RELATIVE SUSCEPTIBILITY OF VARIETIES OF PADDY GRAINS TO INFESTATION BY THE ANGOUMOIS GRAIN MOTH (*Sitotroga cerealella* OLIVIER)

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THESIS

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C E R T I F I C A T E

This is to certify that the thesis herewith submitted contains the results of bonafide research work carried out by Sri. Abraham, C.C., under my supervision. No part of the work embodied in this thesis has been submitted earlier for the award of any degree.

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C O N T E N T S

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INTRODUCTION

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Insect infestations in stored grains have been variously estimated to cause 5-10% loss. So it is essentially a matter of utmost importance to protect our food grains while under storage, especially at this time when India is passing through a state of national emergency and all our resources have to be mobilised.

Rice, the staple food of Kerala, is stored in the unhusked form for long periods either for consumption or for seed purposes. In storage this is subject to considerable damage by a variety of pests, among which the Angoumois grain moth Sitotroga cerealella Oliv. is of major importance in Kerala. It is commonly observed that the depredations by this pest are more serious in the main season produce, harvested in July-August. This is presumably on account of inadequate drying consequent on the occurrence of intermittent showers at the time of harvest.

Control measures like fumigation, though effective against the pest, is difficult to be applied in rural areas on account of meagre godown facilities. Using varieties of seeds which show relatively less susceptibility to attack by the moth, may prove to be adequate in minimising infestations in storage.

Very little work has so far been done in this line.

Ramiah (1937) has reported varietal differences in rice with regard to attack by <u>Sitotroga cerealella</u> Ol. According to him glutinous rices and rice with golden brown glumes are comparatively more susceptible than others. Israel and Vedamurti (1958) have observed that generally fine grained scented varieties are more susceptible than coarse grained ones and that this is presumably because of the higher moisture content of finer varieties.

With a view to grade the different varieties of paddy seeds in use in this State, with reference to susceptibility to attack of <u>S. cerealella</u> and to prevent the deterioration thereby in storage, the present investigations were taken up. In these studies twenty nine varieties of paddy seeds grown in different parts of the State have been subjected to infestation by a single generation of <u>S. cerealella</u> under laboratory conditions and under natural conditions existing in godowns. Besides studying the extent of infestation in the different varieties, observations have also been made on the effect of the different varieties of seeds on the developmental period, size and fecundity of the moths. Significant variations in all these factors have been observed in the different varieties of paddy seeds under test. There are varieties which appear to be highly resistant, or highly susceptible or showing intermediate susceptibilities of varying degrees.

A comprehensive review of work done so far on insect pests affecting rice under storage is also given.

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REVIEW OF LITERATURE

II REVIEW OF LITERATURE

PESTS OF STORED RICE

Thirty one species of insects and two species of mites have been so far recorded as pests infesting stored rice. Following is a review of the work done on these pests.

ORDER: COLEOPTERA

1. Calandra (Sitophilus) Oryzae Linn. (Curculionidae)

Commonly called rice weevil, this insect was first recorded in India by Lefroy (1909). Fletcher (1914) observed it on ripe grains in the field. Fletcher and Ghosh (1920) found that at Pusa, Bihar, the weevils are active from August to October when they complete three generations in quick succession. Its development is extremely slow from November to July, a single generation during this period taking 1½ - 6 months. Cotton (1923) recorded Aplastomorpha vandinei Tucker (Chalcidae) on S. oryzae and S. granaria, all stages of the pest being attacked, though larvae are preferred. The parasite was observed to complete its life cycle in a little less than half the time required by its host. Wille (1923) observed in Brazil, that rice in husk is not attacked by this weevil. In the sub-tropical climate of South Brazil, there were at least five generations in a year, the duration of the various stages being 6-9 days for egg, 12-17 days for larva, and 7-11 days for pupa. Lord (1928) noticed that rice seeds exposed to attack by S. oryzae deteriorated in storage by 23.25%.

Hozawa (1929) described the life history of the weevil, breeding in rice in Japan. Eggs are generally deposited singly within rice kernel. These hatch in 4-16 days. There are four larval instars. The larval stage lasts 2-3 weeks, the prepupal period 1-2 days, and the pupal stage 4-9 days. Takahashi (1934) studied the causes of heat in stored rice infested by C. sasaki Tak. The temperature reaches a maximum of 35° C, 12 days after the larvae hatch, when their body temperature and respiration rate are highest. Commun (1934) stated that rice is protected from weevils by storing it in metal or reinforced concrete containers. Square (1934) proved that rethreshing infested grains reduced infestation from 1.5 to 0.6%. He (1935) also found that 1 pound of calcium carbonate per 180 pounds of rice was effective in preventing weevil infestation for at least eight months.

Kunike (1936) working out the biology of C. granaria L., mentioned that the weevils do not feed on unhusked rice. According to Kuo Li-Sien (1936), boric acid was effective in the control of C. oryzae in stored rice. Kono (1937) observed that at 30°C all pupae and larvae of _C. oryzae_ are killed in three hours by chloropicrin applied at the rate of 1 pound per 100 cubic feet of space. Adults and eggs are killed in less than one hour. Treiman (1937) found that polished rice was found to be almost immune from infestation by _C. oryzae_, which he said was probably because it is dried, and the grains are too hard for the weevils to oviposit. According to Voute (1937) migration of _C. oryzae_, which is placed deeply in the grain escape polishing machinery. Romanova _et al_ (1938) reported _Lariophagus distinguendus_ Forst., parasitising _S. oryzae_. Kunike (1938) stated that this weevil could not feed on unhusked rice, while husked and otherwise untreated rice was a good medium for them.

Kawano (1939) observing oviposition sites of _C. oryzae_, showed that the females oviposit more commonly on the middle part of a rice grain than near the ends. Nakayama (1939) studied the rates of multiplication of _C. oryzae_ in Japan. He obtained a population of 252 males and 614 females out of a pair of adult progeny, reared in rice medium for about 150 days. According to Herford (1939) in Hongkong, the weevils breed rapidly in first quality polished rice. Kinoshita and Ishikura (1940) observed that in the weevils, the length of elytra, rostrum, and the hind femora decreased with a fall in humidity below 50-60%. Nakayama (1940) recorded that the average duration of life cycle of the weevil ranged from 33 days for eggs laid in July, to 60 days in case of those eggs laid in September. It was further observed that development of the weevil is considerably accelerated by a higher temperature obtaining inside rice bags.

According to Corbett and Pagden (1941) C. oryzae breed rapidly in rice at a relative humidity of 70%, but reproduction was much slower at 50 or 60% relative humidity. Balzer (1942) mentioned that the weevil bores into the hull of the grain that are broken or have failed to close properly after blooming. Cheo and Chang (1943) suggested covering of stored rice with a layer of fine sand 2-4 cms. thick, and storing in unhusked condition to prevent damage by the weevils. Pruthi and Singh (1943) recorded C. oryzae as a serious pest of paddy and almost all other cereals in India. Ghosh (1947) found that a 5% B.H.C. dust applied to rice in bags at the rate of 1½ pounds per 165 square feet of exposed area controls the pest. Reinfestation was not apparent for six months following dusting. Richards (1945) attributed the cause of variation in size of C. oryzae to the existence of two strains, one of which being about twice as heavy as the other. Crossing of the two strains was difficult and the hybrids appeared to produce no viable offspring. Khan (1948) estimated the average annual loss caused by the weevils alone in India to be 1,00,000 tons of stored rice. Krishnamurti and Rao (1950) found rice less attractive to the weevils than 'Jowar' or wheat. Rao (1953) further observed that a larger population of the weevil developed in fine rice than in coarse variety during the first six months of continuous feeding.

Pingale *et al* (1957) noted that husked rice is infested to a greater extent than hand pounded rice, milled raw rice, and parboiled rice. Infestation of the rice grain causes loss of starch in the gruel during cooking. Israel and Vedamurti (1958) observed that *S. oryzae* may infest the developing grain in the field and reach the store along with harvested grain, here under favourable conditions the pest multiplies. According to Lin Tsung (1958) in Formosa, the egg, larval prepupal, and pupal stages last 3-10, 15-29, 1-2 and 3-13 days respectively. A female lays from 4 to 356 eggs and the adult males and females survive for 12-230 and 9-139 days respectively. There are eight generations in the year. Breeze (1960) pointed out that the rice weevil is unable to feed and breed on a grain with an intact husk even when the moisture content is high. Its rapid multiplication, according to him, is dependent on a high proportion of grains with badly damaged husks. Kushel (1961), after examining the available type material, considered that S. oryzae Var. minor is a synonym of S. oryzae. Bang Yong and Floyd (1962) observed that malathion 8 parts per million, gave excellent protection from damage by the rice weevil. Sander (1962) studying the effect of food on the weight, size and fecundity of C. granaria and C. oryzae, found that the weevils emerging from rice are the lightest and their fecundity the lowest.

2. Rhizopertha dominica Fab. (Bostrychidae)
Lesser grain borer.

Lefroy (1909) recorded it first as a household pest boring into biscuits and other dry stored produce as well as stored paddy. Fletcher (1914) mentioned it as widely distributed in S. India on stored paddy. Fletcher and Ghosh (1920) found that Rhizopertha does not infest grain if free air finds access into storage receptacle. Herdman (1921) reported two Chalcids Chaetospila elegans and Lariophagus calandrae parasitising larvae or Rhizopertha beetles. Goodrich (1921) stated that larvae and rarely pupae of the lesser grain borer were parasitised by Lariophagus distinguendus Forst. Stracener (1931) recorded the pest as the most serious on rough stored rice in Louisiana. Herford (1939) found the beetles damaging unpolished rice in Hong Kong. Geijskes (1940) demonstrated that hulled rice is less severely infested by Rhizopertha than unhulled rice. Experiments in Madras (1941) showed that stored grain is more effectively protected against R. dominica by drying it monthly in the sun, than by mixing various materials with it. Of the various materials tried, powdered acorins and a mix of lime and creosote gave better results than several others. Corbett and Pagden (1941) recorded it as an important pest of stored rice in Malaya. Pruthi and Singh (1943) observed that in India, the egg, larval, prepupal, and pupal stages last 5-11 days, 44 days, 7-8 days, respectively and that the insect does not flourish in grain infested with fungi. Narasimhan and Krishnamurti (1944) found that finely powdered burnt rice husk adhere readily to paddy grains when thoroughly mixed with them, and under laboratory conditions gave 100% mortality to R. dominica.

