0	50.0	63	8.0	16	9	JAY E.G.	1983
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	60.0	65	12.0	24	10	WHITE ET AL.	1987
TRIBOLIUM CASTANEUM	ADULT	38.2	62.0	66	7.0	336	100	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	ADULT	38.2	62.0	66	7.0	168	100	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	LARVA	38.2	62.0	66	7.0	168	100	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	LARVA	38.2	62.0	66	7.0	336	100	HAREIN P.K. & A.F.PRESS	1968

## CONTROLLED ATMOSPHERE STORAGE DATA BASE

INSECT NAME	STAGE	TEMP C	R.H. %	CO2 %	O2 %	EXP h	MOR %	AUTHOR	YEAR
PLODIA	LARVA	38.2	62.0	66	7.0	168	100	HAREIN P.K.	1968
INTERPUNCTELLA								& A.F.PRESS	
PLODIA	LARVA	38.2	62.0	66	7.0	336	100	HAREIN P.K.	1968
INTERPUNCTELLA								& A.F.PRESS	
PLODIA	LARVA	27.1	64.0	68	6.7	336	100	HAREIN P.K.	1968
INTERPUNCTELLA								& A.F.PRESS	
PLODIA	LARVA	27.1	64.0	68	6.7	168	100	HAREIN P.K.	1968
INTERPUNCTELLA								& A.F.PRESS	
TRIBOLIUM	ADULT	27.1	64.5	68	6.7	336	100	HAREIN P.K.	1968
CASTANEUM								& A.F.PRESS	
TRIBOLIUM	ADULT	27.1	64.5	68	6.7	168	100	HAREIN P.K.	1968
CASTANEUM								& A.F.PRESS	
TRIBOLIUM	LARVA	27.1	64.0	68	6.7	336	100	HAREIN P.K.	1968
CASTANEUM								& A.F.PRESS	
TRIBOLIUM	LARVA	27.1	64.0	68	6.7	168	100	HAREIN P.K.	1968
CASTANEUM								& A.F.PRESS	
CRYPTOLESTES	ADULT	10.0	62.0	70	0.0	48	11	RAMESHBABU	1989
FERRUGINEUS								ET AL.	
CRYPTOLESTES	ADULT	10.0	62.0	70	0.0	24	2	RAMESHBABU	1989
FERRUGINEUS								ET AL.	
CRYPTOLESTES	ADULT	10.0	62.0	70	0.0	96	39	RAMESHBABU	1989
FERRUGINEUS								ET AL.	
CRYPTOLESTES	ADULT	10.0	74.0	70	0.0	24	1	RAMESHBABU	1989
FERRUGINEUS								ET AL.	
CRYPTOLESTES	ADULT	10.0	74.0	70	0.0	96	39	RAMESHBABU	1989
FERRUGINEUS								ET AL.	
CRYPTOLESTES	ADULT	10.0	74.0	70	0.0	48	12	RAMESHBABU	1989
FERRUGINEUS								ET AL.	
CRYPTOLESTES	ADULT	10.0	83.0	70	0.0	48	2	RAMESHBABU	1989
FERRUGINEUS								ET AL.	
CRYPTOLESTES	ADULT	10.0	83.0	70	0.0	96	31	RAMESHBABU	1989
FERRUGINEUS								ET AL.	
CRYPTOLESTES	ADULT	10.0	83.0	70	0.0	24	0	RAMESHBABU	1989
FERRUGINEUS								ET AL.	
CRYPTOLESTES	ADULT	15.0	62.0	70	0.0	60	7	RAMESHBABU	1989
FERRUGINEUS								ET AL.	
CRYPTOLESTES	ADULT	15.0	62.0	70	0.0	48	7	RAMESHBABU	1989
FERRUGINEUS								ET AL.	
CRYPTOLESTES	ADULT	15.0	62.0	70	0.0	24	3	RAMESHBABU	1989
FERRUGINEUS								ET AL.	
CRYPTOLESTES	ADULT	15.0	62.0	70	0.0	24	8	RAMESHBABU	1989
FERRUGINEUS								ET AL.	
CRYPTOLESTES	ADULT	15.0	62.0	70	0.0	96	45	RAMESHBABU	1989
FERRUGINEUS								ET AL.	
CRYPTOLESTES	ADULT	15.0	62.0	70	0.0	84	45	RAMESHBABU	1989
FERRUGINEUS								ET AL.	
CRYPTOLESTES	ADULT	15.0	62.0	70	0.0	72	34	RAMESHBABU	1989
FERRUGINEUS								ET AL.	
CRYPTOLESTES	ADULT	15.0	74.0	70	0.0	84	37	RAMESHBABU	1989
FERRUGINEUS								ET AL.	

Page No. 33  
08/18/89

## CONTROLLED ATMOSPHERE STORAGE DATA BASE

INSECT NAME	STAGE	TEMP C	R.H. %	CO2 %	O2 %	EXP h	MOR %	AUTHOR	YEAR
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	74.0	70	0.0	96	40	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	74.0	70	0.0	60	17	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	74.0	70	0.0	24	0	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	74.0	70	0.0	48	3	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	74.0	70	0.0	72	19	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	83.0	70	0.0	48	5	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	83.0	70	0.0	72	37	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	83.0	70	0.0	24	0	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	83.0	70	0.0	84	28	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	83.0	70	0.0	60	14	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	83.0	70	0.0	96	38	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	62.0	70	0.0	48	12	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	62.0	70	0.0	72	20	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	62.0	70	0.0	84	58	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	62.0	70	0.0	60	15	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	62.0	70	0.0	24	4	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	62.0	70	0.0	96	49	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	74.0	70	0.0	84	30	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	74.0	70	0.0	60	12	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	74.0	70	0.0	96	44	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	74.0	70	0.0	24	5	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	74.0	70	0.0	48	5	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	74.0	70	0.0	72	17	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	83.0	70	0.0	72	20	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	83.0	70	0.0	48	6	RAMESHBABU ET AL.	1989

## CONTROLLED ATMOSPHERE STORAGE DATA BASE

INSECT NAME	STAGE	TEMP C	R.H. %	CO2 %	O2 %	EXP h	MOR %	AUTHOR	YEAR
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	83.0	70	0.0	84	23	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	83.0	70	0.0	24	6	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	83.0	70	0.0	60	7	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	83.0	70	0.0	96	28	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	10.0	62.0	70	0.0	48	25	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	10.0	62.0	70	0.0	96	60	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	10.0	62.0	70	0.0	24	15	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	10.0	74.0	70	0.0	24	15	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	10.0	74.0	70	0.0	96	50	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	10.0	74.0	70	0.0	48	30	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	10.0	83.0	70	0.0	48	20	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	10.0	83.0	70	0.0	96	40	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	10.0	83.0	70	0.0	24	15	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	20.0	62.0	70	0.0	24	30	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	20.0	62.0	70	0.0	96	75	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	20.0	74.0	70	0.0	24	20	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	20.0	74.0	70	0.0	48	30	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	20.0	83.0	70	0.0	48	30	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	20.0	83.0	70	0.0	24	20	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	20.0	83.0	70	0.0	96	55	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	20.0	74.0	70	0.0	96	60	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	62.0	70	4.0	48	9	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	62.0	70	4.0	84	39	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	62.0	70	4.0	24	3	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	62.0	70	4.0	60	17	RAMESHBABU ET AL.	1989

## CONTROLLED ATMOSPHERE STORAGE DATA BASE

INSECT NAME	STAGE	TEMP C	R.H. %	CO2 %	O2 %	EXP h	MOR %	AUTHOR	YEAR
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	62.0	70	4.0	72	32	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	62.0	70	4.0	96	58	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	74.0	70	4.0	60	13	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	74.0	70	4.0	96	63	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	74.0	70	4.0	24	4	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	74.0	70	4.0	72	26	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	74.0	70	4.0	84	34	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	74.0	70	4.0	48	5	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	83.0	70	4.0	48	4	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	83.0	70	4.0	84	29	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	83.0	70	4.0	24	0	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	83.0	70	4.0	72	24	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	83.0	70	4.0	60	11	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	83.0	70	4.0	96	50	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	62.0	70	4.0	84	50	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	62.0	70	4.0	48	15	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	62.0	70	4.0	72	30	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	62.0	70	4.0	60	21	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	62.0	70	4.0	96	75	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	74.0	70	4.0	96	48	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	74.0	70	4.0	60	15	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	74.0	70	4.0	24	0	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	74.0	70	4.0	72	22	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	74.0	70	4.0	84	22	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	74.0	70	4.0	48	8	RAMESHBABU ET AL.	1989

## CONTROLLED ATMOSPHERE STORAGE DATA BASE

INSECT NAME	STAGE	TEMP C	R.H. %	CO2 %	O2 %	EXP h	MOR %	AUTHOR	YEAR
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	83.0	70	4.0	84	18	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	83.0	70	4.0	48	4	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	83.0	70	4.0	72	13	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	83.0	70	4.0	60	8	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	83.0	70	4.0	24	5	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	83.0	70	4.0	96	46	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	62.0	70	4.0	84	46	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	62.0	70	4.0	48	7	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	62.0	70	4.0	96	73	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	62.0	70	4.0	24	4	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	62.0	70	4.0	72	24	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	62.0	70	4.0	60	20	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	74.0	70	4.0	72	24	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	74.0	70	4.0	60	19	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	74.0	70	4.0	24	5	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	74.0	70	4.0	96	48	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	74.0	70	4.0	48	11	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	74.0	70	4.0	84	38	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	83.0	70	4.0	84	35	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	83.0	70	4.0	48	9	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	83.0	70	4.0	96	60	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	83.0	70	4.0	24	1	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	83.0	70	4.0	72	19	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	83.0	70	4.0	60	11	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	10.0	62.0	70	4.0	48	15	RAMESHBABU ET AL.	1989

## CONTROLLED ATMOSPHERE STORAGE DATA BASE

INSECT NAME	STAGE	TEMP C	R.H. %	CO2 %	O2 %	EXP h	MOR %	AUTHOR	YEAR
CRYPTOLESTES FERRUGINEUS	EGG	10.0	62.0	70	4.0	96	60	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	10.0	62.0	70	4.0	24	10	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	10.0	74.0	70	4.0	24	10	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	10.0	74.0	70	4.0	96	60	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	10.0	74.0	70	4.0	48	20	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	10.0	83.0	70	4.0	48	15	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	10.0	83.0	70	4.0	96	50	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	10.0	83.0	70	4.0	24	5	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	20.0	62.0	70	4.0	48	20	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	20.0	62.0	70	4.0	24	10	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	20.0	62.0	70	4.0	96	45	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	20.0	74.0	70	4.0	24	0	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	20.0	74.0	70	4.0	96	40	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	20.0	74.0	70	4.0	48	15	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	20.0	83.0	70	4.0	48	40	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	20.0	83.0	70	4.0	24	20	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	20.0	83.0	70	4.0	96	40	RAMESHBABU ET AL.	1989
FRANKLINIELLA OCCIDENTALI	ADULT	2.5	0.0	70	4.0	48	100	YAIR AKARONI ET AL.	1981
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	62.0	70	8.0	48	11	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	62.0	70	8.0	84	48	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	62.0	70	8.0	96	70	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	62.0	70	8.0	72	40	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	62.0	70	8.0	60	19	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	62.0	70	8.0	24	0	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	74.0	70	8.0	24	2	RAMESHBABU ET AL.	1989



## CONTROLLED ATMOSPHERE STORAGE DATA BASE

INSECT NAME	STAGE	TEMP C	R.H. %	CO2 %	O2 %	EXP h	MOR %	AUTHOR	YEAR
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	74.0	70	8.0	60	15	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	74.0	70	8.0	72	27	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	74.0	70	8.0	96	73	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	74.0	70	8.0	84	31	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	74.0	70	8.0	48	9	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	83.0	70	8.0	48	5	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	83.0	70	8.0	84	32	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	83.0	70	8.0	60	13	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	83.0	70	8.0	96	54	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	83.0	70	8.0	24	0	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	83.0	70	8.0	72	23	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	62.0	70	8.0	48	16	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	62.0	70	8.0	84	65	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	62.0	70	8.0	24	3	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	62.0	70	8.0	60	26	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	62.0	70	8.0	72	34	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	62.0	70	8.0	96	74	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	74.0	70	8.0	24	0	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	74.0	70	8.0	60	14	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	74.0	70	8.0	96	63	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	74.0	70	8.0	72	38	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	74.0	70	8.0	48	4	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	74.0	70	8.0	84	54	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	83.0	70	8.0	84	34	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	83.0	70	8.0	48	6	RAMESHBABU ET AL.	1989

## CONTROLLED ATMOSPHERE STORAGE DATA BASE

INSECT NAME	STAGE	TEMP C	R.H. %	CO2 %	O2 %	EXP h	MOR %	AUTHOR	YEAR
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	83.0	70	8.0	60	11	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	83.0	70	8.0	72	39	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	83.0	70	8.0	96	58	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	83.0	70	8.0	24	2	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	62.0	70	8.0	84	66	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	62.0	70	8.0	48	10	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	62.0	70	8.0	96	73	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	62.0	70	8.0	72	58	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	62.0	70	8.0	60	31	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	62.0	70	8.0	24	0	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	74.0	70	8.0	96	65	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	74.0	70	8.0	24	0	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	74.0	70	8.0	60	24	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	74.0	70	8.0	72	44	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	74.0	70	8.0	48	9	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	74.0	70	8.0	84	53	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	83.0	70	8.0	84	53	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	83.0	70	8.0	48	4	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	83.0	70	8.0	72	44	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	83.0	70	8.0	60	32	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	83.0	70	8.0	96	71	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	83.0	70	8.0	24	0	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	20.0	62.0	70	8.0	48	40	RAMESHBABU ET AL.	1989
SITOPHILUS GRANARIS	ADULT	26.6	0.0	70	23.0	72	95	LINDGREN & VINCENT	1970
SITPHILUS ORYZAE	ADULT	26.6	0.0	70	23.0	36	95	LINDGREN & VINCENT	1970