Krishnamurti and Rao (1950) observed that infestation of cereals by the pest appears after the peak period of attack by the weevils. Eikichi Iso (1954) stated the pest as noxious in rice godowns in Japan. Salmond (1956) conducted a market survey in Nayasaland and found *R. dominica* as one of the important primary pests of stored rice. Lin Tsung (1958) stated that in Formosa, the insect has 5-6 generations in a year. Adult males and females survive for 64.6 and 80.1 days respectively on an average. The females lay up to 970 eggs each. The egg and the pupal stages average 13.3 and 5.9 days, and the four larval instars require 5-11, 5-15, 5-19, and 6-14 days respectively. The only natural enemy observed is *Tyroglyphus farinae* Deg. which feed on eggs.

Prevett (1959) found that temperatures within the raw rice stack lightly infested by *Rhizopertha* beetles show a fairly close correlation with the trend of ambient conditions. Breese (1961) observed a marked reduction in feeding and oviposition when females are supplied with cut grains of hulled rice. The relatively reduced rate of oviposition observed on rice, is according to him, due to nutritional values or the harder texture of the rice kernel.

3. *Dinoderus minutum* F. (Bostrychidae)

Menory Ortega (1934) recorded the beetle infesting stored rice in Santo Domingo, Herford (1939) in Hong Kong and Cotton (1947) in the tropical countries.

4. Trogoderma Spp. (Dermestidae)

'Khapra'beetle.

Barns and Grove (1916) observed that infestation by this pest in stored rice generally appears when the prevailing temperature is 90-110°F. Attack is mostly confined to layers of grain adjoining the container. A single female lays upto 125 eggs. Egg period lasts 6-16 days, larval period 50-200 days and pupal period 6-17 days. Fletcher (1916) recorded *T. versicolor* Creutz. in rice in India. Voelkel (1927) observed that rice is eaten well by the pest while malt and wheat are preferred foods. The young larva feeds on the floury debris resulting from the feeding of older larvae, because it cannot attack entire grains.

Nakayama (1932) working on the binomics of *T. granarium* on stored rice in Korea, observed that adults chiefly emerge in July-August and oviposit among the grains and that the larvae hibernate from October to May. Solodovnikova (1938) recorded that in *T. versicolor* C. on stored rice, the egg period is 8-14 days, the larval period 11 months, and the pupal stage 7-15 days, there being only one generation in an year. Rahman *et al* (1945) found that in Punjab the percentage of larvae of *T. granarium* surviving was greatest on rice than on sorghum. De and

Gopa konar (1956) found that the effect of *Bacillus thuringiensis* B. on *T. granarium* E. was insignificant because the spore powder ingested by the pest while boring into the kernel was insufficient to cause appreciable mortality. Esin (1959) observed that in S.Turkey, D.D.T. did not give good control of *T. granarium*, while residues from 0.1% and 0.2% emulsion sprays of malathion gave complete kill for 3 and about 20 days respectively. Strong *et al* (1959) collected *T. granarium*, *T. inclutum*, *T. parabile*, *T. simplex*, and *T. sternale*, from stored rice in California.

5. *Attagenus* spp. (Dermestidae)
   Black carpet beetle.

Barns and Grove (1916) indicated that *A. undulatus* has four generations in an year in Punjab. The adult does not damage the grain, but the larva is a voracious feeder passing through as many as ten moults. Takahashi and Uchiumi (1934) recorded *A. piceus* Oliv. as attacking stored rice in Japan, where it had usually one generation in an year. Solodovnikova (1938) recorded *A. bytüroides* Sols. as an important pest in flour mills and stores in C. Asia, the larva of which fed on uninjured rice from second instar. The duration of the egg, larval, and pupal stages were 8-14 days, 11 months, 6-8 days respectively

Hinton (1943) recorded A. piceus Oliv. as a serious pest of cereals in Britain. Pruthi and Singh (1943) stated that A. piceus cannot be considered as a serious pest of stored grain in India.

6. Lasioderma serricorne Fabr. (Dermestidae)

Cigaratte beetle.

Jones (1913), Van Der Veen (1940) and Cotton (1947) have reported it as breeding on stored rice.

7. Oryzaephilus surinamensis Linn.(Cucujidae)

Saw toothed grain beetle.

Lefroy (1906)recorded the insect feeding on flour as well as dried calyx of Bassia latifolia. According to Jack (1923) this beetle is an important pest of stored rice in Malaya. Simmonds (1923) observed it as commonly present in rice mills in Fiji damaging rice. Roepke (1926) listed the pest among more important Coleoptera found in rice imported into Java. Back and Cotton (1926) studied the binomics of this insect, in detail. Kuwayama (1928) noted this to be a common pest of stored rice in Hokkaido. Baerg et al (1929) observed that polished rice is infested by adults only. Newly hatched larvae which fed on polished rice did not show evidence of growth and died within a few weeks. The immature stages appeared to be passed in the rice refuse, in which larval development was completed in 11 days. Corbett (1931) found O.surinamensis associated with stored rice in Malaya. Baerg et al (1932) from their trials, indicated that rice polish produced beetles most rapidly; rice bran, brown rice, rough rice, and polished rice being successively less favourable. Stracener (1934) observed it feeding on cleaned rice in Louisiana.

Schwardt (1934) mentioned O. surinamensis as a major pest in rice mills in Arkansas. He demonstrated that it cannot develop in whole polished rice alone. Development was most rapid in rice polish, but mortality was high. Vitamin B which is abundant in rice polish, is apparently essential to them. A deficiency of vitamin A, appears to increase larval mortality. According to Lever (1939) this beetle is a major pest of stored rice in Fiji. Cephalonomia tarsalis A. was bred at Lyallupur (1939) from this insect. Geijakes (1940) showed that hulled rice was less severely infested by the pest in Dutch Guiana. Douglas (1941) mentioned O.surinamensis as a pest of minor importance on stored clean rice in Southern United States. Corbett and Pagden (1941) observed that it fed on the germ of hand hulled rice, but caused minor damage to sound rice. Balzer (1942) reported this insect as a minor pest of unhulled rice in United States. Pruthi and Singh (1943) gave brief description on the biology of the pest. Its attack generally follows that of other insects such as Calandra oryzae. The life-cycle from egg to egg ranged from 27 to 315 days.

Krishnamoorti and Rao (1950) found that the insect is restricted to stored rice, particularly the imported varieties. Howe (1956) presented evidence and showed that O. surinamensis and O. mercator Fauv. are distinct species which do not inter-breed. Salmond (1956) noted the insect as a secondary pest of rice, in Nayasaland. Parkin et al (1957) found that the dried deposit from an aqueous suspension of a proprietary colloidal silica preparation applied to the internal walls of the granary had proved very effective against O. surinamensis. Turney (1957) carried out experiments to determine the effect of cracked cereal grains on the reproduction of the pest. The population developing in 2-3 months increased with increase in the proportion of cracked grain. A still greater production of progeny was obtained when the moisture content as well as the proportion of cracked grains were increased. Little or no reproduction occurred in cleaned rough rice with a moisture content of 12% or below. Israel and Vedamoorti (1958) reported wide occurrence of the pest on stored paddy in India. Rouse and Rolston (1961) demonstrated that cleaning of rice readily removed a high proportion of adults of the insect. Gordon Surtees (1963) showed that over the range of conditions used, 1-10% of the individuals of the insect appeared on the surface of the grain.

8. Laemophloeus Spp.(Cucujidae)

Red rust grain beetle.

Maskew (1920) recorded Laemophloeus Sp. occurring in paddy and rice in Sacramento. According to Ghesquire (1922) this is common in the Belgian Congo in stored rice. He observed that adults remain confined to their habitat during the day and take flight in the evening to invade fresh stocks of grain. Kuwayama (1928) recorded it on rice, under storage in Japan, while Stracener (1934) reported its presence in Louisiana, and Herford(1939) mentioned it as a pest in Hong Kong.

Corbett and Pagden (1941) observed that when pest infested grains were exposed to a temperature of 60oC for 45 minutes all the pests excepting Laemophloeus died. This insect survived exposure to 50°C for 2 hours. Aiyar (1945) reported this insect from stored rice flour sold in Trivandrum. Davies (1945) worked out in detail the biology of the pest. Rilett (1949) made some observations on the life history of L. ferrugineus St. in cereals. Finlayson (1950) observed dead larvae and adults of L. minutus and L. ferrugineus which was abnormally subject to infestation by a Schizogregarine Mattesia dispora Nav.

Steel and Howe (1952) recorded L. pusilloides sp. n. on rice from Brazil.

9. Ahasvera advena Waltl. (Cucujidae)

Foreign grain beetle.

Myers (1934) recorded this beetle in a cargo of rice from Burma. Cotton (1946) stated that the insect is attracted to damp grains where it feeds on the developing moulds.

10. Cathartus quadricollis Gue. (Cucujidae)

Square necked grain beetle.

Maskew (1920) intercepted Cathartus Sp. on stored paddy and rice in Sacramento. According to Stracener (1931) this insect caused minor loss to stored cleaned rice in Louisiana.

11. Tenebroides mauritanicus Linn. (Tenebrionidae)

Cadelle, or Yellow meal worm.

Lefroy (1906) reared it out from rice and almonds.

Fletcher (1916) showed that adults and larvae of the insect eat rice and wheat grains, the latter being preferred. The adult preys upon the adults of Calandra oryzael., so that in grain infested by the latter, the presence of T. mauritanicus is beneficial. Fletcher and Ghosh (1920) reported it as common in India on stored cereals. Myers (1934) detected it on a cargo of rice from Burma, and Stracener (1934) noted them on stored clean rice in Louisiana. Hutson (1939) observed it on stored rice in Ceylon. Pruthi and Singh (1943) observed that the eggs are laid in batches of 10-40 in food material or crevices of floor, a single female laying up to 500 eggs. The larva becomes full grown in 10-20 months only. The pupal stage lasts 8-12 days. Candura (1952) studied the morphology and biology of T. mauritanicus in Italy. The adults are predominantly carnivorous searching for other grain infesting insects or devour their own larvae. The natural enemies recorded were Pediculoides ventricosus Newp. and a Bethylid Cephalonomia nigricornis Sarra. Liching Sing (1953) observed the insect as commonly present on milled rice in Formosa, while Eikichi Iso (1954) mentioned this as one among the noxious pests appearing in Japan. Israel and Vedamoorti (1958) stated that T. mauritanicus was common in rice, in India. They moved about the surface of bags and godown floors. Thomas et al (1960) pointed out that the insect attacks sound rice grains, the germ portion being preferred.

12. Tenebrio obscuris Linn. (Tenebrionidae)

Rao (1915) studied some aspects of the binomics of this insect. The duration of the pupal stage is stated to vary from 4-24 days with an average of 15 days. The adult stage varies from 10-55 days. The food of both larvae and adults consist of rice and other cereals.

13. Tribolium spp. (Tenebrionidae)

Confused flour beetle.

Lefroy (1906) quoted Indian museum notes in which T. confusum has been recorded as a pest of stored rice in Rangoon. Balzer (1906) stated that it is a major pest in Southern United States, infesting unhulled rice. Fletcher and Ghosh (1920) observed it as a serious pest of ground rice to which they impart a nauseous smell. Frappa (1929) noted that in Madagascar T.navale F. often attack growing rice, particularly when harvest is delayed. Herford (1939) pointed out that the pest infest polished rice, broken rice, and fresh rice-meal in Hongkong. It breeds rapidly in rice that has previously been broken down by Calandra oryzae.

Lever (1939) reported it as abundant in stored rice in Fiji, while Geijskes (1940) noted them readily breeding in rice bran. Corbett and Pagden (1941) showed that T.castaneum causes no appreciable damage to sound rice. Mathlein (1943) made observations on the development of T. destructor Uytt. in cereal products. Though the adults survived for long periods and laid eggs in ground rice, very few of the larvae completed their development. Narasimhan and Krishnamurti (1944) found that under laboratory conditions 68.4% mortality was caused to Tribolium when grains were thoroughly mixed with finely powdered rice husk ash. Bouriquet (1949) recorded that T. castaneum caused serious injury to stored rice in Madagascar. Krishnamurti and Rao (1950) observed it infesting only broken grains and milled products, particularly bran and flour. Ghosh et al (1956) included T. castaneum among a dozen pests that are common to both husked and unhusked rice in India. Previtt (1959) mentioned that infestation in Sierraleone of imported rice by T. casteneum constitutes a major problem which has arisen from the widespread use of gamma B.H.C. to which the pest is not susceptible. Rouse and Rolston (1961) found that a high proportion of T.castaneum could be removed by cleaning rice. Bang Yong et al (1962) demonstrated that malathion mixed with polished rice at 4 parts per million did not give sufficient protection from T.castaneum.

Majumdar et al (1962) found that T. castaneum in milled cereals can be successfully controlled either by mixing it with malathion @ 8 parts per million or spore powder of Bacillus thuringiensis Var. cereus @ 1 part per million.

14. Palorus Spp. (Tenebrionidae)

Small eyed flour beetle.

Liching Sing (1953) reported P. ratzburgi Wissm., as a pest of milled rice in Taiwan. Prevett (1959) recorded P. mahenus G. in a consignment of rice from Italy. Sarup et al (1960) have described a new species P. shikhae which was collected among other storage pests in old rice. The adults did not feed on sound rice, but could feed on broken grains which were out of condition.

15. Latheticus oryzae Wat.(Tenebrionidae)

Long headed flour beetle

It was first described by Waterhouse (1880) as occurring in rice from Calcutta. Krishnamurti and Rao (1950) recorded the insect as a minor pest of broken grains and milled products in Mysore State. Sarup et al (1960) recorded Palorus mulsant, as predatory on L.oryzae. Chatterji et al (1961) observed that both adults and larvae of Palorus shikhae predate on larvae of L.oryzae.

16. *Alphitobius* Spp. (Tenebrionidae)

Black fungus beetle.

Tryon (1916) intercepted *A. piceus* Ol. in quarantine, in bags of rice from the east. Simmonds (1923) noted *A. diaperinus* Panzer, in stored products including rice in Fiji. Hayhurst (1940) recorded *A. piceus* on rice-meal in United States and Lever (1945) tried fumigation with carbon bisulphide and sulphur oxide. A satisfactory kill of adults of *A. laevigatus* congregating in large numbers on concrete walls of a rice godown, was obtained with a spray of 2 fluid ounces of diesel oil and 1/4 pound of lead arsenate in 3 gallons of water. According to Thomas *et al* (1960) the pest is abundant in Assam, Bengal, Kerala, and Bombay, where humidity is high throughout the year. The beetle is a scavanger and does not cause serious damage to sound grains unless present in large numbers.

17. *Necrobia rufipes* (Cleridae)

The only record of this insect on rice is that of Lever (1939) as feeding on rice bran in Suva, Fiji.

18. *Carpophilus* Spp. (Nitidulidae)

Corn sap beetle.

Okuni (1928) reported *C. obsoletus* E., breeding in stored rice in Formosa. Balzer (1942) observed that *C. dimidiatus* breeds in brown, milled and rough rice in

Southern United States. The female deposits 175-225 eggs in the food material. The larvae hatch within 24 hours and mature in 10-11 days under optimum conditions, though those reared on cracked rice required 34 days. The mature larvae pupates in the food material or soil. The pupal stage lasts for 7 days in summer and upto 140 days in winter. The adult lives for 63 days in summer and up to 200 days in winter. According to Hinton (1943) C. marginellus Mot. is widely distributed in the Indo-Australian region where they injure stored rice. Dobson (1954) observed C. halli attacking stored rice in British Honduras.

19. Lophocateres pusillus Klug

Siamese grain beetle

Roepke (1926) recorded it on stored unshelled rice in Java. A report of the Division of Entomology, Malaya (1941) stated that sound rice in husk was not damaged by the insect while when the husk was punctured by a needle it was fed upon. Cotton (1947) stated that it was first observed in the United States on rice from Siam.

20. Thorictodes heydeni Reitt. (Thorictidae)

Van Emden (1920) recorded this beetle as a probable pest of stored rice. Previtt (1959) stated that it was the dominant secondary pest of parboiled paddy in Sierra leone.

21. Ptinus tectus (Ptinidae)

Hayhurst (1940) reported this beetle on stored rice, rice meal, and rice bran.

ORDER: LEPIDOPTERA

22. Sitotroga cerealella Oliv. (Gelechiidae)

Fletcher (1916) recorded this insect on stored rice in India along with other Gelechiid pests. Peluffo (1923) gave an account of the biology of the pest on stored cereals in Uruguay, where some years it has four generations in an year, taking 25-30 days from hatching of the larva to the emergence of the moth. Duport (1925) suggested rapid drying of rice grains after harvest to prevent infestation by Sitotroga. Candura (1926) recorded Dibrachys boucheanus R.(Chalcidae) as a primary parasite of the pest. Kuwayama (1928) reported that Sitotroga which was common on stored rice in Hokkaido, had two generations in a year. Lord (1928) showed that stored rice subjected to attack by the moth for 4 months deteriorated in germinability by 23.25%. Noble (1932) worked out the biology of Habrocytus cerealellae Ashm., a Pteromalid parasite of the grain moth. Commun (1934) recorded the insect as a chief pest of rice in Indochina and stated that large quantities of grain are best protected by storage in metal magazines. According to Wille (1934) stored rice in Peru is commonly attacked by the grain moth.

Gonzales et al (1935) have recorded Dibrachys cavus Wlk., as parasitising pupae of S. cerealella.

Harukawa and Kumashiro (1936) observed that in Japan it passes the winter as the larval or occasionally pupal stage. The optimum temperature for oviposition there, is 20-30° C. Corbett (1937) showed that sunning rice grains for 8 hours failed to destroy immature stages of the insect. Meir (1939) noted that the predacious Acarid Pediculoides ventricosus Newp. destroyed large numbers of the immature stages of the moth in Russia. Geijskes (1940) noted this insect as causing substantial damage to unhulled rice in Dutch Guiana while Otanes et al (1941) described it as a major pest of stored rice in Phillippines. Richardson (1943) did some experiments on the toxicity of derris, nicotine, and pyrethrum to eggs of the pest and found that pyrethrins I and II at a concentration of 0.007% were much more toxic than nicotine sulphate at 0.07%. Pruthi and Singh (1943) stated that the insect has usually three to four broods in an year. Infestation is heavy when the grains lie exposed or when they are stored in receptacles that are not full. The pest is not capable of penetrating deep into the mass of grain but capable of causing sufficient havoc in superficial layers. Eikichi Iso (1954) noted this pest as widely present in Japanese rice godowns.

Central Rice Research Institute, Cuttack, reported (1949-51) that infestation by the pest originates in the field on standing crop. In the field the attack was mainly confined to grain in the milk or dough stage. Usman and Puttarudraiah (1955) recorded S.cerealella as a serious pest of stored unhusked paddy throughout Mysore State. Salmond (1956) remarked that the grain moth was a major pest of stored rice in Phillipines. Quednau (1956) mentioned that Trichogramma embryophagum parasitised eggs of the moth.

Usman (1957) stated that the moths laid eggs on the young or old ears of the growing plants, on the leaves, straw, or stacked grain. When the young larva has access to the soft unripe grain in the field, infestation is easily established. Its life-cycle occupy 5 weeks. Previtt (1959) reported the pest in Sierra leone, infesting rice in the field either before harvest or during drying.

25. Epithectis studiosa Meyr. (Gelechiidae)

Fletcher (1916) recorded this moth in stored rice in India

24. Aristotelia austeropa Meyr.(Gelechiidae)

Fletcher (1916) reared this moth from stored rice in India.

25. Ephestia Spp. (Phycitidae)

Fig moth

Lefroy (1909) recorded E. cahiritella Zell. and E. cautella Wlk. as feeding on rice flour in India, the larvae producing abundant silk with which they form gallerie of webbing. De Charmoy (1915) mentioned that E.cahiritella attack stored rice in Mauritius. He suggested fumigation with sulphur dioxide, against the pest. Andrews (1918) found that large quantities of rice was attacked by E. kuhniella, when stored in buildings that had previously contained infested flour, the remnants of which had not been properly cleaned out. Jack (1923) stated E. kuhniella to be a common pest of stored rice in Malaya. Nakayama (1935) worked out the biology of E. elutella H. in rice in Korea. When fed on threshed rice, the larval period was shorter than the corresponding period in stored tobacco. Kunike (1938) did some experiments to ascertain the suitability of various forms of rice products and rice, as food for E. kuhniella. It did not feed on unhusked rice but thrived on husked but otherwise untreated rice. Larvae could not feed on glazed rice, but fed on polished rice. The waste obtained in polishing rice was the most favourable medium for the insect, 200 eggs giving rise to 193 adults. Froggatt and Moody (1939) found that infestation of copra by E. elutella originated from stored rice.

Herford (1939) recorded E. kuhniella attacking rice meal in Hong kong.