## CONTROLLED ATMOSPHERE STORAGE DATA BASE

INSECT NAME	STAGE	TEMP C	R.H. %	CO2 %	O2 %	EXP h	MOR %	AUTHOR	YEAR
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	0.0	72	9.5	168	100	WHITE ET.AL	1988
RHYZOPERTHA DOMINICA	ADULT	19.0	70.0	75	5.0	27	50	DESMERCHELIE R ET.AL	1983
RHYZOPERTHA DOMINICA	EGG	19.0	70.0	75	5.0	94	50	DESMERCHELIE R ET.AL	1983
RHYZOPERTHA DOMINICA	LARVA	19.0	70.0	75	5.0	31	50	DESMERCHELIE R ET.AL	1983
RHYZOPERTHA DOMINICA	PUPA	19.0	70.0	75	5.0	50	50	DESMERCHELIE R ET.AL	1983
SITOPHILUS GRANARIS	ADULT	19.0	70.0	75	5.0	63	50	DESMARCHELIE R ET.AL	1983
SITOPHILUS GRANARIS	EGG	19.0	70.0	75	5.0	56	50	DESMERCHELIE R ET.AL	1983
SITOPHILUS GRANARIS	LARVA	19.0	70.0	75	5.0	68	50	DESMERCHELIE R ET.AL	1983
SITOPHILUS GRANARIUS	ADULT	25.0	100	75	5.0	199	99	BOND E.J & BUCKLAND C.T.	1979
SITOPHILUS ORYZAE	ADULT	19.0	70.0	75	5.0	15	50	DESMERCHELIE R ET.AL	1983
SITOPHILUS ORYZAE	EGG	19.0	70.0	75	5.0	73	50	DESMERCHELIE R ET.AL	1983
SITOPHILUS ORYZAE	LARVA	19.0	70.0	75	5.0	48	50	DESMERCHELIE R ET.AL	1983
SITOPHILUS ORYZAE	PUPA	19.0	70.0	75	5.0	63	50	DESMERCHELIE R ET.AL	1983
TRIBOLIUM CASTANEUM	ADULT	19.0	70.0	75	5.0	39	50	DESMERCHELIE R ET.AL	1983
TRIBOLIUM CASTANEUM	EGG	19.0	70.0	75	5.0	28	50	DESMERCHELIE R ET.AL	1983
TRIBOLIUM CASTANEUM	LARVA	19.0	70.0	75	5.0	51	50	DESMERCHELIE R ET.AL	1983
TRIBOLIUM CASTANEUM	PUPA	19.0	70.0	75	5.0	99	50	DESMERCHELIE R ET.AL	1983
TRIBOLIUM CONFUSUM	ADULT	19.0	70.0	75	5.0	45	50	DESMERCHELIE R ET.AL	1983
TRIBOLIUM CONFUSUM	EGG	19.0	70.0	75	5.0	15	50	DESMERCHELIE R ET.AL	1983
TRIBOLIUM CONFUSUM	LARVA	19.0	70.0	75	5.0	47	50	DESMERCHELIE R ET.AL	1983
TRIBOLIUM CONFUSUM	PUPA	19.0	70.0	75	5.0	75	50	DESMERCHELIE R ET.AL	1983
TRIBOLIUM GRANARIUM	ADULT	19.0	70.0	75	5.0	40	50	DESMERCHELIE R ET.AL	1983
TRIBOLIUM GRANARIUM	EGG	19.0	70.0	75	5.0	115	50	DESMERCHELIE R ET.AL	1983
TRIBOLIUM GRANARIUM	LARVA	19.0	70.0	75	5.0	312	50	DESMERCHELIE R ET.AL	1983
TRIBOLIUM GRANARIUM	PUPA	19.0	70.0	75	5.0	238	50	DESMERCHELIE R ET.AL	1983

Page No. 41  
08/18/89

## CONTROLLED ATMOSPHERE STORAGE DATA BASE

INSECT NAME	STAGE	TEMP C	R.H. %	CO2 %	O2 %	EXP h	MOR %	AUTHOR	YEAR
TRIBOLIUM GRANARIUM	LARVA	36.0	50.0	76	5.0	24	37	JAY E.G.	1983
TRIBOLIUM GRANARIUM	PUPA	36.0	50.0	76	5.0	24	49	JAY E.G.	1983
TRIBOLIUM VARIABILIE	LARVA	36.0	50.0	76	5.0	24	23	JAY E.G.	1983
TRIBOLIUM VARIABILIE	PUPA	36.0	50.0	76	5.0	24	45	JAY E.G.	1983
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	60.0	76	9.0	168	47	WHITE ET AL.	1987
ORYZAEPHILUS SURINAMENSIS	ADULT	16.0	50.0	77	5.0	72	100	JAY E.G.	1983
ORYZAEPHILUS SURINAMENSIS	ADULT	27.0	50.0	77	5.0	48	100	JAY E.G.	1983
ORYZAEPHILUS SURINAMENSIS	ADULT	32.0	50.0	77	5.0	24	100	JAY E.G.	1983
ORYZAEPHILUS SURINAMENSIS	LARVA	16.0	50.0	77	5.0	72	100	JAY E.G.	1983
ORYZAEPHILUS SURINAMENSIS	LARVA	21.0	50.0	77	5.0	48	100	JAY E.G.	1983
ORYZAEPHILUS SURINAMENSIS	LARVA	31.0	50.0	77	5.0	24	100	JAY E.G.	1983
ORYZAEPHILUS SURINAMENSIS	PUPA	16.0	50.0	77	5.0	240	100	JAY E.G.	1983
ORYZAEPHILUS SURINAMENSIS	PUPA	27.0	50.0	77	5.0	72	100	JAY E.G.	1983
ORYZAEPHILUS SURINAMENSIS	PUPA	31.0	50.0	77	5.0	72	100	JAY E.G.	1983
CRYPTOLESTES FERRUGINEUS	ADULT	2.5	60.0	77	6.0	24	8	WHITE ET AL.	1987
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	60.0	77	9.0	24	12	WHITE ET AL.	1987
CRYPTOLESTES FERRUGINEUS	ADULT	2.5	60.0	79	8.0	168	32	WHITE ET AL.	1987
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	62.0	80	0.0	48	7	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	62.0	80	0.0	96	52	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	62.0	80	0.0	24	1	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	74.0	80	0.0	24	0	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	74.0	80	0.0	96	34	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	74.0	80	0.0	48	3	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	83.0	80	0.0	48	4	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	83.0	80	0.0	24	4	RAMESHBABU ET AL.	1989

Page No. 42  
08/18/89

## CONTROLLED ATMOSPHERE STORAGE DATA BASE

INSECT NAME	STAGE	TEMP C	R.H. %	CO2 %	O2 %	EXP h	MOR %	AUTHOR	YEAR
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	83.0	80	0.0	96	31	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	62.0	80	0.0	84	55	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	62.0	80	0.0	48	8	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	62.0	80	0.0	72	32	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	62.0	80	0.0	24	0	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	62.0	80	0.0	96	76	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	74.0	80	0.0	24	3	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	74.0	80	0.0	60	18	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	74.0	80	0.0	96	75	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	74.0	80	0.0	72	25	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	74.0	80	0.0	48	6	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	74.0	80	0.0	84	54	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	83.0	80	0.0	84	46	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	83.0	80	0.0	48	18	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	83.0	80	0.0	24	5	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	83.0	80	0.0	72	20	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	83.0	80	0.0	96	75	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	83.0	80	0.0	60	18	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	62.0	80	0.0	84	75	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	62.0	80	0.0	48	3	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	62.0	80	0.0	72	35	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	62.0	80	0.0	96	77	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	62.0	80	0.0	24	8	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	74.0	80	0.0	24	0	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	74.0	80	0.0	96	79	RAMESHBABU ET AL.	1989

## CONTROLLED ATMOSPHERE STORAGE DATA BASE

INSECT NAME	STAGE	TEMP C	R.H. %	CO2 %	O2 %	EXP h	MOR %	AUTHOR	YEAR
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	74.0	80	0.0	60	16	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	74.0	80	0.0	72	23	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	74.0	80	0.0	48	3	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	74.0	80	0.0	84	69	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	83.0	80	0.0	48	1	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	83.0	80	0.0	84	65	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	83.0	80	0.0	96	31	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	83.0	80	0.0	72	22	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	83.0	80	0.0	24	1	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	83.0	80	0.0	96	75	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	83.0	80	0.0	60	11	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	10.0	62.0	80	0.0	24	20	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	10.0	74.0	80	0.0	24	15	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	10.0	74.0	80	0.0	96	50	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	10.0	74.0	80	0.0	48	45	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	10.0	83.0	80	0.0	48	35	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	10.0	83.0	80	0.0	96	40	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	10.0	83.0	80	0.0	24	15	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	20.0	62.0	80	0.0	48	50	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	20.0	62.0	80	0.0	24	35	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	20.0	62.0	80	0.0	96	80	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	20.0	74.0	80	0.0	96	65	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	20.0	74.0	80	0.0	24	30	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	20.0	74.0	80	0.0	48	35	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	20.0	83.0	80	0.0	48	30	RAMESHBABU ET AL.	1989

## CONTROLLED ATMOSPHERE STORAGE DATA BASE

INSECT NAME	STAGE	TEMP C	R.H. %	CO2 %	O2 %	EXP h	MOR %	AUTHOR	YEAR
CRYPTOLESTES FERRUGINEUS	EGG	20.0	83.0	80	0.0	24	20	RAMESHBABU ET AL.	1989
EPHESTIA KUHENILLA	EGG	15.0	0.0	80	0.0	120	90	BELL C.H.	1983
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	62.0	80	4.0	84	53	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	62.0	80	4.0	48	12	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	62.0	80	4.0	60	20	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	62.0	80	4.0	96	66	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	62.0	80	4.0	24	1	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	62.0	80	4.0	72	39	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	74.0	80	4.0	24	3	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	74.0	80	4.0	60	14	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	74.0	80	4.0	96	56	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	74.0	80	4.0	72	23	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	74.0	80	4.0	48	8	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	74.0	80	4.0	84	19	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	83.0	80	4.0	84	26	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	83.0	80	4.0	48	2	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	83.0	80	4.0	24	4	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	83.0	80	4.0	96	55	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	83.0	80	4.0	72	19	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	62.0	80	4.0	48	27	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	62.0	80	4.0	84	27	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	62.0	80	4.0	60	25	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	62.0	80	4.0	24	6	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	62.0	80	4.0	72	27	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	62.0	80	4.0	96	69	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	74.0	80	4.0	72	26	RAMESHBABU ET AL.	1989

## CONTROLLED ATMOSPHERE STORAGE DATA BASE

INSECT NAME	STAGE	TEMP C	R.H. %	CO2 %	O2 %	EXP h	MOR %	AUTHOR	YEAR
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	74.0	80	4.0	24	6	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	74.0	80	4.0	60	25	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	74.0	80	4.0	96	68	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	74.0	80	4.0	48	19	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	74.0	80	4.0	84	31	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	83.0	80	4.0	84	29	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	83.0	80	4.0	48	10	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	83.0	80	4.0	24	2	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	83.0	80	4.0	60	20	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	83.0	80	4.0	72	29	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	83.0	80	4.0	96	60	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	62.0	80	4.0	48	12	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	62.0	80	4.0	84	66	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	62.0	80	4.0	72	34	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	62.0	80	4.0	24	1	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	62.0	80	4.0	60	25	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	62.0	80	4.0	96	73	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	74.0	80	4.0	72	31	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	74.0	80	4.0	60	14	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	74.0	80	4.0	24	2	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	74.0	80	4.0	96	80	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	74.0	80	4.0	48	6	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	74.0	80	4.0	84	69	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	83.0	80	4.0	48	7	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	83.0	80	4.0	84	43	RAMESHBABU ET AL.	1989



## CONTROLLED ATMOSPHERE STORAGE DATA BASE

INSECT NAME	STAGE	TEMP C	R.H. %	CO2 %	O2 %	EXP h	MOR %	AUTHOR	YEAR
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	83.0	80	4.0	72	29	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	83.0	80	4.0	24	3	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	83.0	80	4.0	96	50	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	10.0	62.0	80	4.0	48	10	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	10.0	62.0	80	4.0	96	60	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	10.0	62.0	80	4.0	24	0	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	10.0	74.0	80	4.0	24	15	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	10.0	74.0	80	4.0	96	40	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	10.0	74.0	80	4.0	48	30	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	10.0	83.0	80	4.0	48	25	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	10.0	83.0	80	4.0	96	30	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	10.0	83.0	80	4.0	24	15	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	20.0	62.0	80	4.0	48	20	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	20.0	62.0	80	4.0	24	20	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	20.0	74.0	80	4.0	96	60	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	20.0	74.0	80	4.0	24	15	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	20.0	74.0	80	4.0	48	15	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	20.0	83.0	80	4.0	48	20	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	20.0	83.0	80	4.0	24	5	RAMESHBABU ET AL.	1989
TRIBOLIUM CASTANEUM	ADULT	26.7	41.0	80	4.0	44	95	ALINIAZEE T.	1971
TRIBOLIUM CONFUSUM	ADULT	26.7	41.0	80	4.0	48	95	ALINIAZEE T.	1971
CRYPTOLESTES FERRUGINEUS	EGG	20.0	62.0	*80	4.0	96	60	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	62.0	80	8.0	84	59	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	62.0	80	8.0	48	18	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	62.0	80	8.0	24	3	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	62.0	80	8.0	72	43	RAMESHBABU ET AL.	1989