Nicol (1941) recorded Microbracon hebetor Say., parasitising both E. cautella and E. elutella. Hinton (1942) furnished keys for the identification of larvae of E. kuhniella, E. elutella, and E. cautella. Kunike (1942) conducted experiments on the protection of packing materials against penetration by E. kuhniella and E. elutella Oviposition took place on the outer surface of the food packets and the larvae bore through the package material. It was suggested that completely sealed packing, reduces risk of infestation. Lever (1945) noted it as of major importance in Fiji as a pest of stored rice. Waloff (1948) studied the development of E. elutella on some natural foods including uppolished rice. The larvae fed on the embryos alone in unpolished rice and the percentage of survival was greatest in this medium than manitoba wheat, oats, tobacco, and soybean flour. Cotton (1950) reported E. cautella in Gulf States where it was found on rough rice.

26. Plodia interpunctella Hub. (Phycitidae)

Indian meal moth

Kazui (1919) found that larvae of the insect eat only the outer husk of rice grain, rendering it far whiter.

Lyne (1921) recorded it on stored rice in Victoria. Tosi (1929) obtained complete generations of the insect from stored rice, and observed that considerable larval mortality was caused by Pediculoides ventricosus N., Microbracon hebetor, and Opius carianatus. Musgrave and Mackinnon (1938) recorded larvae of Plodia being infested by a Schizogregarine Mattesia dispora . Observations indicated that the Protozoan was highly pathogenic, also occuring on pupae and adults. Abe (1939) gave an account of the effect of atmospheric humidity on the eggs of Plodia, which is a pest of stored rice in Japan. The optimum relative humidity for egg hatching was found to be 57-91%.

Kawano (1939) suggested that rice should be stored at a temperature of 15°C or lower in order to avoid infestation by storage pests including P. interpunctella. Nakayama (1939) observed that in S.Korea, the larval stage averaged 43.2 days. In experiments on control, the percentage of larval mortality given by exposure to 130° and 120-130° F for 5 and 6 hours were 99 and 98-100 respectively. According to Kono (1940) it can be controlled by fumigation with chloropicrin.

Douglas (1941) reported P. interpunctella as feeding on cleaned rice in Southern United States, while Balzer (1942) noted that it fed on rice kernels or broken grains.

Kantack (1959) conducted tests on the effect of Bacillus thuringiensis B. on the meal moth larvae. When the spores were incorporated with whole grains, larvae showed symptoms after feeding for a few hours.

27. Corcyra cephalonica Staint. (Galleriidae)

Rice moth.

Fletcher (1916) recorded its occurrence as a common pest in stored rice in India and Burma. Chittenden (1919) first recorded this moth attacking rice in United States. Ayyar (1919) first recorded Corcyra on stored rice in Madras and Hutson (1920) in Ceylon. Roepke (1921) stated that C. cephalonica was common in rice meal in Berlin. Iyyar (1934) studied in detail the biology of the pest in S. India. The number of eggs laid varies from 89-191. The larva passes through seven instars and pupates in a silken cocoon. The larval period ranged from 46 to 56 days, while the pupal stage occupied 10-14 days. The entire life cycle in rice and rice flour is 58 days.

Goidanich (1934) recorded Microbracon hebetor S. parasitic on Corcyra larva, infesting stored rice in Sicily. Diakonoff (1937) reared this insect from rice flour received from Haarlem and stated that it established well in Holland. Otanes (1941) recorded it on stored rice in Phillippines while Douglas (1941) reported its presence in United States. Lal (1944) noted Corcyra in various cereals in the United Province. Krishnamurti and Rao (1950) pointed out that rice was most susceptible to Corcyra attack . They suggest stocking of unhusked paddy to minimise damage by Corcyra. Rao (1954) determined experimentally the acceptability or otherwise to Corcyra, of a variety of edible stuffs. Cereals are the most favoured group among its recorded food materials. The insect completed development in 61.6 days, 79.5 days, and 98.6 days in fine rice, coarse rice, and rice-bran respectively.

28. *Tinea granella* C. (Tineidae)

Kuwayama (1928) noted this as a pest of stored rice and rice products in Hokkaido.

29. *Setomorpha rutella* Zell. (Tineidae)

Ommen and Joseph (1961) recorded this insect as a major pest of stored rice in Kerala. The insect commonly occurs on whole grain and grain products, which are reduced to a mass of webbing frass and excreta.

30. *Erechthias zebrina* But. (Lyonetiidae)

Ommen and Joseph (1961) observed it as a pest infesting stored rice in Kerala. The life cycle in stored rice flour was completed in 65 days during October to November. There are five generations in an year.

O R D E R : H E M I P T E R A

31. *Ampera intrusa* Dist. (Lygaeidae)

Distant (1919) orginally described this bug which was obtained from stored rice in Java. The biology of the pest in rice has not so far been worked out.

O R D E R : A C A R I N A

32. *Tyroglyphus farinae* de G.(Tyroglyphidae)

Hayhurst (1940) recorded it on Rangoon-rice and rice-meal.

33. *Chrotoglyphus arcuatus* Troup.

Zakhvatkin (1937) has mentioned this mite as infesting rice grain in Russia.

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MATERIALS AND METHODS

III MATERIALS AND METHODS

MATERIALS.

1. Stock cultures of *Sitotroga cerealella* Ol.

Adults of *Sitotroga* moths required for studies were reared in the laboratory on paddy seeds of the variety PTB.10, of uniform moisture content.

2. Rice seeds required for the experiment.

Out of the twenty nine varieties used in the trial, twenty seven were obtained from the Central Rice Research Station, Pattambi. The variety Japonica (Gimbozu) was received from the Central Rice Research Station, Cuttack and MO.2 seeds from the Rice Research Station, Moncompu, Kerala.

3. Oviposition chamber. (Fig. 1)

This consists of a glass vial, 11 cm. x 2.5 cm., into which is fitted a bent glass tube through a cork as shown in the Figure. Two strips of fairly stiff, black, card-board are tied closely on either side of the inner half of the bent tube.

4. Moth introduction tube. (Fig.2)

This is just a glass tube 1 cm. in diameter, 8 cm. long, and bent at a right angle in the middle. One arm of it bears a circular card-board disc 8 cm. in diameter, piercing it through the centre.

METHODS.

1. Determination of the moisture content of the seeds.

To determine the moisture content of the different varieties, samples of the seeds were weighed before and after drying them in an oven at 105°C for 6 hours. The varieties which showed higher moisture content were dried till the moisture level of all the varieties were made uniform at 13.45 ± 0.41%.

2. Conditioning the seeds.

The seeds required for the experiments were thoroughly cleaned to remove chaff, small kernels, and other foreign particles. In order to eliminate any infection already present, the seeds were fumigated with E.D./C.T.mixture at 454 g. for 100 cu.ft. space. Fumigation was done in September 1963 at room temperature in a wooden fumigatorium of 16 cu.ft. capacity. After exposure of the seeds in small jute bags for 36 hours they were removed from the chamber and allowed to air for 12 hours. After fumigation, the seeds were stored in museum jars under insect proof conditions.

3. Maintenance of stock culture of moths.

The moths required for the experiments were drawn from stock cultures. These were maintained in glass museum jars 18 cm. x 10 cm. x 27 cm., using paddy seeds of the variety PTB.10 as the host material. The museum jars were filled to half capacity with the seeds and about fifty moths were introduced and closed with muslin cloth. The jars were kept away from strong light.

4. Determination of the relative susceptibility of different varieties of paddy seeds to attack by paddy moth.

For this, the conditioned seeds were weighed out in required quantities (100 g.) into 1 pound wide-mouthed glass bottles. The required number of moths (10 females and 10 males) were then introduced into the bottle. For this, the bottle was first closed with a thin muslin having a small hole - a slit - in the middle. The arm of the 'moth introducer' with the card-board disc was then introduced into the bottle through the hole in the muslin, till the disc came to rest on the muslin, closing the mouth of the bottle. Moths from bulk rearing jars were collected in a small vial 10 cm. x 1.2 cm. This could easily be done by showing the mouth of the tube in front of the moving moths. The tube which could just slip over the outer tip of the 'moth introducer', was thus fitted, when all the moths in the tube readily moved down the bent tube reaching inside the bottles. This procedure prevented any damage to the moths and enabled easy transference of the moths from stock culture. After introducing the moths, the 'moth introducer' was removed and the mouth of the bottle covered over by another muslin held in position by rubber band. Particular care was taken to see that adults introduced were invariably those which had emerged on the same day.

For determining the intensity of infestation, counts were made of moths emerging out of each lot. For this, each bottle was kept under observation commencing from the twentieth day of innoculation. When only a few moths emerged, their counts were made after lowering the bottle into an empty museum jar, and removing its muslin covering. With the slightest disturbance moths escape from the bottle and crawl over sides of the jar. At the peak period of emergence, the moths were counted after anaesthetizing them with chloroform, after collecting them in museum jar and removing the rearing bottle.

5. Determination of the duration of development of *S. cerealella*, on different varieties of seeds.

For this, after exposing the different varieties of seeds to infestation by the moth as described above, the time taken for the life cycle was found out. A weighted mean of the number of days taken by all the moths was calculated as the developmental period.

Following is an example of this calculation:-

Days after moth infestation	Number of moths emerged	Total developmental period of the moths
20	10	200
22	15	330
24	18	432
26	25	650
Total	68	1612

Mean developmental period = 1612/68 = 23.7 days.

6. Fecundity of females reared from different varieties of paddy seeds.

The fecundity of moths reared on different varieties was studied by taking counts of eggs laid by three females in each of the three replications. For this purpose the method of Elington (1930) was followed. Moths were selected randomnly at the peak period of emergence. A pair of male and female moths were introduced into the oviposition vial through the bent tube. The female moth laid eggs in between the card-board strips. The number of eggs laid daily were recorded without allowing the moths to escape.

7. Size of moths reared on different varieties of paddy seeds.

To study the effect of different varieties of paddy seeds on size of moths reared on them, ten each of male and female moths (Fig. 3 and 4) reared out from each variety, were separately weighed in a chemical balance , after anaesthetizing with chloroform. This was done separately for each of the three replications.

8. Trial under godown conditions.

With a view to determine the relative suceptibility of different varieties of paddy seeds to infestation by the paddy moth, under natural conditions obtaining in godowns, an experiment was laid out in a store room. This godown had a stock of PTB.10 seeds heavily infested with S. cerealella . Lots weighing 100 g. of each variety (replicated thrice) contained in small gunny bags, 13 cm. x 8 cm., were exposed to natural infestation in the godown. The bags were kept for 10 days over the stack of infested stock, after which they were transferred to polythene bags, 20 cm. x 12 cm., and kept in the laboratory under observation for 45 days. Besides the number of moths emerging, and duration of development the percentage of infestation was also recorded. The percentage of infestation was calculated from random samples of grain drawn from each lot and counting infested grains.