Page No. 47  
08/18/89

## CONTROLLED ATMOSPHERE STORAGE DATA BASE

INSECT NAME	STAGE	TEMP C	R.H. %	CO2 %	O2 %	EXP h	MOR %	AUTHOR	YEAR
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	62.0	80	8.0	60	33	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	62.0	80	8.0	96	77	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	74.0	80	8.0	72	39	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	74.0	80	8.0	24	1	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	74.0	80	8.0	96	70	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	74.0	80	8.0	60	30	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	74.0	80	8.0	48	16	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	74.0	80	8.0	84	51	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	83.0	80	8.0	48	5	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	83.0	80	8.0	84	45	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	83.0	80	8.0	72	29	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	83.0	80	8.0	24	0	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	83.0	80	8.0	96	61	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	62.0	80	8.0	84	52	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	62.0	80	8.0	48	9	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	62.0	80	8.0	24	0	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	62.0	80	8.0	96	70	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	62.0	80	8.0	60	26	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	62.0	80	8.0	72	29	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	74.0	80	8.0	60	23	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	74.0	80	8.0	72	30	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	74.0	80	8.0	24	0	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	74.0	80	8.0	96	64	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	74.0	80	8.0	48	11	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	74.0	80	8.0	84	49	RAMESHBABU ET AL.	1989

## CONTROLLED ATMOSPHERE STORAGE DATA BASE

INSECT NAME	STAGE	TEMP C	R.H. %	CO2 %	O2 %	EXP h	MOR %	AUTHOR	YEAR
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	83.0	80	8.0	84	38	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	83.0	80	8.0	48	9	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	83.0	80	8.0	72	34	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	83.0	80	8.0	96	48	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	83.0	80	8.0	24	0	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	62.0	80	8.0	48	13	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	62.0	80	8.0	84	55	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	62.0	80	8.0	60	23	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	62.0	80	8.0	24	8	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	62.0	80	8.0	96	60	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	62.0	80	8.0	72	45	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	74.0	80	8.0	96	53	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	74.0	80	8.0	24	3	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	74.0	80	8.0	72	40	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	74.0	80	8.0	60	21	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	74.0	80	8.0	84	49	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	74.0	80	8.0	48	9	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	83.0	80	8.0	84	45	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	83.0	80	8.0	48	4	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	83.0	80	8.0	96	49	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	83.0	80	8.0	72	36	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	83.0	80	8.0	24	0	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	10.0	62.0	80	8.0	48	45	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	10.0	62.0	80	8.0	96	60	RAMESHBABU ET AL.	1989
EPHESTIA CAUTELLA	EGG	15.0	0.0	80	16.0	96	90	BELL C.H.	1983
SITOPHILUS GRANARIS	ADULT	26.6	0.0	80	16.0	48	95	LINDGREN & VINCENT	1970

Page No. 49  
08/18/89

## CONTROLLED ATMOSPHERE STORAGE DATA BASE

INSECT NAME	STAGE	TEMP C	R.H. %	CO2 %	O2 %	EXP h	MOR %	AUTHOR	YEAR
SITPHILUS ORYZAE	ADULT	26.6	0.0	80	16.0	20	95	LINDGREN & VINCENT	1970
CRYPTOLESTES FERRUGINEUS	ADULT	2.5	60.0	81	5.5	168	44	WHITE ET AL.	1987
SITOPHILUS GRANARIUS	ADULT	4.4	0.0	83	4.1	168	91	FREDRICK ET AL.	1970
SITOPHILUS GRANARIUS	ADULT	4.4	0.0	83	4.1	72	71	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	ADULT	4.4	0.0	83	4.1	72	53	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	ADULT	4.4	0.0	83	4.1	168	98	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	LARVA	4.4	0.0	83	4.1	168	56	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	LARVA	4.4	0.0	83	4.1	72	22	FREDRICK ET AL.	1970
SITOPHILUS GRANARIUS	ADULT	15.6	0.0	84	4.2	72	100	FREDRICK ET AL.	1970
SITOPHILUS GRANARIUS	ADULT	15.6	0.0	84	4.2	168	100	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	ADULT	15.6	0.0	84	4.2	72	100	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	ADULT	15.6	0.0	84	4.2	168	100	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	LARVA	15.6	0.0	84	4.2	168	98	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	LARVA	15.6	0.0	84	4.2	72	63	FREDRICK ET AL.	1970
PLODIA INTERPUNCTELLA	LARVA	38.2	62.0	85	3.5	168	100	HAREIN P.K. & A.F.PRESS	1968
PLODIA INTERPUNCTELLA	LARVA	38.2	62.0	85	3.5	336	100	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	ADULT	38.2	62.0	85	3.5	336	100	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	ADULT	38.2	62.0	85	3.5	168	100	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	LARVA	38.2	62.0	85	3.5	336	100	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	LARVA	38.2	62.0	85	3.5	168	100	HAREIN P.K. & A.F.PRESS	1968
SITOPHILUS GRANARIUS	ADULT	15.6	0.0	86	2.9	168	100	FREDRICK ET AL.	1970
SITOPHILUS GRANARIUS	ADULT	15.6	0.0	86	2.9	72	100	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	ADULT	15.6	0.0	86	2.9	72	72	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	ADULT	15.6	0.0	86	2.9	168	100	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	LARVA	15.6	0.0	86	2.9	72	36	FREDRICK ET AL.	1970

Page No. 50  
08/18/89

## CONTROLLED ATMOSPHERE STORAGE DATA BASE

INSECT NAME	STAGE	TEMP C	R.H. %	CO2 %	O2 %	EXP h	MOR %	AUTHOR	YEAR
TROGODERMA GLABARUM	LARVA	15.6	0.0	86	2.9	168	94	FREDRICK ET AL.	1970
PLODIA INTERPUNCTELLA	LARVA	27.1	64.0	86	3.7	168	100	HAREIN P.K. & A.F.PRESS	1968
PLODIA INTERPUNCTELLA	LARVA	27.1	64.0	86	3.7	336	100	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	ADULT	27.1	64.0	86	3.7	168	100	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	ADULT	27.1	64.0	86	3.7	336	100	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	LARVA	27.1	64.0	86	3.7	168	100	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	LARVA	27.1	64.0	86	3.7	336	100	HAREIN P.K. & A.F.PRESS	1968
PLODIA INTERPUNCTELLA	LARVA	16.0	67.5	86	3.5	336	100	HAREIN P.K. & A.F.PRESS	1968
PLODIA INTERPUNCTELLA	LARVA	16.0	67.5	86	3.5	168	100	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	ADULT	16.0	67.5	86	3.5	336	100	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	ADULT	16.0	67.5	86	3.5	168	100	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	LARVA	16.0	67.5	86	3.5	336	100	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	LARVA	16.0	67.5	86	3.5	336	100	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	LARVA	16.0	67.5	86	3.5	168	88	HAREIN P.K. & A.F.PRESS	1968
SITOPHILUS GRANARIUS	ADULT	26.7	0.0	87	3.5	72	100	FREDRICK ET AL.	1970
SITOPHILUS GRANARIUS	ADULT	26.7	0.0	87	3.5	168	100	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	ADULT	26.7	0.0	87	3.5	72	100	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	ADULT	26.7	0.0	87	3.5	168	100	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	LARVA	26.7	0.0	87	3.5	72	99	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	LARVA	26.7	0.0	87	3.5	168	100	FREDRICK ET AL.	1970
TROGODERMA GRANARIUM	ADULT	25.3	62.0	88	2.0	168	100	PRESS	1967
TROGODERMA GRANARIUM	ADULT	25.3	62.0	88	2.0	168	89	PRESS	1967
TROGODERMA GRANARIUM	ADULT	25.3	62.0	88	2.0	168	100	PRESS	1967
TRIBOLIUM GRANARIUM	LARVA	36.0	50.0	89	2.0	24	42	JAY E.G.	1983
TRIBOLIUM GRANARIUM	PUPA	36.0	50.0	89	2.0	24	61	JAY E.G.	1983

## CONTROLLED ATMOSPHERE STORAGE DATA BASE

INSECT NAME	STAGE	TEMP C	R.H. %	CO2 %	O2 %	EXP h	MOR %	AUTHOR	YEAR
TRIBOLIUM VARIABILIE	LARVA	36.0	50.0	89	2.0	24	20	JAY E.G.	1983
TRIBOLIUM VARIABILIE	PUPA	36.0	50.0	89	2.0	24	67	JAY E.G.	1983
TROGODERMA GRANARIUM	ADULT	25.3	62.0	89	2.0	48	67	PRESS	1967
TROGODERMA GRANARIUM	ADULT	25.3	62.0	89	2.0	48	30	PRESS	1967
TROGODERMA GRANARIUM	ADULT	25.3	62.0	89	2.0	48	41	PRESS	1967
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	62.0	90	0.0	48	8	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	62.0	90	0.0	96	57	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	62.0	90	0.0	24	8	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	74.0	90	0.0	96	35	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	74.0	90	0.0	24	4	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	74.0	90	0.0	48	5	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	83.0	90	0.0	48	7	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	83.0	90	0.0	24	3	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	83.0	90	0.0	96	31	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	62.0	90	0.0	48	8	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	62.0	90	0.0	84	66	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	62.0	90	0.0	60	21	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	62.0	90	0.0	96	86	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	62.0	90	0.0	72	41	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	62.0	90	0.0	24	4	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	62.0	90	0.0	60	27	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	74.0	90	0.0	96	79	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	74.0	90	0.0	72	27	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	74.0	90	0.0	24	2	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	74.0	90	0.0	60	21	RAMESHBABU ET AL.	1989

## CONTROLLED ATMOSPHERE STORAGE DATA BASE

INSECT NAME	STAGE	TEMP C	R.H. %	CO2 %	O2 %	EXP h	MOR %	AUTHOR	YEAR
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	74.0	90	0.0	48	4	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	74.0	90	0.0	84	55	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	83.0	90	0.0	48	3	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	83.0	90	0.0	84	50	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	83.0	90	0.0	96	74	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	83.0	90	0.0	60	12	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	83.0	90	0.0	24	0	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	83.0	90	0.0	72	26	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	62.0	90	0.0	48	21	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	62.0	90	0.0	24	0	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	62.0	90	0.0	96	99	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	62.0	90	0.0	60	13	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	74.0	90	0.0	24	3	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	74.0	90	0.0	96	96	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	74.0	90	0.0	48	5	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	83.0	90	0.0	48	7	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	83.0	90	0.0	24	1	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	10.0	62.0	90	0.0	48	30	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	10.0	62.0	90	0.0	24	20	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	10.0	62.0	90	0.0	96	60	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	10.0	74.0	90	0.0	24	15	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	10.0	74.0	90	0.0	96	65	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	10.0	74.0	90	0.0	48	35	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	10.0	83.0	90	0.0	48	30	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	10.0	83.0	90	0.0	24	20	RAMESHBABU ET AL.	1989

## CONTROLLED ATMOSPHERE STORAGE DATA BASE

INSECT NAME	STAGE	TEMP C	R.H. %	CO2 %	O2 %	EXP h	MOR %	AUTHOR	YEAR
CRYPTOLESTES FERRUGINEUS	EGG	10.0	83.0	90	0.0	96	55	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	20.0	62.0	90	0.0	48	30	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	20.0	62.0	90	0.0	24	30	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	20.0	62.0	90	0.0	96	85	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	20.0	74.0	90	0.0	96	75	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	20.0	74.0	90	0.0	24	25	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	20.0	74.0	90	0.0	48	60	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	20.0	83.0	90	0.0	48	60	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	20.0	83.0	90	0.0	96	55	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	20.0	83.0	90	0.0	24	30	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	20.0	83.0	90	0.0	96	50	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	62.0	90	4.0	48	17	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	62.0	90	4.0	84	61	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	62.0	90	4.0	24	2	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	62.0	90	4.0	96	84	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	62.0	90	4.0	72	33	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	62.0	90	4.0	60	27	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	70.0	90	4.0	168	100	WHITE ET AL.	1988
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	74.0	90	4.0	24	1	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	74.0	90	4.0	96	65	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	74.0	90	4.0	72	30	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	74.0	90	4.0	60	25	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	74.0	90	4.0	48	7	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	74.0	90	4.0	84	49	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	83.0	90	4.0	84	33	RAMESHBABU ET AL.	1989



## CONTROLLED ATMOSPHERE STORAGE DATA BASE

INSECT NAME	STAGE	TEMP C	R.H. %	CO2 %	O2 %	EXP h	MOR %	AUTHOR	YEAR
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	83.0	90	4.0	48	4	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	83.0	90	4.0	60	15	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	83.0	90	4.0	96	69	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	83.0	90	4.0	24	3	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	83.0	90	4.0	60	12	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	83.0	90	4.0	72	20	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	62.0	90	4.0	84	53	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	62.0	90	4.0	48	23	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	62.0	90	4.0	72	34	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	62.0	90	4.0	96	75	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	62.0	90	4.0	60	27	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	62.0	90	4.0	24	5	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	74.0	90	4.0	60	26	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	74.0	90	4.0	72	29	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	74.0	90	4.0	24	5	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	74.0	90	4.0	96	72	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	74.0	90	4.0	84	48	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	74.0	90	4.0	48	18	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	83.0	90	4.0	84	42	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	83.0	90	4.0	48	24	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	83.0	90	4.0	60	19	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	83.0	90	4.0	72	20	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	83.0	90	4.0	96	60	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	83.0	90	4.0	24	4	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	62.0	90	4.0	84	71	RAMESHBABU ET AL.	1989

## CONTROLLED ATMOSPHERE STORAGE DATA BASE

INSECT NAME	STAGE	TEMP C	R.H. %	CO2 %	O2 %	EXP h	MOR %	AUTHOR	YEAR
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	62.0	90	4.0	48	14	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	62.0	90	4.0	60	25	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	62.0	90	4.0	72	43	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	62.0	90	4.0	96	97	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	62.0	90	4.0	24	7	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	74.0	90	4.0	96	80	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	74.0	90	4.0	72	47	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	74.0	90	4.0	24	0	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	74.0	90	4.0	60	22	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	74.0	90	4.0	48	10	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	74.0	90	4.0	84	63	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	83.0	90	4.0	48	12	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	83.0	90	4.0	84	58	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	83.0	90	4.0	60	16	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	83.0	90	4.0	96	77	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	83.0	90	4.0	60	21	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	83.0	90	4.0	24	0	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	83.0	90	4.0	72	39	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	10.0	62.0	90	4.0	48	15	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	10.0	62.0	90	4.0	24	10	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	10.0	62.0	90	4.0	96	55	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	10.0	74.0	90	4.0	24	5	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	10.0	74.0	90	4.0	96	50	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	10.0	74.0	90	4.0	48	15	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	10.0	83.0	90	4.0	48	15	RAMESHBABU ET AL.	1989