Experimental conditions.

The experiments were conducted in the laboratory during the period from October 1963 to March 1964. The data on temperature and humidity for the period are given in Appendix V.

Design of the experiments and statistical studies.

The completely randomised design was followed in all the experiments in the present investigation. The data were statistically analysed using the analysis of variance technique and correlation concept.

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DETAILS OF INVESTIGATIONS AND RESULTS

IV. DETAILS OF INVESTIGATIONS AND RESULTS.

(A) Determination of the number of grains per gramme weight.

The relationship between weight and number of 29 varieties of paddy seeds was determined by weighing out 10 random samples of 1 g. each of different varieties of paddy seeds which were conditioned previously as described above, and counting the number of seeds in each sample. The mean value of these was taken as the number of grains per gramme weight of the different varieties. Results are given in Table V. It will be seen that the mean number of grains per gramme ranged between 54.30 in PTB. 16 and 30.80 in PTB. 22.

(B) Relative susceptibility of different varieties of paddy seeds to natural infestation by *S. cerealella*.

Experimental details:

Varieties of paddy seeds used:	29 varieties given in Table I were used.
Number of replications:	3 for each variety.
Quantity of seeds used in each replication:	100 g.
Design of the experiment:	Completely randomised.

Date of exposure of the samples to natural infestation in the godown:	15-10-1963.
Date of removal of the samples from the godown to the laboratory:	29-10-1963.
Date of completion of the experiment:	18-12-1963.
Temperature during the experiment:	Given in Appendix V.
Humidity during the experiment:	Given in Appendix V.

Procedure:

The 100 gramme samples of the varieties were packed in small jute bags and exposed to infestation by the moths in the godown. They were taken back from there, after 10 days and the grains transferred to polythene bags. Observations on the extent of damage, moth emergence, developmental period, and percentage of infestation were made as described under 'methods'.

Results.

The data are given in Appendix I, the mean values of which are furnished in Table I.

(i) Period of development in different varieties.

Graphical representation of the data is given in Figure 5 (C). In varieties like GEB.24, Co.25, Mo.2, PTB.25 and PTB.16, moth emergence took place only from one out of three replications, while no emergence was observed from PTB.2. The data was therefore considered for analysis separately for the varieties having observations in all the three replications and those having observations in two replications alone. Analysis of variance for the former group is given in Table II (a) and that for the latter group in Table II (b).

TABLE II (a)

ANALYSIS OF VARIANCE

PERIOD OF DEVELOPMENT.

Varieties: PTB.32, PTB.24, PTB.27, PTB.4, MTU.3, PTB.1, PTB.9, PTB.23, PTB.10, PTB.18, PTB.5, Japonica, PTB.33.

Sources of variation.	Degrees of freedom.	Sum of squares.	Mean squares.	Variance ratio.	'F' from Table at 5% level.
Varieties	12	410.98	34.248	2.573*	2.150
Error	26	346.00	13.309		
Total	38	756.98			

*Significant at 5% level.

C.D. at 5% level = 6.1127.

T A B L E I

Mean values of the period of development, moth emergence and percentage infestation for different varieties of paddy seeds under godown conditions.

Sl. No.	Varieties	Duration of develop- ment	Moth recorded data	emergence after transfor- mation.	percentage infestation recorded data	after transforma- tion.
1	2	3	4	5	6	7
1	PTB.1	31.00	31.66	5.4911	1.330	1.2879
2	PTB.2	-	-	-	-	-
3	PTB.4	32.33	4.33	1.9914	1.500	1.1464
4	PTB.5	28.00	9.00	2.4019	1.830	1.1044
5	PTB.7	27.00	1.00	0.8047	0.330	0.4714
6	PTB.8	27.00	2.33	1.2440	0.410	0.5000
7	PTB.9	30.66	10.33	3.0702	1.330	1.2879
8	PTB.10	28.33	7.33	2.6635	1.030	0.8381
9	PTB.12	35.00	0.66	0.4714	0.330	0.3333
10	PTB.15	22.00	0.33	0.3333	0.060	0.1491
11	PTB.16	35.00	1.66	0.7453	0.330	0.3333
12	PTB.18	28.66	22.00	4.5936	1.416	1.1660
13	PTB.20	29.00	7.66	2.1595	2.830	1.3591
14	PTB.21	35.00	1.00	0.5773	0.330	0.3330
15	PTB.22	36.66	6.00	2.1579	1.410	1.0084
16	PTB.23	29.66	13.60	3.6892	2.000	1.3661
17	PTB.24	34.00	2.00	1.3821	1.330	1.1150
18	PTB.25	34.50	3.66	1.5201	0.660	0.6439
19	PTB.26	41.00	15.66	3.2316	4.830	1.7948
20	PTB.27	33.66	60.30	7.6584	5.000	2.0128
21	PTB.31	35.50	6.66	2.0838	1.330	0.9107
22	PTB.32	32.00	1.66	0.7453	0.330	0.3333
23	PTB.33	23.66	16.00	3.8495	3.000	1.6329
24	PTB.34	32.00	2.66	0.9428	0.500	0.4082
25	MTU.3	31.00	27.00	5.1662	1.660	1.2341
26	GEB.24	32.00	1.66	0.7453	0.016	0.0230
27.	Japonica	27.33	53.33	7.2459	6.830	2.4620
28.	MO.2	29.00	6.00	1.4142	0.830	0.5270
29.	Co.25	32.00	3.33	1.0541	0.030	0.0333

Inference.

PTB.22, PTB.24, PTB.27; Japonica, PTB.33

Analysis of variance reveals significant differences among the thirteen varieties included in this group. The variability was from 36.66 days in PTB.22 to 23.66 days in PTB.33. Varieties PTB.22,PTB.24, and PTB.27 could be grouped together with regard to the period of development of the moth, but all these varieties differed significantly from PTB.33 and Japonica in which shortest periods of development were recorded. It will be noticed that in PTB.22, which is the coarsest among the varieties, moth took longest period of development.

TABLE II (b)

ANALYSIS OF VARIANCE
PERIOD OF DEVELOPMENT

Varieties: PTB.7, PTB.8, PTB.20, PTB.25, PTB.26, PTB.31.

Sources of variation	Degrees of freedom	Sum of squares	Mean squares	Variance Ratio	'F'from Table at 5% level
Varieties	5	331.42	66.284	1.281*	4.390
Error	6	263.50	43.910		
Total	11	594.92			

* Not significant at 5% level.

No significant difference was indicated among the six varieties included in this group.

In varieties PTB.12, PTB.15, PTB.16, PTB.21, PTB.32, PTB.34, GEB.24, MO.2, and Co. 25 data were available only in one out of the three replications and hence no statistical interpretations were possible. These results are also represented by histograms in Figure 5 (C). It will be seen that the duration of development in these varieties ranged from 22 to 32 days, in PTB. 12 and Co.25 respectively.

(ii) Moth emergence from different varieties.

Data in column 4 of Table I show the mean number of moths that have emerged from different varieties. These are also graphically represented in Figure 5 (B). A poisson distribution was assumed for the data and hence analysis of variance technique was employed after square root transformation. Analysis of variance is given in Table III. No emergence occurred from PTB.2 while breeding was very poor in PTB.7, PTB.12, PTB.15, PTB.16, PTB.32, and Co.25.

It will be seen from the Table that moth emergence is significantly different in different varieties. Varieties Japonica and PTB.27 show the highest number of emergence, the average numbers being 53.3 and 60.3 respectively. Varieties PTB.7, Co.25, GEB.24, PTB.32, PTB.12, PTB.21, PTB.15, and PTB.16 produce the lowest number of moths, the average per 100 g. being 0.33 to 3.33 moths. The remaining varieties show intermediate susceptibility producing on an average 7.33 to 22.0 moths per 100 g. of grains.

TABLE III

ANALYSIS OF VARIANCE

MOTH EMERGENCE

Sources of variation	Degrees of freedom	Sum of squares	Mean squares	Varience ratio	'F' from Table at 5% level
Varieties	27	250.1155	9.2635	2.6801*	1.411[illegible]
Error	56	189.3035	3.3804		
Total	83	439.4190			

* Significant at 5% level

C.D. at 5% level = 3.0022.

Inference.

PTB.27, Japonica; PTB.18, PTB.33, PTB.26, PTB.9, PTB.10, PTB.5, Co.25, PTB.7, GEB.24, PTB.16, PTB.32, PTB.12, PTB.21 PTB.15, PTB.16.

(iii) Percentage of infestation in different varieties.

Data on this are furnished in columns 6 and 7 of Table I. Analysis of varianco was applied after square root transformation.

TABLE IV

ANALYSIS OF VARIANCE

PERCENTAGE INFESTATION

Sources of variation.	Degrees of freedom	Sum of squares	Mean squares	Variance ratio	'F' from Table at 5% level
Varieties	27	31.286	1.1580	2.3623*	1.414
Error	56	27.4545	0.4902		
Total	83	58.7405			

* Significant at 5% level

C.D. at 5% level = 0.3589.

Inference.

Japonica; PTB.27, PTB.26, PTB.33, PTB.23, PTB.1, PTB.9, MTU.3
PTB.7, PTB.34, PTB.12, PTB.16, PTB.21, PTB.32,-
PTB.15, Co.25, GEB.24.

From the analysis of variance table it will be seen that the percentage of infestation is significantly different among the varieties. The range of mean percentage values, is from 6.830 in Japonica to 0.016 in GEB.24. Varieties Japonica, PTB.27, and PTB.26 suffer the greatest loss due to attack by S. cerealella, causing 6.83, 5.00, and 4.83% loss respectively. Varieties PTB.33, PTB.23, PTB.1, PTB.9 and MTU.3 show intermediate susceptibility with 1.3 to 3.0% damage and the remaining varieties show very low susceptibilities with 0.016 to .5% damage. No damage occurred in PTB.2

These features are clearly observed in Figure 5 (A)

(C) Effect of different varieties of paddy seeds on duration of development, moth emergence, size and fecundity of moths of *S. cerealella* under laboratory conditions.

Experimental details

Varieties of paddy seeds used:	29 varieties given in Table I were used
Number of replications:	3 for each variety
Quantity of seeds used in each replication:	100 g.
Design of the experiment :	Completely randomised
Date of commencement of the experiment:	7--10--1963
Date of completion:	15--3--1964
Temperature during the experiment:	Furnished in Appendix V
Humidity during the experiment:	Furnished in Appendix V

Procedure: The replicate samples of 100 g. each of the seed were weighed out into

1 pound wide-mouthed bottles. Ten pairs of moths were then introduced into the bottles with the 'moth introducer' as described under 'methods'. Each bottle was kept under observation commencing from the twentieth day and date-war moth emergence recorded. Care was taken to release all moths out of the bottles immediately after their emergence. This prevented oviposition and breeding of a second generation. Observations on moth emergence, duration of development, percentage infestation, size and fecundity of moths, were recorded in the manner described under 'methods'

Results.