## CONTROLLED ATMOSPHERE STORAGE DATA BASE

INSECT NAME	STAGE	TEMP C	R.H. %	CO2 %	O2 %	EXP h	MOR %	AUTHOR	YEAR
CRYPTOLESTES FERRUGINEUS	EGG	10.0	83.0	90	4.0	96	35	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	10.0	83.0	90	4.0	24	5	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	20.0	62.0	90	4.0	48	15	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	20.0	62.0	90	4.0	24	5	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	20.0	62.0	90	4.0	96	70	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	20.0	74.0	90	4.0	96	60	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	20.0	74.0	90	4.0	24	15	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	20.0	74.0	90	4.0	48	15	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	20.0	83.0	90	4.0	48	20	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	20.0	83.0	90	4.0	24	5	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	20.0	83.0	90	4.0	96	50	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	EGG	20.0	83.0	90	4.0	96	55	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	62.0	90	8.0	84	59	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	62.0	90	8.0	48	23	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	62.0	90	8.0	24	4	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	62.0	90	8.0	96	69	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	62.0	90	8.0	60	29	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	62.0	90	8.0	72	43	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	74.0	90	8.0	96	65	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	74.0	90	8.0	24	2	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	74.0	90	8.0	60	33	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	74.0	90	8.0	72	36	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	74.0	90	8.0	48	13	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	74.0	90	8.0	84	47	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	83.0	90	8.0	48	14	RAMESHBABU ET AL.	1989

Page No. 57  
08/18/89

## CONTROLLED ATMOSPHERE STORAGE DATA BASE

INSECT NAME	STAGE	TEMP C	R.H. %	CO2 %	O2 %	EXP h	MOR %	AUTHOR	YEAR
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	83.0	90	8.0	84	50	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	83.0	90	8.0	60	20	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	83.0	90	8.0	72	34	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	83.0	90	8.0	60	27	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	83.0	90	8.0	96	63	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	83.0	90	8.0	24	1	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	62.0	90	8.0	48	14	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	62.0	90	8.0	84	66	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	62.0	90	8.0	96	73	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	62.0	90	8.0	24	0	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	62.0	90	8.0	72	51	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	62.0	90	8.0	60	25	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	74.0	90	8.0	72	35	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	74.0	90	8.0	24	0	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	74.0	90	8.0	60	15	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	74.0	90	8.0	96	65	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	74.0	90	8.0	48	3	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	74.0	90	8.0	84	51	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	83.0	90	8.0	84	40	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	83.0	90	8.0	48	4	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	83.0	90	8.0	72	33	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	83.0	90	8.0	24	2	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	83.0	90	8.0	96	54	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	83.0	90	8.0	60	11	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	15.0	83.0	90	8.0	60	15	RAMESHBABU ET AL.	1989

## CONTROLLED ATMOSPHERE STORAGE DATA BASE

INSECT NAME	STAGE	TEMP C	R.H. %	CO2 %	O2 %	EXP h	MOR %	AUTHOR	YEAR
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	62.0	90	8.0	48	18	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	62.0	90	8.0	84	65	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	62.0	90	8.0	96	81	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	62.0	90	8.0	24	11	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	62.0	90	8.0	60	37	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	62.0	90	8.0	72	48	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	74.0	90	8.0	60	34	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	74.0	90	8.0	72	45	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	74.0	90	8.0	96	85	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	74.0	90	8.0	24	8	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	74.0	90	8.0	84	70	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	74.0	90	8.0	48	20	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	83.0	90	8.0	48	17	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	83.0	90	8.0	84	66	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	83.0	90	8.0	60	30	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	83.0	90	8.0	24	9	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	83.0	90	8.0	72	47	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	83.0	90	8.0	96	81	RAMESHBABU ET AL.	1989
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	83.0	90	8.0	60	16	RAMESHBABU ET AL.	1989
SITOPHILUS GRANARIS	ADULT	26.6	0.0	90	8.0	50	95	LINDGREN & VINCENT	1970
SITOPHILUS ORYZAE	ADULT	26.6	0.0	90	8.0	24	95	LINDGREN & VINCENT	1970
ORYZAEPHILUS SURINAMENSIS	PUPA	16.0	50.0	91	2.0	240	100	JAY E.G.	1983
ORYZAEPHILUS SURINAMENSIS	PUPA	27.0	50.0	91	2.0	72	100	JAY E.G.	1983
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	60.0	91	4.0	168	100	WHITE ET AL.	1987
SITOPHILUS GRANARIUS	ADULT	4.4	0.0	91	2.1	168	100	FREDRICK ET AL.	1970

## CONTROLLED ATMOSPHERE STORAGE DATA BASE

INSECT NAME	STAGE	TEMP C	R.H. %	CO2 %	O2 %	EXP h	MOR %	AUTHOR	YEAR
SITOPHILUS GRANARIUS	ADULT	4.4	0.0	91	2.1	72	49	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	ADULT	4.4	0.0	91	2.1	168	93	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	ADULT	4.4	0.0	91	2.1	72	52	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	LARVA	4.4	0.0	91	2.1	72	82	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	LARVA	4.4	0.0	91	2.1	72	12	FREDRICK ET AL.	1970
CRYPTOLESTES FERRUGINEUS	ADULT	10.0	60.0	92	3.0	24	2	WHITE ET AL.	1987
PLODIA INTERPUNCTELLA	LARVA	38.2	62.0	92	2.0	336	100	HAREIN P.K. & A.F.PRESS	1968
PLODIA INTERPUNCTELLA	LARVA	38.2	62.0	92	2.0	168	100	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	ADULT	38.2	62.0	92	2.0	168	100	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	ADULT	38.2	62.0	92	2.0	336	100	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	LARVA	38.2	62.0	92	2.0	336	100	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	LARVA	38.2	62.0	92	2.0	168	100	HAREIN P.K. & A.F.PRESS	1968
TROGODERMA GRANARIUM	ADULT	25.3	62.0	92	2.0	96	80	PRESS	1967
TROGODERMA GRANARIUM	ADULT	25.3	62.0	92	2.0	96	98	PRESS	1967
TROGODERMA GRANARIUM	ADULT	25.3	62.0	92	2.0	96	74	PRESS	1967
PLODIA INTERPUNCTELLA	LARVA	16.0	67.5	93	2.0	168	100	HAREIN P.K. & A.F.PRESS	1968
PLODIA INTERPUNCTELLA	LARVA	16.0	67.5	93	2.0	336	100	HAREIN P.K. & A.F.PRESS	1968
SITOPHILUS GRANARIUS	ADULT	26.7	0.0	93	2.0	168	100	FREDRICK ET AL.	1970
SITOPHILUS GRANARIUS	ADULT	26.7	0.0	93	2.0	72	100	FREDRICK ET AL.	1970
TRIBOLIUM CASTANEUM	ADULT	16.0	67.5	93	2.0	336	100	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	ADULT	16.0	67.5	93	2.0	168	100	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	LARVA	11.6	67.5	93	2.0	336	100	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	LARVA	16.0	67.5	93	2.0	168	94	HAREIN P.K. & A.F.PRESS	1968
TROGODERMA GLABARUM	ADULT	26.7	0.0	93	2.0	72	100	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	ADULT	26.7	0.0	93	2.0	168	100	FREDRICK ET AL.	1970

## CONTROLLED ATMOSPHERE STORAGE DATA BASE

INSECT NAME	STAGE	TEMP C	R.H. %	CO2 %	O2 %	EXP h	MOR %	AUTHOR	YEAR
TROGODERMA GLABARUM	LARVA	26.7	0.0	93	2.0	168	100	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	LARVA	26.7	0.0	93	2.0	72	100	FREDRICK ET AL.	1970
PLODIA INTERPUNCTELLA	LARVA	27.1	64.0	94	1.8	168	100	HAREIN P.K. & A.F.PRESS	1968
PLODIA INTERPUNCTELLA	LARVA	27.1	64.0	94	1.8	336	100	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	ADULT	27.1	64.0	94	1.8	168	100	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	ADULT	27.1	64.0	94	1.8	336	100	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	LARVA	27.1	64.0	94	1.8	168	100	HAREIN P.K. & A.F.PRESS	1968
TRIBOLIUM CASTANEUM	LARVA	27.1	64.0	94	1.8	336	100	HAREIN P.K. & A.F.PRESS	1968
CRYPTOLESTES FERRUGINEUS	ADULT	20.0	0.0	95	3.0	168	100	WHITE ET.AL	1988
SITOPHILUS GRANARIUS	ADULT	4.4	0.0	96	0.9	72	45	FREDRICK ET AL.	1970
SITOPHILUS GRANARIUS	ADULT	4.4	0.0	96	0.9	168	19	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	ADULT	4.4	0.0	96	0.9	72	48	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	ADULT	4.4	0.0	96	0.9	168	96	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	LARVA	4.4	0.0	96	0.9	168	65	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	LARVA	4.4	0.0	96	0.9	72	7	FREDRICK ET AL.	1970
TRIBOLIUM CASTANEUM	ADULT	27.0	50.0	97	0.6	24	100	JAY E.G.	1983
TRIBOLIUM CASTANEUM	LARVA	27.0	50.0	97	0.6	72	99	JAY E.G.	1983
TRIBOLIUM CASTANEUM	PUPA	27.0	50.0	97	0.6	72	100	JAY E.G.	1983
CRYPTOLESTES FERRUGINEUS	ADULT	2.5	60.0	97	3.0	24	8	WHITE ET.AL	1987
SITOPHILUS GRANARIUS	ADULT	15.6	0.0	97	0.7	168	100	FREDRICK ET AL.	1970
SITOPHILUS GRANARIUS	ADULT	15.6	0.0	97	0.7	72	100	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	ADULT	15.6	0.0	97	0.7	72	100	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	ADULT	15.6	0.0	97	0.7	168	100	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	LARVA	15.6	0.0	97	0.7	72	83	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	LARVA	15.6	0.0	97	0.7	168	96	FREDRICK ET AL.	1970

## CONTROLLED ATMOSPHERE STORAGE DATA BASE

INSECT NAME	STAGE	TEMP C	R.H. %	CO2 %	O2 %	EXP h	MOR %	AUTHOR	YEAR
ORYZAEPHILUS SURINAMENSIS	PUPA	16.0	50.0	98	0.3	72	100	JAY E.G.	1983
ORYZAEPHILUS SURINAMENSIS	PUPA	27.0	50.0	98	0.3	48	100	JAY E.G.	1983
ORYZAEPHILUS SURINAMENSIS	PUPA	32.0	50.0	98	0.3	17	100	JAY E.G.	1983
SITOPHILUS GRANARIUS	ADULT	26.7	0.0	98	0.5	72	100	FREDRICK ET AL.	1970
SITOPHILUS GRANARIUS	ADULT	26.7	0.0	98	0.5	168	100	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	ADULT	26.7	0.0	98	0.5	168	100	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	ADULT	26.7	0.0	98	0.5	72	100	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	LARVA	26.7	0.0	98	0.5	72	100	FREDRICK ET AL.	1970
TROGODERMA GLABARUM	LARVA	26.7	0.0	98	0.5	168	100	FREDRICK ET AL.	1970
TRIBOLIUM CASTANEUM	ADULT	27.0	38.0	98	2.0	36	100	ALINIAZEE T.	1971
TRIBOLIUM CONFUSUM	ADULT	27.0	38.0	98	2.0	36	100	ALINIAZEE T.	1971
EPHESTIA CAUTELLA	ADULT	27.0	66.0	99	0.3	48	100	JAY E.G.	1983
EPHESTIA CAUTELLA	EGG	27.0	66.0	99	0.3	72	100	JAY E.G.	1983
EPHESTIA CAUTELLA	LARVA	27.0	66.0	99	0.3	160	100	JAY E.G.	1983
EPHESTIA CAUTELLA	PUPA	27.0	66.0	99	0.3	48	100	JAY E.G.	1983
TRIBOLIUM CASTANEUM	ADULT	27.0	66.0	99	0.3	72	100	JAY E.G.	1983
TRIBOLIUM CASTANEUM	EGG	27.0	66.0	99	0.3	72	100	JAY E.G.	1983
TRIBOLIUM CASTANEUM	LARVA	27.0	66.0	99	0.3	48	100	JAY E.G.	1983
TRIBOLIUM CASTANEUM	PUPA	27.0	66.0	99	0.3	96	100	JAY E.G.	1983
TRIBOLIUM CASTANEUM	LARVA	36.0	50.0	99	0.3	24	100	JAY E.G.	1983
TRIBOLIUM GRANARIUM	PUPA	33.0	50.0	99	0.3	48	100	JAY E.G.	1983
TRIBOLIUM GRANARIUM	PUPA	33.0	50.0	99	0.3	24	92	JAY E.G.	1983
TRIBOLIUM GRANARIUM	PUPA	36.0	50.0	99	0.3	24	100	JAY E.G.	1983
TRIBOLIUM GRANARIUM	PUPA	38.0	50.0	99	0.3	16	100	JAY E.G.	1983
TRIBOLIUM VARIABILIE	LARVA	36.0	50.0	99	0.3	24	100	JAY E.G.	1983
TRIBOLIUM VARIABILIE	PUPA	33.0	50.0	99	0.3	24	87	JAY E.G.	1983
TRIBOLIUM VARIABILIE	PUPA	33.0	50.0	99	0.3	48	100	JAY E.G.	1983
TRIBOLIUM VARIABILIE	PUPA	36.0	50.0	99	0.3	24	100	JAY E.G.	1983



Page No. 62  
08/18/89

## CONTROLLED ATMOSPHERE STORAGE DATA BASE

INSECT NAME	STAGE	TEMP C	R.H. %	CO2 %	O2 %	EXP h	MOR %	AUTHOR	YEAR
TRIBOLIUM VARIABILIE	PUPA	38.0	50.0	99	0.3	24	100	JAY E.G.	1983
TRIBOLIUM VARIABILIE	PUPA	38.0	50.0	99	0.3	16	93	JAY E.G.	1983
PLODIA INTERPUNCTELLA	ADULT	26.7	40.1	99	1.0	72	100	SODERSTORM ET.AL	1982
TRIBOLIUM GRANARIUM	LARVA	33.0	50.0	99	1.0	48	97	JAY E.G.	1983
TRIBOLIUM GRANARIUM	LARVA	33.0	50.0	99	1.0	24	90	JAY E.G.	1983
TRIBOLIUM GRANARIUM	LARVA	33.0	50.0	99	1.0	24	100	JAY E.G.	1983
TRIBOLIUM GRANARIUM	LARVA	33.0	50.0	99	1.0	24	73	JAY E.G.	1983
TRIBOLIUM VARIABILIE	LARVA	38.0	50.0	99	1.0	24	16	JAY E.G.	1983
TRIBOLIUM VARIABILIE	LARVA	38.0	50.0	99	1.0	24	100	JAY E.G.	1983
TRIBOLIUM VARIABILIE	LARVA	38.0	50.0	99	1.0	24	100	JAY E.G.	1983
TRIBOLIUM CASTANEUM	ADULT	26.7	38.0	100	0.0	18	100	ALINIAZEE T.	1971
TRIBOLIUM CASTANEUM	PUPA	15.6	41.0	100	0.0	36	17	ALINIAZEE T.	1971
TRIBOLIUM CONFUSUM	ADULT	26.7	38.0	100	0.0	18	100	ALINIAZEE T.	1971
TRIBOLIUM CONFUSUM	PUPA	15.6	41.0	100	0.0	36	13	ALINIAZEE T.	1971
SITOPHILUS GRANARIS	ADULT	26.6	0.0	100	0.0	84	95	LINDGREN & VINCENT	1970
TRIBOLIUM CASTANEUM	ADULT	15.6	38.0	100	0.0	18	6	ALINIAZEE T.	1971
TRIBOLIUM CASTANEUM	ADULT	15.6	38.0	100	0.0	36	99	ALINIAZEE T.	1971
TRIBOLIUM CASTANEUM	ADULT	15.6	38.0	100	0.0	24	30	ALINIAZEE T.	1971
TRIBOLIUM CASTANEUM	ADULT	15.6	38.0	100	0.0	30	77	ALINIAZEE T.	1971
TRIBOLIUM CASTANEUM	ADULT	15.6	38.0	100	0.0	42	99	ALINIAZEE T.	1971
TRIBOLIUM CASTANEUM	ADULT	15.6	38.0	100	0.0	48	100	ALINIAZEE T.	1971
TRIBOLIUM CASTANEUM	ADULT	15.6	38.0	100	0.0	60	100	ALINIAZEE T.	1971
TRIBOLIUM CASTANEUM	ADULT	21.1	38.0	100	0.0	15	44	ALINIAZEE T.	1971
TRIBOLIUM CASTANEUM	ADULT	21.1	38.0	100	0.0	36	100	ALINIAZEE T.	1971
TRIBOLIUM CASTANEUM	ADULT	21.1	38.0	100	0.0	24	97	ALINIAZEE T.	1971
TRIBOLIUM CASTANEUM	ADULT	21.1	38.0	100	0.0	30	99	ALINIAZEE T.	1971
TRIBOLIUM CASTANEUM	ADULT	21.1	38.0	100	0.0	18	86	ALINIAZEE T.	1971

## CONTROLLED ATMOSPHERE STORAGE DATA BASE

INSECT NAME	STAGE	TEMP C	R.H. %	CO2 %	O2 %	EXP h	MOR %	AUTHOR	YEAR
TRIBOLIUM CASTANEUM	ADULT	26.7	38.0	100	0.0	9	16	ALINIAZEE T.	1971
TRIBOLIUM CASTANEUM	ADULT	26.7	38.0	100	0.0	15	95	ALINIAZEE T.	1971
TRIBOLIUM CASTANEUM	ADULT	26.7	38.0	100	0.0	10	46	ALINIAZEE T.	1971
TRIBOLIUM CASTANEUM	ADULT	26.7	38.0	100	0.0	12	83	ALINIAZEE T.	1971
TRIBOLIUM CASTANEUM	ADULT	26.7	38.0	100	0.0	14	93	ALINIAZEE T.	1971
TRIBOLIUM CASTANEUM	ADULT	26.7	100	100	0.0	15	16	ALINIAZEE T.	1971
TRIBOLIUM CASTANEUM	ADULT	26.7	100	100	0.0	12	3	ALINIAZEE T.	1971
TRIBOLIUM CASTANEUM	ADULT	26.7	100	100	0.0	30	100	ALINIAZEE T.	1971
TRIBOLIUM CASTANEUM	ADULT	26.7	100	100	0.0	18	19	ALINIAZEE T.	1971
TRIBOLIUM CASTANEUM	ADULT	26.7	100	100	0.0	24	59	ALINIAZEE T.	1971
TRIBOLIUM CASTANEUM	EGG	26.7	38.0	100	0.0	48	94	ALINIAZEE T.	1971
TRIBOLIUM CASTANEUM	EGG	26.7	41.0	100	0.0	18	33	ALINIAZEE T.	1971
TRIBOLIUM CASTANEUM	EGG	26.7	41.0	100	0.0	60	100	ALINIAZEE T.	1971
TRIBOLIUM CASTANEUM	EGG	26.7	41.0	100	0.0	30	68	ALINIAZEE T.	1971
TRIBOLIUM CASTANEUM	EGG	26.7	41.0	100	0.0	36	89	ALINIAZEE T.	1971
TRIBOLIUM CASTANEUM	LARVA	15.6	41.0	100	0.0	18	8	ALINIAZEE T.	1971
TRIBOLIUM CASTANEUM	LARVA	15.6	41.0	100	0.0	36	27	ALINIAZEE T.	1971
TRIBOLIUM CASTANEUM	LARVA	15.6	41.0	100	0.0	48	62	ALINIAZEE T.	1971
TRIBOLIUM CASTANEUM	LARVA	15.6	41.0	100	0.0	72	99	ALINIAZEE T.	1971
TRIBOLIUM CASTANEUM	LARVA	26.7	41.0	100	0.0	30	72	ALINIAZEE T.	1971
TRIBOLIUM CASTANEUM	LARVA	26.7	41.0	100	0.0	18	69	ALINIAZEE T.	1971
TRIBOLIUM CASTANEUM	LARVA	26.7	41.0	100	0.0	12	11	ALINIAZEE T.	1971
TRIBOLIUM CASTANEUM	LARVA	26.7	41.0	100	0.0	42	98	ALINIAZEE T.	1971
TRIBOLIUM CASTANEUM	PUPA	15.6	41.0	100	0.0	84	50	ALINIAZEE T.	1971
TRIBOLIUM CASTANEUM	PUPA	15.6	41.0	100	0.0	144	95	ALINIAZEE T.	1971

## CONTROLLED ATMOSPHERE STORAGE DATA BASE

INSECT NAME	STAGE	TEMP C	R.H. %	CO2 %	O2 %	EXP h	MOR %	AUTHOR	YEAR
TRIBOLIUM CASTANEUM	PUPA	15.6	41.0	100	0.0	48	33	ALINIAZEE T.	1971
TRIBOLIUM CASTANEUM	PUPA	15.6	41.0	100	0.0	120	78	ALINIAZEE T.	1971
TRIBOLIUM CASTANEUM	PUPA	15.6	41.0	100	0.0	168	100	ALINIAZEE T.	1971
TRIBOLIUM CASTANEUM	PUPA	26.7	41.0	100	0.0	18	25	ALINIAZEE T.	1971
TRIBOLIUM CASTANEUM	PUPA	26.7	41.0	100	0.0	30	56	ALINIAZEE T.	1971
TRIBOLIUM CASTANEUM	PUPA	26.7	41.0	100	0.0	36	79	ALINIAZEE T.	1971
TRIBOLIUM CASTANEUM	PUPA	26.7	41.0	100	0.0	60	100	ALINIAZEE T.	1971
TRIBOLIUM CONFUSUM	ADULT	15.6	38.0	100	0.0	42	89	ALINIAZEE T.	1971
TRIBOLIUM CONFUSUM	ADULT	15.6	38.0	100	0.0	24	13	ALINIAZEE T.	1971
TRIBOLIUM CONFUSUM	ADULT	15.6	38.0	100	0.0	30	52	ALINIAZEE T.	1971
TRIBOLIUM CONFUSUM	ADULT	15.6	38.0	100	0.0	18	1	ALINIAZEE T.	1971
TRIBOLIUM CONFUSUM	ADULT	15.6	38.0	100	0.0	48	98	ALINIAZEE T.	1971
TRIBOLIUM CONFUSUM	ADULT	15.6	38.0	100	0.0	60	100	ALINIAZEE T.	1971
TRIBOLIUM CONFUSUM	ADULT	15.6	38.0	100	0.0	36	85	ALINIAZEE T.	1971
TRIBOLIUM CONFUSUM	ADULT	21.1	38.0	100	0.0	18	54	ALINIAZEE T.	1971
TRIBOLIUM CONFUSUM	ADULT	21.1	38.0	100	0.0	36	100	ALINIAZEE T.	1971
TRIBOLIUM CONFUSUM	ADULT	21.1	38.0	100	0.0	30	97	ALINIAZEE T.	1971
TRIBOLIUM CONFUSUM	ADULT	21.1	38.0	100	0.0	15	13	ALINIAZEE T.	1971
TRIBOLIUM CONFUSUM	ADULT	21.1	38.0	100	0.0	24	88	ALINIAZEE T.	1971
TRIBOLIUM CONFUSUM	ADULT	26.7	38.0	100	0.0	9	14	ALINIAZEE T.	1971
TRIBOLIUM CONFUSUM	ADULT	26.7	38.0	100	0.0	12	46	ALINIAZEE T.	1971
TRIBOLIUM CONFUSUM	ADULT	26.7	38.0	100	0.0	15	98	ALINIAZEE T.	1971
TRIBOLIUM CONFUSUM	ADULT	26.7	38.0	100	0.0	14	82	ALINIAZEE T.	1971
TRIBOLIUM CONFUSUM	ADULT	26.7	38.0	100	0.0	10	30	ALINIAZEE T.	1971
TRIBOLIUM CONFUSUM	ADULT	26.7	100	100	0.0	18	36	ALINIAZEE T.	1971
TRIBOLIUM CONFUSUM	ADULT	26.7	100	100	0.0	15	27	ALINIAZEE T.	1971
TRIBOLIUM CONFUSUM	ADULT	26.7	100	100	0.0	30	100	ALINIAZEE T.	1971
TRIBOLIUM CONFUSUM	ADULT	26.7	100	100	0.0	12	11	ALINIAZEE T.	1971
TRIBOLIUM CONFUSUM	ADULT	26.7	100	100	0.0	24	80	ALINIAZEE T.	1971
TRIBOLIUM CONFUSUM	EGG	26.7	38.0	100	0.0	48	92	ALINIAZEE T.	1971
TRIBOLIUM CONFUSUM	EGG	26.7	41.0	100	0.0	60	100	ALINIAZEE T.	1971
TRIBOLIUM CONFUSUM	EGG	26.7	41.0	100	0.0	36	80	ALINIAZEE T.	1971
TRIBOLIUM CONFUSUM	EGG	26.7	41.0	100	0.0	30	72	ALINIAZEE T.	1971
TRIBOLIUM CONFUSUM	EGG	26.7	41.0	100	0.0	18	31	ALINIAZEE T.	1971
TRIBOLIUM CONFUSUM	LARVA	15.6	41.0	100	0.0	36	32	ALINIAZEE T.	1971
TRIBOLIUM CONFUSUM	LARVA	15.6	41.0	100	0.0	18	8	ALINIAZEE T.	1971
TRIBOLIUM CONFUSUM	LARVA	15.6	41.0	100	0.0	72	99	ALINIAZEE T.	1971
TRIBOLIUM CONFUSUM	LARVA	15.6	41.0	100	0.0	48	91	ALINIAZEE T.	1971
TRIBOLIUM CONFUSUM	LARVA	26.7	41.0	100	0.0	42	100	ALINIAZEE T.	1971
TRIBOLIUM CONFUSUM	LARVA	26.7	41.0	100	0.0	18	68	ALINIAZEE T.	1971
TRIBOLIUM CONFUSUM	LARVA	26.7	41.0	100	0.0	30	92	ALINIAZEE T.	1971

**Appendix B**

Table. 1. Mean and standard deviation (S.D) of the mortality of *C. ferrugineus* adults exposed to various controlled atmospheres.