The results of the experiment are given in Appendix II and the corresponding mean values in Table V.

(1) Period of development.

The data are graphically represented in Figure 6 (C)

T A B L E V

Mean values of the period of development, number of moths emerging, size of moths, percentage infestation, number of grains per gramme and fecundity of moths for different varieties under laboratory conditions.

Sl. No.	Varieties	No. of grains per gramme	Developmental period	No. of moths emerging.	Weight of 10 female moths (mg)	Weight of 10 male moths (mg.)	No. of eggs laid by a single female.
	1	2	3	4	5	6	7
1	PTB.1	34.50	31.33	83.33	25.70	11.40	75.80
2	PTB.2	35.64	33.66	37.33	14.00	10.00	75.80
3	PTB.4	34.87	34.66	71.66	15.30	11.00	50.80
4	PTB.5	34.50	33.00	85. 33	17.66	11.33	58.20
5	PTB.7	37.00	42.00	39.00	20.00	10.00	31.20
6	PTB.8	39.01	45.66	76.00	14.00	9.00	37.00
7	PTB.9	46.81	37.33	109.66	21.66	17.33	116.70
8	PTB.10	37.00	33.66	68.66	11.66	8.00	39.40
9.	PTB.12	36.57	35.66	52.33	14.16	10.76	90.00
10	PTB.15	51.31	36.66	83.33	12.90	9.10	69.66
11	PTB.16	54.30	32.66	95.33	12.73	10.73	62.40
12	PTB.18	36.12	38.33	81.33	17.80	10.46	44.40
13	PTB.20	37.80	33.00	76.33	19.46	15.96	67.00
14.	PTB.21	38.50	35.33	67.33	18.96	16.20	44.20
15	PTB.22	30.80	37.66	48.33	15.60	12.30	57.00
16	PTB.23	36.40	37.66	61.00	16.43	11.03	57.80
17	PTB.24	40.10	36.00	50.33	13.73	8.43	57.00
18	PTB.25	32.20	34.33	66.66	17.83	14.33	47.40
19	PTB.26	36.40	34.00	78.33	15.86	10.63	95.80
20	PTB.27	33.90	27.00	137.33	13.93	12.33	74.40

contd....

Table V continued

Sl. No.	1	2	3	4	5	6	7
21	PTB.31	37.60	33.00	64.66	15.93	11.96	68.20
22	PTB.32	34.80	29.66	17.33	11.83	10.56	43.40
23	PTB.33	39.60	33.00	97.00	20.16	15.36	71.00
24	PTB.34	34.10	36.66	26.00	23.46	16.66	53.40
25	MTU.3	40.15	40.33	115.66	20.00	15.40	62.00
26	GEB.24	50.94	35.66	84.00	13.56	8.00	50.60
27.	Japonica	42.30	33.00	220.33	19.00	12.93	110.20
28.	Co.2	41.01	40.66	86.66	23.33	19.63	78.20
29.	Co.25	45.40	34.00	142.66	17.86	10.43	74.40

TABLE VI

ANALYSIS OF VARIANCE

PERIOD OF DEVELOPMENT

Sources of variation	Degrees of freedom	Sum of squares	Mean squares	Variance ratio	'F' from Table at 5% level
Varieties	28	1188.71	42.453	4.313*	1.40
Error	58	570.67	9.839		
Total	86	1759.38			

* Highly significant at 5% level

C.D. at 5% level = 5.1275

Inference.

PTB.8, PTB.7, MO.2; PTB.21, PTB.4, PTB.26, Co.25, -- GEB.24, PTB.10, PTB.2, PTB.31, Japonica, PTB.33, PTB.5, -- PTB.20, PTB.16, PTB.1, PTB.32, PTB.27.

The development period of the moth is highest in the varieties PTB.8, PTB.7, and MO.2, the average values being 45.66, 42.00 and 40.33 days respectively. The development periods in these three varieties are significantly higher than those in the rest. There appears to be no significant difference in developmental period among the rest of the varieties. The average duration of development in these varieties ranges between 27 and 35.33 days. The shortest developmental period of 27 days is observed in PTB.27.

(2) Moth emergence in different varieties.

Histograms in Figure 6 (B) represent the data, which are also given in column 4 of Table V. Analysis of variance is furnished in Table VII.

TABLE VII

ANALYSIS OF VARIANCE

MOTH EMERGENCE.

Sources of variation.	Degrees of freedom	Sum of squares	Mean squares	Variance ratio	'F' from Table at 5% level
Varieties	28	133313.36	4761.18	24.67*	1.40
Error	58	11207.34	193.23		
Total	86	144520.70			

* Highly significant at 5% level

C.D. at 5% level = 22.665.

Inference:

Japonica; Co. 25, PTB.27; MTU.3, PTB.9, PTB.33, PTB.16; - PTB.4, PTB.10, PTB.21, PTB.25, PTB.31, PTB.23, PTB.12, - PTB.24; PTB.22, PTB.7, PTB.2, PTB.34; PTB.32.

It may be seen that the largest number of moths emerge from the variety Japonica, the average per 100 g. of seeds being 220.33. The next group of the varieties Co.25 and PTB.27 produce on an average 142.66 and 137.33 moths per 100 g. seeds. PTB.4, PTB.10, PTB.21, PTB.25, PTB.31, PTB.23, PTB.12 and PTB.24, produce on an average from 2 48.33 to 71.66 moths out of 100 g. seeds. The least number of moths emerge from PTB.7, PTB.2, PTB.34, and PTB.32, the numbers being 39.0, 37.33, 26.00 and 17.33 respectively.

(3) Size of female moths emerging from different varieties.

Data are presented in Appendix IV (B), the mean values of which are given in column 5 of Table V. Graphical representation is given in Figure 6 (A)

TABLE VIII
ANALYSIS OF VARIANCE
SIZE OF FEMALE MOTHS.

Sources of variation	Degrees of freedom	Sum of squares	Mean squares	Variance ratio	'F' from Table at 5% level
Varieties	28	578.126	20.647	2.7003*	1.400
Error	58	444.500	7.646		
Total	86	1022.626			

* Significant at 5% level
C.D. at 5% level = 4.5199.

Inference.

$\overline{\text{PTB.1, PTB.34, MO.2, PTB.9}}$;

$\overline{\text{PTB.33, MTU.3, PTB.7, PTB.20, Japonica}}$ -

$\overline{\text{PTB.21, Co.25, PTB.25, PTB.18, PTB.5}}$ --

$\overline{\text{PTB.23, PTB.26, PTB.22, PTB.4}}$; $\overline{\text{PTB.24}}$ -

$\overline{\text{GEB.24, PTB.16, PTB.32, PTB.10}}$.

Scrutiny of the analysis of variance table suggests that the varieties differ significantly in regard to the weight of female moths reared out of them. The range in the mean weight of female moths was from 1.166 mg. in PTB 10, to 2.570 mg. in PTB.1. It may be noted that heaviest female moths emerges out of PTB.1, PTB.34, PTB.9, and MO.2, their respective mean weights being 2.570, 2.346, 2.166 and 2.333 mg. respectively. Moths emerging from PTB.24, GEB 24, PTB.16, PTB.32 and PTB.10 are the smallest, the range in mean weight being 1.166 to 1.373. In the remaining varieties, the female moths are of intermediate size.

(4) Size of male moths emerging from different varieties.

Data, in regard to size of male moths are furnished in column 6 of Table V, and the analysis of variance in Table IX.

TABLE IX

ANALYSIS OF VARIANCE

SIZE OF MALE MOTHS

Sources of variation	Degrees of freedom	Sum of squares	Mean squares	Variance ratio	'F' from Table at 5% level
Varieties	28	678.637	24.237	15.74*	1.40
Error	58	89.360	1.540		
Total	86	767.997			

* Highly significant at 5% level

C.D. at 5% level = 2.0261

Inference.

Mo.2; PTB.34, PTB.21, PTB.20;

Japonica, PTB.22, PTB.27, PTB.31, PTB.1, PTB.5, -

PTB.9, PTB.23, PTB.4; PTB.15, PTB.8, PTB.24, -

GEB.24, PTB.10.

Significant varietal variability is indicated by the analysis of variance. Male moths obtained from Mo.2 are the heaviest, their mean weight being 1.963 mg., while those emerged from PTB.10 and GEB.24 are lightest, their mean weight being 0.8 mg.

(5) Fecundity of females reared from different paddy varieties.

From data presented in Appendix IV (A) and Table V it will be seen that the mean number of eggs produced by females show wide variation from 31.2 in PTB.7 to 116.7 in PTB.9. Largest number of eggs are laid in PTB.9 (116.7), closely followed by Japonica (110.2) and PTB.26 (95.8) while the least number is found in PTB.7 (31.2), PTB.8 (37.0) and PTB.10 (39.40).

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DISCUSSION

V. D I S C U S S I O N.

Relative susceptibility of twenty nine varieties of paddy seeds to attack by the Angoumois grain moth *Sitotroga cerealella* Oliv. has been worked out. Besides this, the effect of different varieties on the number of moths developing within them, as well as the developmental period, size and fecundity of the moths also, have been studied. These studies have been made under two conditions, namely:

(1) In a godown where heavy infestation of the moth has been in existence and wherein the different varieties of the seeds are exposed to the natural infestation by the moth, and

(2) in the laboratory where the moths are confined on the different varieties of the seeds.