TEMPERATURE	CO2	O2	N2	EXPOSURE	R.H.	MORTALITY	S.D
C	%	%	%	h	%	%	%
10.30	80.10	0.00	19.90	24.00	61.00	1.00	1
10.30	80.10	0.00	19.90	24.00	74.00	0.00	0
10.30	80.10	0.00	19.90	24.00	81.00	4.00	2
10.30	80.10	0.00	19.90	48.00	80.00	4.00	0
10.30	80.10	0.00	19.90	48.00	74.00	3.00	2
10.30	80.10	0.00	19.90	48.00	63.00	7.00	2
10.30	80.10	0.00	19.90	96.00	75.00	34.00	3
10.30	80.10	0.00	19.90	96.00	81.00	25.00	3
10.30	80.10	0.00	19.90	96.00	63.00	52.00	4
10.43	90.50	0.00	9.50	24.00	84.00	3.00	2
10.43	90.50	0.00	9.50	24.00	75.00	4.00	0
10.43	90.50	0.00	9.50	24.00	63.00	8.00	4
10.43	90.50	0.00	9.50	48.00	74.00	7.00	4
10.43	90.50	0.00	9.50	48.00	82.00	5.00	2
10.43	90.50	0.00	9.50	48.00	63.00	8.00	3
10.43	90.50	0.00	9.50	96.00	81.00	26.00	2
10.43	90.50	0.00	9.50	96.00	73.00	35.00	4
10.43	90.50	0.00	9.50	96.00	63.00	57.00	8
20.40	89.70	0.00	31.40	24.00	80.00	0.00	0
20.40	89.70	0.00	31.40	24.00	73.00	3.00	2
20.40	89.70	0.00	31.40	24.00	60.70	0.00	0
20.40	89.70	0.00	31.40	48.00	80.00	5.00	2
20.40	89.70	0.00	31.40	48.00	72.00	5.00	2
20.40	89.70	0.00	31.40	48.00	60.50	18.00	2
20.40	89.70	0.00	31.40	96.00	80.00	80.00	2
20.40	89.70	0.00	31.40	96.00	72.50	84.00	3
20.40	89.70	0.00	31.40	96.00	60.80	99.00	2
20.30	80.10	0.00	19.90	24.00	80.00	1.00	2
20.30	80.10	0.00	19.90	24.00	72.00	0.00	0
20.30	80.10	0.00	19.90	24.00	61.00	8.00	3
20.30	80.10	0.00	19.90	48.00	83.00	1.00	1
20.30	80.10	0.00	19.90	48.00	74.00	3.00	1
20.30	80.10	0.00	19.90	48.00	63.20	3.00	2
20.30	80.10	0.00	19.90	60.00	62.80	13.00	2
20.30	80.10	0.00	19.90	60.00	73.50	16.00	3
20.30	80.10	0.00	19.90	60.00	82.60	11.00	2
20.30	80.10	0.00	19.90	72.00	82.50	22.00	3
20.30	80.10	0.00	19.90	72.00	74.00	23.00	4
20.30	80.10	0.00	19.90	72.00	61.90	35.00	4
20.30	80.10	0.00	19.90	84.00	82.00	65.00	4
20.30	80.10	0.00	19.90	84.00	74.00	69.00	5
20.30	80.10	0.00	19.90	84.00	62.00	75.00	4
20.30	80.10	0.00	19.90	96.00	82.00	75.00	5
20.30	80.10	0.00	19.90	96.00	74.00	79.00	5

..... continued

..... continued Table. 1

TEMPERATURE	CO2	O2	N2	EXPOSURE	R.H.	MORTALITY	S.D
C	%	%	%	h	%	%	%
20.30	80.10	0.00	19.90	96.00	63.90	77.00	5
20.15	68.60	0.00	10.30	24.00	82.00	6.00	3
20.15	68.60	0.00	10.30	24.00	72.70	5.00	3
20.15	68.60	0.00	10.30	24.00	61.80	4.00	3
20.15	68.60	0.00	10.30	48.00	60.90	12.00	3
20.15	68.60	0.00	10.30	48.00	71.80	5.00	2
20.15	68.60	0.00	10.30	48.00	81.70	6.00	4
20.15	68.60	0.00	10.30	60.00	83.00	7.00	4
20.15	68.60	0.00	10.30	60.00	74.00	12.00	3
20.15	68.60	0.00	10.30	60.00	63.00	15.00	2
20.15	68.60	0.00	10.30	72.00	82.00	20.00	3
20.15	68.60	0.00	10.30	72.00	73.00	17.00	2
20.15	68.60	0.00	10.30	72.00	62.50	20.00	2
20.15	68.60	0.00	10.30	84.00	62.50	58.00	4
20.15	68.60	0.00	10.30	84.00	73.00	30.00	4
20.15	68.60	0.00	10.30	84.00	82.00	23.00	4
20.15	68.60	0.00	10.30	96.00	61.90	49.00	3
20.15	68.60	0.00	10.30	96.00	72.50	44.00	4
20.15	68.60	0.00	10.30	96.00	81.90	28.00	3
15.20	69.60	0.00	30.40	24.00	83.70	0.00	0
15.20	69.60	0.00	30.40	24.00	74.90	0.00	0
15.20	69.60	0.00	30.40	24.00	63.10	3.00	2
15.20	69.60	0.00	30.40	48.00	83.00	5.00	2
15.20	69.60	0.00	30.40	48.00	74.50	3.00	2
15.20	69.60	0.00	30.40	48.00	62.90	7.00	2
15.20	69.60	0.00	30.40	60.00	82.50	7.00	2
15.20	69.60	0.00	30.40	60.00	74.00	14.00	3
15.20	69.60	0.00	30.40	60.00	62.50	17.00	2
15.20	69.60	0.00	30.40	72.00	82.00	19.00	2
15.20	69.60	0.00	30.40	72.00	74.00	37.00	2
15.20	69.60	0.00	30.40	72.00	62.00	34.00	3
15.20	69.60	0.00	30.40	84.00	82.00	28.00	3
15.20	69.60	0.00	30.40	84.00	74.00	37.00	2
15.20	69.60	0.00	30.40	84.00	62.00	29.00	3
15.20	69.60	0.00	30.40	96.00	61.90	45.00	3
15.20	69.60	0.00	30.40	96.00	73.50	40.00	3
15.20	69.60	0.00	30.40	96.00	81.90	38.00	2
15.23	78.20	0.00	21.80	24.00	81.90	40.00	0
15.23	78.20	0.00	21.80	24.00	73.60	3.00	4
15.23	78.20	0.00	21.80	24.00	62.00	0.00	3
15.23	78.20	0.00	21.80	48.00	81.80	5.00	4
15.23	78.20	0.00	21.80	48.00	73.00	6.00	3
15.23	78.20	0.00	21.80	48.00	62.00	8.00	0
15.23	78.20	0.00	21.80	60.00	81.80	18.00	3
15.23	78.20	0.00	21.80	60.00	73.00	18.00	3

..... continued

..... continued Table. 1

TEMPERATURE	CO2	O2	N2	EXPOSURE	R.H.	MORTALITY	S.D
C	%	%	%	h	%	%	%
15.23	78.20	0.00	21.80	60.00	62.00	21.00	2
15.23	78.20	0.00	21.80	72.00	73.20	25.00	3
15.23	78.20	0.00	21.80	72.00	81.90	20.00	4
15.23	78.20	0.00	21.80	72.00	61.90	32.00	0
15.23	78.20	0.00	21.80	84.00	73.00	54.00	3
15.23	78.20	0.00	21.80	84.00	81.50	46.00	3
15.23	78.20	0.00	21.80	84.00	61.50	55.00	3
15.23	78.20	0.00	21.80	96.00	81.40	73.00	4
15.23	78.20	0.00	21.80	96.00	73.00	75.00	2
15.23	78.20	0.00	21.80	96.00	61.40	76.00	3
14.83	69.60	4.80	25.60	24.00	62.30	8.00	0
14.83	69.60	4.80	25.60	24.00	83.50	0.00	0
14.83	69.60	4.80	25.60	24.00	75.00	5.00	2
14.83	69.60	4.80	25.60	48.00	62.10	15.00	2
14.83	69.60	4.80	25.60	48.00	83.00	4.00	0
14.83	69.60	4.80	25.60	48.00	74.80	8.00	3
14.83	69.60	4.80	25.60	60.00	62.50	21.00	2
14.83	69.60	4.80	25.60	60.00	83.00	8.00	0
14.83	69.60	4.80	25.60	60.00	74.50	15.00	2
14.83	69.60	4.80	25.60	72.00	62.00	30.00	3
14.83	69.60	4.80	25.60	72.00	82.90	13.00	2
14.83	69.60	4.80	25.60	72.00	74.30	22.00	3
14.83	69.60	4.80	25.60	84.00	61.90	50.00	3
14.83	69.60	4.80	25.60	84.00	82.90	18.00	2
14.83	69.60	4.80	25.60	84.00	74.00	22.00	3
14.83	69.60	4.80	25.60	96.00	61.90	75.00	4
14.83	69.60	4.80	25.60	96.00	74.00	26.00	3
14.83	69.60	4.80	25.60	96.00	82.50	23.00	3
14.98	78.20	5.00	16.80	24.00	84.10	2.00	2
14.98	78.20	5.00	16.80	24.00	75.00	6.00	3
14.98	78.20	5.00	16.80	24.00	64.10	6.00	3
14.98	78.20	5.00	16.80	48.00	84.00	10.00	3
14.98	78.20	5.00	16.80	48.00	74.90	19.00	2
14.98	78.20	5.00	16.80	48.00	63.80	27.00	2
14.98	78.20	5.00	16.80	60.00	83.80	20.00	3
14.98	78.20	5.00	16.80	60.00	74.60	25.00	3
14.98	78.20	5.00	16.80	60.00	63.10	25.00	2
14.98	78.20	5.00	16.80	72.00	82.90	21.00	3
14.98	78.20	5.00	16.80	72.00	74.00	26.00	2
14.98	78.20	5.00	16.80	72.00	63.00	27.00	3
14.98	78.20	5.00	16.80	84.00	83.00	29.00	3
14.98	78.20	5.00	16.80	84.00	73.00	31.00	2
14.98	78.20	5.00	16.80	84.00	62.00	27.00	2
14.98	78.20	5.00	16.80	96.00	83.00	60.00	3
14.98	78.20	5.00	16.80	96.00	73.00	68.00	3

..... continued

..... continued Table. 1

TEMPERATURE	CO2	O2	N2	EXPOSURE	R.H.	MORTALITY	S.D
C	%	%	%	h	%	%	%
14.98	78.20	5.00	16.80	96.00	62.00	69.00	3
20.30	69.60	4.00	26.40	24.00	84.00	1.00	2
20.30	69.60	4.00	26.40	24.00	74.50	5.00	2
20.30	69.60	4.00	26.40	24.00	62.90	4.00	3
20.30	69.60	4.00	26.40	48.00	83.90	9.00	2
20.30	69.60	4.00	26.40	48.00	73.80	11.00	2
20.30	69.60	4.00	26.40	48.00	62.50	7.00	2
20.30	69.60	4.00	26.40	60.00	82.90	11.00	3
20.30	69.60	4.00	26.40	60.00	74.60	19.00	2
20.30	69.60	4.00	26.40	60.00	62.90	20.00	3
20.30	69.60	4.00	26.40	72.00	82.80	19.00	2
20.30	69.60	4.00	26.40	72.00	74.30	24.00	0
20.30	69.60	4.00	26.40	72.00	62.00	24.00	0
20.30	69.60	4.00	26.40	84.00	82.50	35.00	2
20.30	69.60	4.00	26.40	84.00	74.60	38.00	3
20.30	69.60	4.00	26.40	84.00	61.90	46.00	4
20.30	69.60	4.00	26.40	96.00	82.50	57.00	2
20.30	69.60	4.00	26.40	96.00	61.90	73.00	2
20.30	69.60	4.00	26.40	96.00	74.30	48.00	4
20.40	79.30	3.50	17.20	24.00	82.00	3.00	2
20.40	79.30	3.50	17.20	24.00	74.50	2.00	3
20.40	79.30	3.50	17.20	24.00	63.20	1.00	2
20.40	79.30	3.50	17.20	48.00	81.50	7.00	2
20.40	79.30	3.50	17.20	48.00	74.00	6.00	2
20.40	79.30	3.50	17.20	48.00	63.00	12.00	0
20.40	79.30	3.50	17.20	60.00	81.40	16.00	0
20.40	79.30	3.50	17.20	60.00	73.80	14.00	3
20.40	79.30	3.50	17.20	60.00	62.90	25.00	2
20.40	79.30	3.50	17.20	72.00	73.50	31.00	2
20.40	79.30	3.50	17.20	72.00	61.90	34.00	3
20.40	79.30	3.50	17.20	72.00	81.00	29.00	2
20.40	79.30	3.50	17.20	84.00	61.90	66.00	2
20.40	79.30	3.50	17.20	84.00	73.00	69.00	3
20.40	79.30	3.50	17.20	84.00	81.00	43.00	3
20.40	79.30	3.50	17.20	96.00	61.50	73.00	2
20.40	79.30	3.50	17.20	96.00	72.80	80.00	0
20.40	79.30	3.50	17.20	96.00	81.00	50.00	3
15.20	88.00	0.00	12.00	24.00	84.00	0.00	3
15.20	88.00	0.00	12.00	24.00	73.90	2.00	2
15.20	88.00	0.00	12.00	24.00	62.80	4.00	2
15.20	88.00	0.00	12.00	48.00	83.80	3.00	4
15.20	88.00	0.00	12.00	48.00	73.10	4.00	0
15.20	88.00	0.00	12.00	48.00	62.40	8.00	4
15.20	88.00	0.00	12.00	60.00	83.00	12.00	0
15.20	88.00	0.00	12.00	60.00	72.90	21.00	4