The results of these trials are discussed below:

I. Relative susceptibility of different varieties of paddy seeds to attack by *S. cerealella*.

The damage caused by one generation of the moth has been ascertained by exposing lots of different varieties of paddy seeds to natural infestation in a godown In this case the moths are at liberty to prefer the varieties they like and to avoid those which they do not like. Thus it is seen from Table I Column 6 and Fig.5(A) that the moth does not oviposit at all in the variety

PTB.2, and so no damage is caused to it by the moth. The varieties PTB.7, PTB.34, PTB.32, PTB.8, PTB.21, PTB.25, PTB.16, PTB.15, Co.25 and GEB.24show only slight damage ranging from 0.016% in GEB.24 to 0.5% in PTB.34. The varieties Japonica, PTB.27, PTB.26 and PTB.20 suffer the greatest damage of 2.83 to 6.83%. The remaining varieties show intermediate susceptibilities causing 1.25 to 2.80%. Figure 5 (A) gives a rating of different varieties with reference to damage caused by S. cerealella, under natural conditions, in which the varieties are arranged from left to right in the ascending order of the number of grains per gramme weight. It is evident that the fineness or coarseness of the grain has no relation with susceptibility to infestation by S. cerealella. Though Krishnamurthi and Rao (1950) have indicated that finer varieties are less attractive to storage pests like Sitophilus oryzae, it does not appear to hold good in the case of Sitotroga cerealella on paddy seeds. Further, Israel and Vedamurti (1958) have concluded that generally fine grained scented varieties are more susceptible to S. cerealella than the coarse grained varieties and that this may be due to the higher moisture content of the fine grained varieties. In the present studies moisture as a varying factor has been eliminated by keeping the oisture content of all varieties nearly equal and then it is observed that size of the grain is not a factor deciding the susceptibility to infestation. The general indication

FIGURE V. Bar diagrams showing:-

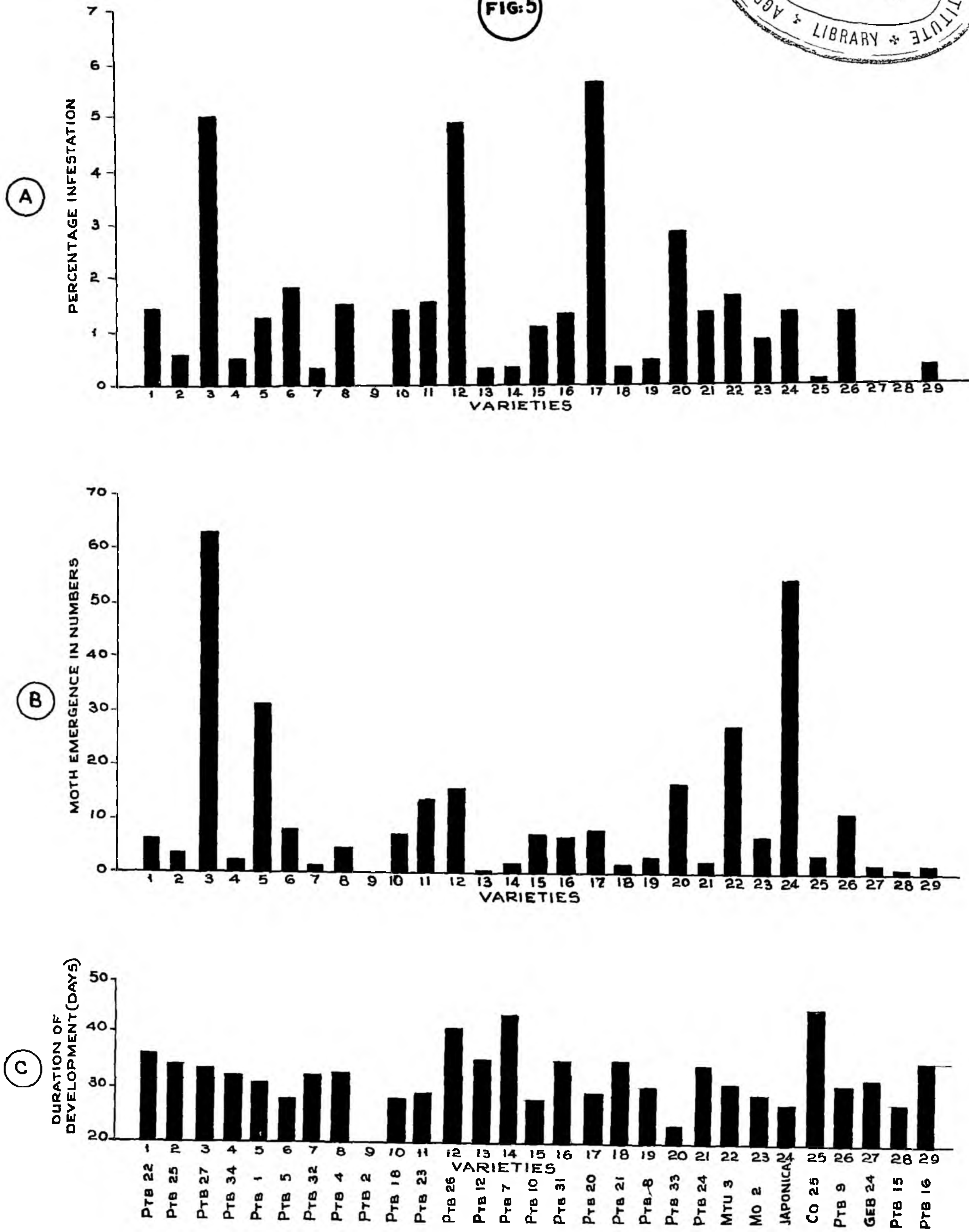
A) Percentago infestation,

B) Moth emergence,

C) Duration of development,

undor godown conditions.

FIG:5



A
PERCENTAGE INFESTATION
B
MOTH EMERGENCE IN NUMBERS
C
DURATION OF DEVELOPMENT (DAYS)
VARIETIES
PTB 22
PTB 25
PTB 27
PTB 34
PTB 1
PTB 5
PTB 32
PTB 4
PTB 2
PTB 18
PTB 23
PTB 26
PTB 12
PTB 7
PTB 10
PTB 31
PTB 20
PTB 21
PTB 8
PTB 33
PTB 24
MTU 3
MO 2
JAPONICA
CO 25
PTB 9
GEB 24
PTB 15
PTB 16

FIGURE VI. Bar diagrams showing:-

A) Size of female moths,

B) Moth emergence,

C) Duration of development,

under laboratory conditions.

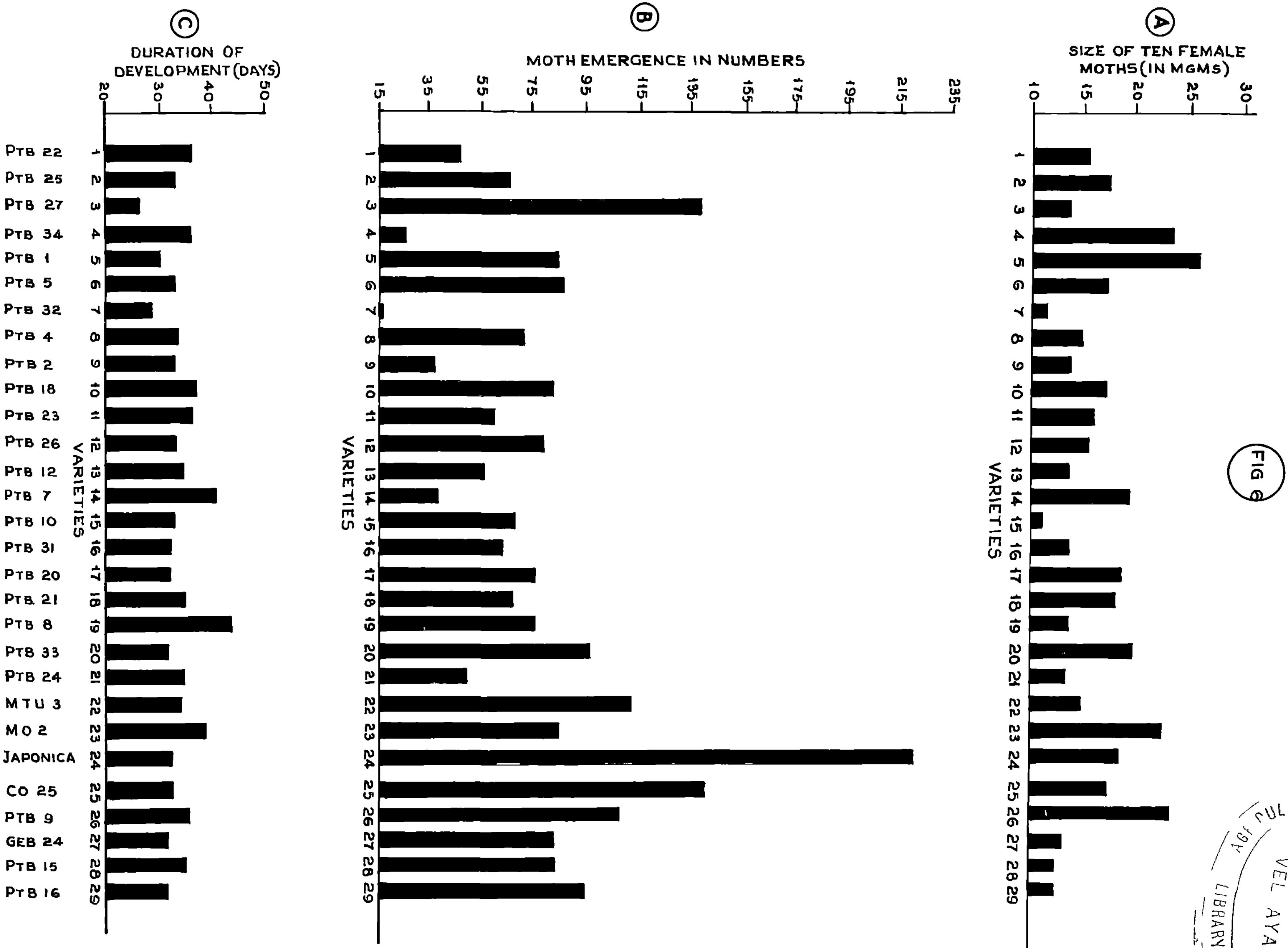


FIG 6
(A)
SIZE OF TEN FEMALE MOTHS (IN MGMS)
10
15
20
25
30
VARIETIES
(B)
MOTH EMERGENCE IN NUMBERS
15
35
55
75
95
115
135
155
175
195
215
235
VARIETIES
(C)
DURATION OF DEVELOPMENT (DAYS)
20
30
40
50
VARIETIES
1 PTB 22
2 PTB 25
3 PTB 27
4 PTB 34
5 PTB 1
6 PTB 5
7 PTB 32
8 PTB 4
9 PTB 2
10 PTB 18
11 PTB 23
12 PTB 26
13 PTB 12
14 PTB 7
15 PTB 10
16 PTB 31
17 PTB 20
18 PTB. 21
19 PTB 8
20 PTB 33
21 PTB 24
22 MTU 3
23 MO 2
24 JAPONICA
25 CO 25
26 PTB 9
27 GEB 24
28 PTB 15
29 PTB 16

is that apart from t e grain size, some other factors govern the susceptibility of paddy seeds to attack by S. cerealella

II. Number of moths developing in the different varieties of paddy seeds infested with S. cerealella .

Data on these relating to both the tests presented in Tables I and V and Figures 5 (B) and 6 (B) show that the maximum number of moths develop in the varieties Japonica and PTB.27 under store room conditions (53.3 and 60.3), and in Japonica. PTB.27 and Co.25 in laboratory test (220.33, 137.33, and 142.66). In the experiment conducted under godown conditions moth emergence is not observed in PTB.2, while breeding is very poor in PTB.7, PTB.32, PTB.21, PTB.34, PTB.15, PTB.16, GEB. 24, Co. 25 and PTB.12, as indicated by a range of 0.33 to 3.33. But under laboratory conditions the lowest moth emergence is seen in PTB. 32 closely followed by PTB. 34 and PTB. 2 (17.33, 26.00 and 37. 33). The poor breeding observed under this condition in PTB.32, PTB.34, and PTB.2 thus appears to indicate the relatively higher degree of resistance of these varieties to infestation by S.cerealella . In varieties such as PTB. 15, PTB.16, Co. 25 and GEB.24 which show very low moth development in the godown, show moderate to high infestation in the laboratory trials as indicated by a range in moth emergence of 83.33 to 142.66. These apparent disparities may be due to the difference in the mode of infestation adopted in the two experiments. In the case of laboratory tests the moths are confined to different varieties of seeds and they are obliged to lay eggs and breed in all of them, while in the other experiment moths are at liberty to avoid the varieties which they do not like.