..... continued



..... continued Table. 1

TEMPERATURE	CO2	O2	N2	EXPOSURE	R.H.	MORTALITY	S.D
C	%	%	%	h	%	%	%
15.20	88.00	0.00	12.00	60.00	62.00	27.00	2
15.20	88.00	0.00	12.00	72.00	84.70	26.00	3
15.20	88.00	0.00	12.00	72.00	75.00	27.00	2
15.20	88.00	0.00	12.00	72.00	62.90	41.00	2
15.20	88.00	0.00	12.00	84.00	84.10	50.00	4
15.20	88.00	0.00	12.00	84.00	74.30	55.00	2
15.20	88.00	0.00	12.00	84.00	62.00	66.00	2
15.20	88.00	0.00	12.00	96.00	84.00	74.00	2
15.20	88.00	0.00	12.00	96.00	74.00	79.00	2
15.20	88.00	0.00	12.00	96.00	62.00	86.00	2
15.20	90.20	4.00	5.80	24.00	84.00	4.00	3
15.20	90.20	4.00	5.80	24.00	74.20	5.00	3
15.20	90.20	4.00	5.80	24.00	62.00	5.00	3
15.20	90.20	4.00	5.80	48.00	83.80	14.00	2
15.20	90.20	4.00	5.80	48.00	74.00	18.00	2
15.20	90.20	4.00	5.80	48.00	61.80	23.00	2
15.20	90.20	4.00	5.80	60.00	83.50	19.00	2
15.20	90.20	4.00	5.80	60.00	73.60	26.00	3
15.20	90.20	4.00	5.80	60.00	61.00	27.00	2
15.20	90.20	4.00	5.80	72.00	83.00	20.00	2
15.20	90.20	4.00	5.80	72.00	73.00	29.00	4
15.20	90.20	4.00	5.80	72.00	61.00	34.00	2
15.20	90.20	4.00	5.80	84.00	84.40	42.00	2
15.20	90.20	4.00	5.80	84.00	74.50	48.00	2
15.20	90.20	4.00	5.80	84.00	62.80	53.00	2
15.20	90.20	4.00	5.80	96.00	84.00	65.00	2
15.20	90.20	4.00	5.80	96.00	74.00	72.00	3
15.20	90.20	4.00	5.80	96.00	62.00	75.00	3
10.43	71.10	4.90	24.00	24.00	83.80	0.00	3
10.43	71.10	4.90	24.00	24.00	74.00	4.00	2
10.43	71.10	4.90	24.00	24.00	62.80	3.00	2
10.43	71.10	4.90	24.00	48.00	83.50	4.00	2
10.43	71.10	4.90	24.00	48.00	74.00	5.00	2
10.43	71.10	4.90	24.00	48.00	61.00	9.00	3
10.43	71.10	4.90	24.00	60.00	83.00	11.00	2
10.43	71.10	4.90	24.00	60.00	73.50	13.00	3
10.43	71.10	4.90	24.00	60.00	60.20	17.00	2
10.43	71.10	4.90	24.00	72.00	82.80	24.00	3
10.43	71.10	4.90	24.00	72.00	73.00	26.00	3
10.43	71.10	4.90	24.00	72.00	60.00	32.00	0
10.43	71.10	4.90	24.00	84.00	82.00	29.00	2
10.43	71.10	4.90	24.00	84.00	73.00	34.00	2
10.43	71.10	4.90	24.00	84.00	60.00	39.00	3
10.43	71.10	4.90	24.00	96.00	84.00	50.00	2
10.43	71.10	4.90	24.00	96.00	74.50	63.00	0

..... continued

..... continued Table. 1

TEMPERATURE	CO2	O2	N2	EXPOSURE	R.H.	MORTALITY	S.D
C	%	%	%	h	%	%	%
10.43	71.10	4.90	24.00	96.00	62.90	58.00	0
20.30	91.30	3.50	5.20	24.00	64.10	7.00	2
20.30	91.30	3.50	5.20	24.00	73.80	0.00	2
20.30	91.30	3.50	5.20	48.00	83.00	12.00	0
20.30	91.30	3.50	5.20	48.00	73.80	10.00	2
20.30	91.30	3.50	5.20	48.00	63.80	14.00	2
20.30	91.30	3.50	5.20	60.00	73.80	22.00	2
20.30	91.30	3.50	5.20	60.00	63.90	25.00	2
20.30	91.30	3.50	5.20	60.00	83.20	21.00	2
20.30	91.30	3.50	5.20	72.00	63.80	43.00	3
20.30	91.30	3.50	5.20	72.00	73.80	47.00	2
20.30	91.30	3.50	5.20	72.00	83.20	39.00	2
20.30	91.30	3.50	5.20	84.00	73.80	63.00	2
20.30	91.30	3.50	5.20	84.00	63.80	71.00	2
20.30	91.30	3.50	5.20	84.00	83.20	58.00	2
20.30	91.30	3.50	5.20	96.00	73.60	80.00	3
20.30	91.30	3.50	5.20	96.00	63.50	97.00	3
20.30	91.30	3.50	5.20	96.00	83.00	77.00	6
10.12	77.20	4.90	17.90	24.00	84.10	4.00	0
10.12	77.20	4.90	17.90	24.00	73.80	3.00	2
10.12	77.20	4.90	17.90	24.00	62.10	1.00	2
10.12	77.20	4.90	17.90	48.00	62.00	12.00	0
10.12	77.20	4.90	17.90	48.00	74.00	8.00	0
10.12	77.20	4.90	17.90	48.00	83.90	2.00	2
10.12	77.20	4.90	17.90	60.00	61.70	20.00	3
10.12	77.20	4.90	17.90	60.00	72.90	14.00	2
10.12	77.20	4.90	17.90	60.00	83.70	12.00	0
10.12	77.20	4.90	17.90	72.00	61.50	39.00	4
10.12	77.20	4.90	17.90	72.00	72.70	23.00	2
10.12	77.20	4.90	17.90	72.00	83.70	19.00	2
10.12	77.20	4.90	17.90	84.00	61.20	53.00	3
10.12	77.20	4.90	17.90	84.00	72.50	19.00	2
10.12	77.20	4.90	17.90	84.00	83.00	26.00	3
10.12	77.20	4.90	17.90	96.00	61.00	65.00	3
10.12	77.20	4.90	17.90	96.00	72.00	56.00	0
10.12	77.20	4.90	17.90	96.00	82.50	55.00	2
10.26	91.70	4.90	3.90	24.00	84.00	3.00	2
10.26	91.70	4.90	3.90	24.00	73.20	1.00	2
10.26	91.70	4.90	3.90	24.00	61.90	2.00	3
10.26	91.70	4.90	3.90	48.00	61.30	17.00	2
10.26	91.70	4.90	3.90	48.00	72.90	7.00	4
10.26	91.70	4.90	3.90	48.00	83.60	4.00	0
10.26	91.70	4.90	3.90	60.00	61.80	27.00	2
10.26	91.70	4.90	3.90	60.00	74.00	25.00	3
10.26	91.70	4.90	3.90	60.00	83.40	15.00	2

..... continued

..... continued Table. 1

TEMPERATURE	CO2	O2	N2	EXPOSURE	R.H.	MORTALITY	S.D
C	%	%	%	h	%	%	%
10.26	91.70	4.90	3.90	72.00	61.90	33.00	2
10.26	91.70	4.90	3.90	72.00	73.80	30.00	2
10.26	91.70	4.90	3.90	72.00	83.20	20.00	3
10.26	91.70	4.90	3.90	84.00	61.50	61.00	3
10.26	91.70	4.90	3.90	84.00	73.00	49.00	2
10.26	91.70	4.90	3.90	84.00	83.00	33.00	2
10.26	91.70	4.90	3.90	96.00	61.90	84.00	3
10.26	91.70	4.90	3.90	96.00	72.50	65.00	2
10.26	91.70	4.90	3.90	96.00	82.10	59.00	2
10.20	68.00	7.30	24.70	24.00	61.90	0.00	0
10.20	68.00	7.30	24.70	24.00	73.20	2.00	0
10.20	68.00	7.30	24.70	24.00	83.30	0.00	2
10.20	68.00	7.30	24.70	48.00	61.50	11.00	2
10.20	68.00	7.30	24.70	48.00	73.00	9.00	2
10.20	68.00	7.30	24.70	48.00	83.50	5.00	2
10.20	68.00	7.30	24.70	60.00	61.40	19.00	2
10.20	68.00	7.30	24.70	60.00	72.90	15.00	2
10.20	68.00	7.30	24.70	60.00	83.40	13.00	2
10.20	68.00	7.30	24.70	72.00	61.50	40.00	4
10.20	68.00	7.30	24.70	72.00	73.00	27.00	2
10.20	68.00	7.30	24.70	72.00	83.50	23.00	3
10.20	68.00	7.30	24.70	84.00	61.00	48.00	5
10.20	68.00	7.30	24.70	84.00	72.60	31.00	3
10.20	68.00	7.30	24.70	84.00	83.00	32.00	2
10.20	68.00	7.30	24.70	96.00	60.90	70.00	2
10.20	68.00	7.30	24.70	96.00	72.50	73.00	3
10.20	68.00	7.30	24.70	96.00	83.00	54.00	3
10.39	88.30	9.20	2.40	24.00	62.00	4.00	2
10.39	88.30	9.20	2.40	24.00	74.00	2.00	2
10.39	88.30	9.20	2.40	24.00	83.00	1.00	2
10.39	88.30	9.20	2.40	48.00	83.20	14.00	2
10.39	88.30	9.20	2.40	48.00	74.10	13.00	2
10.39	88.30	9.20	2.40	48.00	61.90	23.00	3
10.39	88.30	9.20	2.40	60.00	61.80	29.00	2
10.39	88.30	9.20	2.40	60.00	73.80	33.00	2
10.39	88.30	9.20	2.40	60.00	82.80	27.00	3
10.39	88.30	9.20	2.40	72.00	61.90	43.00	3
10.39	88.30	9.20	2.40	72.00	73.80	36.00	2
10.39	88.30	9.20	2.40	72.00	82.80	34.00	2
10.39	88.30	9.20	2.40	84.00	61.80	59.00	3
10.39	88.30	9.20	2.40	84.00	73.80	47.00	3
10.39	88.30	9.20	2.40	84.00	82.90	50.00	2
10.39	88.30	9.20	2.40	96.00	61.90	69.00	3
10.39	88.30	9.20	2.40	96.00	74.00	65.00	2
10.39	88.30	9.20	2.40	96.00	82.80	63.00	2

..... continued

..... continued Table. 1

TEMPERATURE	CO2	O2	N2	EXPOSURE	R.H.	MORTALITY	S.D
C	%	%	%	h	%	%	%
14.93	90.90	8.00	1.10	24.00	80.90	2.00	3
14.93	90.90	8.00	1.10	24.00	74.30	0.00	0
14.93	90.90	8.00	1.10	24.00	61.80	0.00	0
14.93	90.90	8.00	1.10	48.00	61.70	14.00	2
14.93	90.90	8.00	1.10	48.00	74.00	3.00	2
14.93	90.90	8.00	1.10	48.00	80.80	4.00	0
14.93	90.90	8.00	1.10	60.00	61.70	25.00	2
14.93	90.90	8.00	1.10	60.00	74.00	15.00	3
14.93	90.90	8.00	1.10	60.00	80.90	11.00	3
14.93	90.90	8.00	1.10	72.00	61.00	51.00	2
14.93	90.90	8.00	1.10	72.00	73.80	35.00	6
14.93	90.90	8.00	1.10	72.00	81.00	33.00	2
14.93	90.90	8.00	1.10	84.00	60.90	66.00	5
14.93	90.90	8.00	1.10	84.00	73.20	51.00	2
14.93	90.90	8.00	1.10	84.00	80.90	40.00	7
14.93	90.90	8.00	1.10	96.00	60.90	73.00	3
14.93	90.90	8.00	1.10	96.00	73.00	65.00	3
14.93	90.90	8.00	1.10	96.00	80.80	59.00	2
15.18	78.80	7.00	14.20	24.00	83.90	0.00	2
15.18	78.80	7.00	14.20	24.00	74.90	0.00	0
15.18	78.80	7.00	14.20	24.00	63.10	0.00	0
15.18	78.80	7.00	14.20	48.00	83.30	9.00	0
15.18	78.80	7.00	14.20	48.00	74.30	11.00	2
15.18	78.80	7.00	14.20	48.00	62.90	9.00	2
15.18	78.80	7.00	14.20	60.00	61.80	26.00	2
15.18	78.80	7.00	14.20	60.00	74.10	23.00	5
15.18	78.80	7.00	14.20	60.00	83.20	15.00	2
15.18	78.80	7.00	14.20	72.00	83.00	30.00	2
15.18	78.80	7.00	14.20	72.00	74.00	34.00	2
15.18	78.80	7.00	14.20	72.00	61.50	29.00	2
15.18	78.80	7.00	14.20	84.00	73.50	49.00	2
15.18	78.80	7.00	14.20	84.00	61.80	52.00	4
15.18	78.80	7.00	14.20	84.00	82.90	38.00	0
15.18	78.80	7.00	14.20	96.00	61.80	70.00	2
15.18	78.80	7.00	14.20	96.00	74.00	64.00	2
15.18	78.80	7.00	14.20	96.00	83.00	48.00	0
15.10	69.80	8.40	21.80	24.00	83.90	2.00	2
15.10	69.80	8.40	21.80	24.00	74.10	0.00	3
15.10	69.80	8.40	21.80	24.00	62.10	3.00	3
15.10	69.80	8.40	21.80	48.00	62.00	16.00	2
15.10	69.80	8.40	21.80	48.00	74.00	4.00	0
15.10	69.80	8.40	21.80	48.00	83.80	6.00	3
15.10	69.80	8.40	21.80	60.00	61.90	26.00	3
15.10	69.80	8.40	21.80	60.00	74.00	14.00	2
15.10	69.80	8.40	21.80	60.00	83.10	11.00	2

..... continued

..... continued Table. 1

TEMPERATURE	CO2	O2	N2	EXPOSURE	R.H.	MORTALITY	S.D
C	%	%	%	h	%	%	%
15.10	69.80	8.40	21.80	72.00	82.90	39.00	4
15.10	69.80	8.40	21.80	72.00	73.70	38.00	2
15.10	69.80	8.40	21.80	72.00	61.70	34.00	2
15.10	69.80	8.40	21.80	84.00	61.60	65.00	2
15.10	69.80	8.40	21.80	84.00	73.20	54.00	4
15.10	69.80	8.40	21.80	84.00	82.80	34.00	2
15.10	69.80	8.40	21.80	96.00	61.70	74.00	2
15.10	69.80	8.40	21.80	96.00	73.20	63.00	3
15.10	69.80	8.40	21.80	96.00	82.50	58.00	2
20.28	68.00	7.50	24.50	24.00	84.10	0.00	0
20.28	68.00	7.50	24.50	24.00	74.60	0.00	0
20.28	68.00	7.50	24.50	24.00	63.80	0.00	0
20.28	68.00	7.50	24.50	48.00	62.90	10.00	3
20.28	68.00	7.50	24.50	48.00	74.00	9.00	2
20.28	68.00	7.50	24.50	48.00	84.00	4.00	0
20.28	68.00	7.50	24.50	60.00	62.50	31.00	2
20.28	68.00	7.50	24.50	60.00	74.00	24.00	0
20.28	68.00	7.50	24.50	60.00	83.80	32.00	0
20.28	68.00	7.50	24.50	72.00	83.90	44.00	3
20.28	68.00	7.50	24.50	72.00	74.00	44.00	0
20.28	68.00	7.50	24.50	72.00	62.60	58.00	2
20.28	68.00	7.50	24.50	84.00	83.80	53.00	2
20.28	68.00	7.50	24.50	84.00	74.00	53.00	2
20.28	68.00	7.50	24.50	84.00	62.50	66.00	2
20.28	68.00	7.50	24.50	96.00	83.70	71.00	3
20.28	68.00	7.50	24.50	96.00	73.80	65.00	2
20.28	68.00	7.50	24.50	96.00	62.00	73.00	2
19.78	78.70	9.30	12.00	24.00	63.90	8.00	2
19.78	78.70	9.30	12.00	24.00	74.80	3.00	0
19.78	78.70	9.30	12.00	24.00	84.10	0.00	2
19.78	78.70	9.30	12.00	48.00	63.50	13.00	0
19.78	78.70	9.30	12.00	48.00	74.50	9.00	2
19.78	78.70	9.30	12.00	48.00	84.00	4.00	2
19.78	78.70	9.30	12.00	60.00	83.80	16.00	0
19.78	78.70	9.30	12.00	60.00	74.00	21.00	0
19.78	78.70	9.30	12.00	60.00	62.90	23.00	2
19.78	78.70	9.30	12.00	72.00	83.60	36.00	2
19.78	78.70	9.30	12.00	72.00	73.90	40.00	2
19.78	78.70	9.30	12.00	72.00	62.90	45.00	3
19.78	78.70	9.30	12.00	84.00	62.80	55.00	2
19.78	78.70	9.30	12.00	84.00	73.90	49.00	0
19.78	78.70	9.30	12.00	84.00	83.70	45.00	2
19.78	78.70	9.30	12.00	96.00	62.60	60.00	2
19.78	78.70	9.30	12.00	96.00	73.70	53.00	2
19.78	78.70	9.30	12.00	96.00	83.50	49.00	0

..... continued

..... continued Table. 1

TEMPERATURE	CO2	O2	N2	EXPOSURE	R.H.	MORTALITY	S.D
C	%	%	%	h	%	%	%
20.00	91.10	7.50	1.40	24.00	84.00	9.00	2
20.00	91.10	7.50	1.40	24.00	74.50	8.00	2
20.00	91.10	7.50	1.40	24.00	64.00	11.00	2
20.00	91.10	7.50	1.40	48.00	84.00	17.00	0
20.00	91.10	7.50	1.40	48.00	74.20	20.00	2
20.00	91.10	7.50	1.40	48.00	63.80	18.00	2
20.00	91.10	7.50	1.40	60.00	83.90	30.00	2
20.00	91.10	7.50	1.40	60.00	73.80	34.00	2
20.00	91.10	7.50	1.40	60.00	62.50	37.00	3
20.00	91.10	7.50	1.40	72.00	83.80	47.00	2
20.00	91.10	7.50	1.40	72.00	73.60	45.00	0
20.00	91.10	7.50	1.40	72.00	62.80	48.00	3
20.00	91.10	7.50	1.40	84.00	83.60	66.00	2
20.00	91.10	7.50	1.40	84.00	73.40	70.00	2
20.00	91.10	7.50	1.40	84.00	62.50	65.00	3
20.00	91.10	7.50	1.40	96.00	83.50	81.00	2
20.00	91.10	7.50	1.40	96.00	73.00	85.00	0
20.00	91.10	7.50	1.40	96.00	62.50	81.00	1
9.70	80.60	8.00	11.40	24.00	84.00	0.00	2
9.70	80.60	8.00	11.40	24.00	75.00	1.00	2
9.70	80.60	8.00	11.40	24.00	62.00	3.00	0
9.70	80.60	8.00	11.40	48.00	83.80	5.00	3
9.70	80.60	8.00	11.40	48.00	74.20	16.00	0
9.70	80.60	8.00	11.40	48.00	61.90	18.00	2
9.70	80.60	8.00	11.40	60.00	83.00	20.00	2
9.70	80.60	8.00	11.40	60.00	74.00	30.00	2
9.70	80.60	8.00	11.40	60.00	61.00	33.00	2
9.70	80.60	8.00	11.40	72.00	84.70	29.00	3
9.70	80.60	8.00	11.40	72.00	74.70	39.00	3
9.70	80.60	8.00	11.40	72.00	63.00	43.00	4
9.70	80.60	8.00	11.40	84.00	84.30	45.00	2
9.70	80.60	8.00	11.40	84.00	74.20	51.00	2
9.70	80.60	8.00	11.40	84.00	62.00	59.00	2
9.70	80.60	8.00	11.40	96.00	83.00	61.00	2
9.70	80.60	8.00	11.40	96.00	62.00	77.00	2
9.70	80.60	8.00	11.40	96.00	74.00	70.00	2
9.90	68.00	0.00	32.00	24.00	74.00	1.00	2
9.90	68.00	0.00	32.00	24.00	63.00	2.00	1
9.90	68.00	0.00	32.00	24.00	82.00	0.00	0
9.90	68.00	0.00	32.00	48.00	63.00	11.00	4
9.90	68.00	0.00	32.00	48.00	75.00	12.00	3
9.90	68.00	0.00	32.00	48.00	81.00	2.00	2
9.90	68.00	0.00	32.00	96.00	62.80	39.00	2
9.90	68.00	0.00	32.00	96.00	74.90	39.00	2
9.90	68.00	0.00	32.00	96.00	81.00	31.00	2

Table 2. Mean and standard deviation (S.D) of the mortality of *C. ferrugineus* eggs exposed to various controlled atmospheres.

Temperature	CO <sub>2</sub>	O <sub>2</sub>	N <sub>2</sub>	EXPOSURE	R.H.	MORTALITY	S.D
C	%	%	%	h	%	%	%
20.40	70.90	5.00	24.10	24.00	84.00	2.00	0
20.40	70.90	5.00	24.10	24.00	73.80	0.00	0
20.40	70.90	5.00	24.10	24.00	63.40	10.00	0
20.40	70.90	5.00	24.10	48.00	84.00	20.00	0
20.40	70.90	5.00	24.10	48.00	74.20	15.00	4
20.40	70.90	5.00	24.10	48.00	63.80	20.00	0
20.40	70.90	5.00	24.10	96.00	83.00	40.00	7
20.40	70.90	5.00	24.10	96.00	73.00	40.00	7
20.40	70.90	5.00	24.10	96.00	62.50	45.00	4
20.00	80.00	4.20	15.80	24.00	83.10	5.00	4
20.00	80.00	4.20	15.80	24.00	73.50	15.00	4
20.00	80.00	4.20	15.80	24.00	63.10	20.00	0
20.00	80.00	4.20	15.80	48.00	82.90	20.00	0
20.00	80.00	4.20	15.80	48.00	73.00	15.00	4
20.00	80.00	4.20	15.80	48.00	63.00	20.00	0
20.00	80.00	4.20	15.80	96.00	83.00	50.00	5
20.00	80.00	4.20	15.80	96.00	73.00	60.00	0
20.00	80.00	4.20	15.80	96.00	62.50	60.00	0
20.90	90.70	3.50	5.80	48.00	82.50	20.00	0
20.90	90.70	3.50	5.80	48.00	73.80	15.00	4
20.90	90.70	3.50	5.80	48.00	63.50	15.00	4
20.90	90.70	3.50	5.80	24.00	82.50	5.00	4
20.90	90.70	3.50	5.80	24.00	73.80	15.00	4
20.90	90.70	3.50	5.80	24.00	63.50	5.00	4
20.90	90.70	3.50	5.80	96.00	83.70	55.00	4
20.90	90.70	3.50	5.80	96.00	73.40	60.00	0
20.90	90.70	3.50	5.80	96.00	63.00	70.00	5
10.40	68.90	4.00	27.10	24.00	83.00	5.00	4
10.40	68.90	4.00	27.10	24.00	73.50	10.00	5
10.40	68.90	4.00	27.10	24.00	62.50	10.00	5
10.40	68.90	4.00	27.10	48.00	82.90	15.00	4
10.40	68.90	4.00	27.10	48.00	73.50	20.00	0
10.40	68.90	4.00	27.10	48.00	62.00	15.00	4
10.40	68.90	4.00	27.10	96.00	82.50	35.00	6
10.40	68.90	4.00	27.10	96.00	72.90	50.00	5
10.40	68.90	4.00	27.10	96.00	61.80	55.00	8
9.20	79.00	4.90	16.10	24.00	83.80	15.00	4
9.20	79.00	4.90	16.10	24.00	74.00	15.00	4
9.20	79.00	4.90	16.10	24.00	63.70	0.00	0
9.20	79.00	4.90	16.10	48.00	83.60	25.00	4
9.20	79.00	4.90	16.10	48.00	73.80	30.00	5
9.20	79.00	4.90	16.10	48.00	63.00	10.00	5
9.20	79.00	4.90	16.10	96.00	83.00	30.00	5

..... Continued

..... Continued Table 2.

Temperature	CO2	O2	N2	EXPOSURE	R.H.	MORTALITY	S.D
C	%	%	%	h	%	%	%
9.20	79.00	4.90	16.10	96.00	73.00	40.00	0
9.20	79.00	4.90	16.10	96.00	62.00	60.00	0
9.90	90.40	3.80	5.80	24.00	83.50	5.00	4
9.90	90.40	3.80	5.80	24.00	73.50	5.00	4
9.90	90.40	3.80	5.80	24.00	62.80	10.00	5
9.90	90.40	3.80	5.80	48.00	84.00	15.00	5
9.90	90.40	3.80	5.80	48.00	74.00	15.00	4
9.90	90.40	3.80	5.80	48.00	62.50	15.00	4
9.90	90.40	3.80	5.80	96.00	83.00	35.00	4
9.90	90.40	3.80	5.80	96.00	73.00	50.00	0
9.90	90.40	3.80	5.80	96.00	62.00	55.00	0
20.00	70.10	0.20	29.70	24.00	83.00	20.00	5
20.00	70.10	0.20	29.70	24.00	73.00	20.00	5
20.00	70.10	0.20	29.70	24.00	63.00	30.00	5
20.00	70.10	0.20	29.70	48.00	84.00	30.00	7
20.00	70.10	0.20	29.70	48.00	74.20	30.00	4
20.00	70.10	0.20	29.70	48.00	63.80	40.00	0
20.00	70.10	0.20	29.70	96.00	83.00	55.00	4
20.00	70.10	0.20	29.70	96.00	73.00	60.00	0
20.00	70.10	0.20	29.70	96.00	62.50	75.00	4
20.00	80.70	0.30	19.00	24.00	83.00	25.00	0
20.00	80.70	0.30	19.00	24.00	73.00	30.00	5
20.00	80.70	0.30	19.00	24.00	63.00	35.00	4
20.00	80.70	0.30	19.00	48.00	82.90	30.00	4
20.00	80.70	0.30	19.00	48.00	73.00	35.00	5
20.00	80.70	0.30	19.00	48.00	63.00	50.00	5
20.00	80.70	0.30	19.00	96.00	83.00	50.00	5
20.00	80.70	0.30	19.00	96.00	73.00	65.00	4
20.00	80.70	0.30	19.00	96.00	62.50	80.00	0
20.90	88.70	0.50	10.80	24.00	82.50	20.00	0
20.90	88.70	0.50	10.80	24.00	73.80	25.00	4
20.90	88.70	0.50	10.80	24.00	63.50	30.00	5
20.90	88.70	0.50	10.80	48.00	82.50	30.00	5
20.90	88.70	0.50	10.80	48.00	73.80	60.00	0
20.90	88.70	0.50	10.80	48.00	63.50	60.00	0
20.90	88.70	0.50	10.80	96.00	83.70	55.00	4
20.90	88.70	0.50	10.80	96.00	73.40	75.00	4
20.90	88.70	0.50	10.80	96.00	63.00	85.00	4
10.20	68.00	0.00	32.00	24.00	83.00	15.00	4
10.20	68.00	0.00	32.00	24.00	73.50	15.00	4
10.20	68.00	0.00	32.00	24.00	62.50	15.00	4
10.20	68.00	0.00	32.00	48.00	82.90	20.00	4
10.20	68.00	0.00	32.00	48.00	73.00	30.00	2
10.20	68.00	0.00	32.00	48.00	62.00	25.00	6
10.20	68.00	0.00	32.00	96.00	82.00	40.00	5

..... continued



..... continued Table 2

Temperature	CO2	O2	N2	EXPOSURE	R.H.	MORTALITY	S.D
C	%	%	%	h	%	%	%
10.20	68.00	0.00	32.00	96.00	72.90	50.00	5
10.20	68.00	0.00	32.00	96.00	61.00	60.00	7
9.80	79.30	0.30	20.40	24.00	83.80	15.00	4
9.80	79.30	0.30	20.40	24.00	74.00	15.00	4
9.80	79.30	0.30	20.40	24.00	63.70	20.00	0
9.80	79.30	0.30	20.40	48.00	83.60	35.00	4
9.80	79.30	0.30	20.40	48.00	73.80	45.00	3
9.80	79.30	0.30	20.40	48.00	63.00	45.00	7
9.80	79.30	0.30	20.40	96.00	83.00	40.00	7
9.80	79.30	0.30	20.40	96.00	73.00	50.00	5
9.80	79.30	0.30	20.40	96.00	62.00	60.00	6
9.00	90.60	0.20	9.20	24.00	83.50	20.00	0
9.00	90.60	0.20	9.20	24.00	73.50	15.00	4
9.00	90.60	0.20	9.20	24.00	62.80	20.00	6
9.00	90.60	0.20	9.20	48.00	84.00	30.00	5
9.00	90.60	0.20	9.20	48.00	74.00	35.00	4
9.00	90.60	0.20	9.20	48.00	62.50	30.00	5
9.00	90.60	0.20	9.20	96.00	83.00	55.00	4
9.00	90.60	0.20	9.20	96.00	73.00	65.00	4
9.00	90.60	0.20	9.20	96.00	62.00	60.00	5