Whether there exists any significant relationship between number of moths emerging on the one hand, and other factors like fineness of grain, developmental period, and size of moths on the other, the correlation coefficients have been worked out from the laboratory data. These are given in Table X. Significant positive correlation is evident between number of grains per gramme and number of moths emerging ($r_{13} = 0.8201$) under laboratory conditions. This difference in population of the moths can be attributed in part to the large number of grains to be found in fine rice than in a coarse variety, in lots of equal weight

No correlation is present between the number of moths emerging and size of male or female moths ($r_{15} = 0.2903$; $r_{14} = 0.220$) or developmental period ($r_{12} = -0.023$). Partial correlation coefficients have been worked out with a view to ascertain whether the estimates of the simple correlation are influenced by a third factor. These are furnished in Table XI. Scrutiny of the Table reveals that the partial correlation coefficient between the number of moths emerging and developmental period, eliminating the number of grains per gramme, is not significant ($r_{12 \cdot 3}$ = -0.108) This shows that the association between number of moths emerging and developmental period, is not influenced by the size of the grain. There is no correlation between number of moths emerging and size of male moths (r_{15}), but significant positive correlation develops when the number of grains per gramme weight is kept constant ($r_{15.3}$ = 0.3843), indicating that fineness of grain does not have influence on the association tested.

III. Duration of development of *S. cerealella* in the different varieties of paddy seeds.

To test whether number of grains per gramme and developmental period of the moth are related, the correlation coefficients have been worked out. No significant correlation is observed between these variables (r_{32} = 0.0406 There is also no correlation between developmental period and fecundity of moths as seen from Table X . No correlation has however been detected even between developmental period and moth emergence which points to the fact that developmental period of the insect cannot be taken as an index of relative susceptibility of a variety to attack by *S. cerealella*.

Significant positive correlation is observed between developmental period and size of male moths(r_{25} = 0.410),

T A B L E X

Simple correlation coefficients for the various associated characters with regard to moth development under laboratory conditions

Sl. No.	Associations tested	Notations	Coefficients of correlation (r)
1.	Number of moths emerging and developmental period	r_{12}	- 0.023
2.	Number of moths emerging and size of female moths.	r_{14}	0.220
3.	Number of moths emerging and size of male moths.	r_{15}	0.2903
4.	Number of moths emerging and number of grains per gramme.	r_{13}	0.8201*
5.	Number of grains per gramme and size of male moths	r_{35}	-0.4321*
6.	Number of grains per gramme and size of female moths.	r_{34}	-0.4960*
7.	Number of grains per gramme and developmental period	r_{32}	0.0406
8.	Developmental period and fecundity	r_{26}	-0.0254
9.	Developmental period and size of male moths	r_{25}	0.410*
10.	Developmental period and size of female moths.	r_{24}	-0.008
11.	Size of female moths and fecundity	r_{46}	0.030

* Significant at 5% level.

T A B L E XI

Partial correlation coefficients between associated characters.

Sl. No.	Character association	Partial correlation coefficients
1	$r_{12.3}$	-0.108
2	$r_{24.3}$	-0.013
3	$r_{25.3}$	+0.4744*
4	$r_{15.3}$	+0.3843*
5	$r_{14.3}$	+0.053

* Significant at 5% level.

Note: Character association.

1. Number of moths emerging.
2. Developmental period
3. Number of grains per gramme
4. Size of female moths
5. Size of male moths

while there is no relationship between developmental period and size of female moths (r_{24} = - 0.008). Warren (1956) also has observed that there is significant positive correlation between the duration of immature stages and weight of S. cerealella adults, bred out from different hybrid corn varieties. Partial correlation coefficient between developmental period and size of male moths tends to increase ($r_{25.3}$ = 0.4744) when the number of grains per gramme is eliminated, thereby, indicating that fineness of grain does not influence to a marked degree the association between the other variables under test.

IV. Size and fecundity of moths of S.cerealella developing within the different varieties of paddy seeds.

Data presented in Table V Column 6 show that the mean weight of male moths ranges from 0.8 mg.(PTB.10 and GEB.24) to 1.62 mg. in PTB.21 . The range in mean weight of female moths will be seen to be from 1.166 mg. in PTB.10 to 2.570 mg. in PTB.1. Histograms in Figure 6 (A) indicate that under laboratory conditions female moths breeding out of coarser varieties like PTB.1, PTB.4 are significantly heavier than those emerging out of finer varieties like GEB.24, PTB.15 and PTB.16. A similar trend of breeding heavier male moths in coarser and medium varieties like Mo.2, PTB.34, PTB.21 and PTB.20 is also observed from Table IX. In both cases weight of moths is considerably lower in finer varieties like PTB.15 and GEB.24 as seen from analysis of variance tables VIII and IX.

From data given in Table V Column 7 it will be seen that number of eggs laid by females under laboratory conditions shows a wide range of variation from 31.2 to 116.70 . Thus in the moths reared on the varieties PTB.7 and PTB.8 the oviposition rates are 31.2 and 37.0 per moth respectively. These two varieties have been found to suffer very little damage when exposed to infestation by the moth. On the other hand, moths reared out from the varieties Japonica, PTB.27 and PTB.26, produce relatively larger number of eggs per female, the numbers being 110.2, 74.40 and 95.80 per moth respectively and these varieties of paddy seeds appear to be highly susceptible to moth infestation, suffering substantial loss under storage. These observations thus suggest that the food of the insect in the immature stages governs to a great extent the fecundity of the moths and that the moths developing on the more susceptable varieties have higher fecundity than those maturing in the less susceptible ones. This can also lead to the conclusion that the moth will be able to build up its population at a far more higher rate in the more susceptible varieties than in the less susceptible ones.

Further, significant negative correlation is observed between number of grains per gramme and size of male or female moths (r_{35} = - 0.4321 and r_{34} = -0,49 Correlation studies also indicate that size of moths has no relation with either moth emergence or fecundity (r_{46} = 0.03). This observation that there is no correlation between size of female moths and their fecundity is in conformity with the result obtained by Warren (1956) who also has not detected any significant correlation between oviposition and weight of S. cerealella moths breeding in different strains of hybrid maize.

From the correlation studies it is seen that under laboratory conditions, size and number of moths emerging out of a variety are influenced by the number of grains per gramme weight. It is also seen that size of female moths and their fecundity are not related. Thus it appears that it is the size of the female moth and not their oviposition potential, which is governed by the grain size. Moth emergence under laboratory conditions cannot be taken as indicative of the relative susceptibility of a variety, for the reason that even in varietie not preferred by the moths when left to themselves under godown conditions, they breed when confined on the varieties. These confirm the conclusion that the number of grains per gramme is not the sole factor deciding relative susceptibility of a particular variety. This is exemplified by the fact that moderately resistant varieties are found among finer (PTB.15, PTB.16, GEB.24) as well as coarser (PTB.2, PTB.7, PTB.32) grains. The highly susceptible variety Japonica has medium sized grains while PTB.27 is a coarser variety.

Ramia (1927) has made the general observation that glutinous rices are more susceptible to damage by S. cerealella and according to Isaburo Nagai (1959) Japonica rice grains are highly glutinous and their kernels very soft. The high susceptibility of the Japonica rice to infestation by S. cerealella may then be correlated with this character. An additional factor governing susceptibility may be the relatively thin husk possessed by Japonica variety. Thinner husk may offer less resistance to penetrating larvae. Moreover cracks and abrasions in the pericarp are likely to be more in a variety with thinner husk than in a thickly husked variety. As S.cerealella larva penetrates the grain generally through abrasions in the pericarp (Pruthi and Singh - 1943), a variety with thinner husk is likely to offer little resistance to the caterpillars.

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SUMMARY AND CONCLUSIONS

SUMMARY AND CONCLUSIONS

Uptodate literature on the insect pests affecting rice under storage, have been reviewed.

Twenty nine varieties of paddy seeds have been subjected to natural infestations by the Angoumois grain moth Sitotroga cerealella Oliv. for 10 days in a godown heavily infested with the insect to ascertain the relative susceptibility of the different varieties of seeds to the pest infestation, the number of moths maturing within each variety and the developmental period taken by the insect on each variety . The varieties used are: PTB.1, PTB.2, PTB.4, PTB.5, PTB.7, PTB.8, PTB.9, PTB.10, PTB.12, PTB.15, PTB.16, PTB.18, PTB.20, PTB.21, PTB.22, PTB.23, PTB.24, PTB.25, PTB.26, PTB.27,PTB.31, PTB.32,PTB.33,PTB.34, MTU.3, GEB.24, Japonica, Mo.2 and Co.25.

No damage is caused to the variety PTB.2, while varieties PTB.7, PTB.15, PTB.16, Co.25, GEB.24, PTB.8 and PTB.32 suffer very slight damage due to the pest (0.016 to 0.5 per cent). The varieties Japonica PTB. 27 and PTB.26 show high suscepetibility to the attack with 4.83 to 6.83 per cent damage and the remaining varieties show intermediate susceptibilities. Maximum number of moths develop within the varieties Japonica and PTB. 27 (53.3 and 60.3 respectively). Least number of moths mature within the varieties PTB.7, Co.25, GEB.24, PTB.32, PTB.12, PTB.21, PTB.15 and PTB.16 (0.33 to 3.33 moths per 100 g.). Development period of the insect within the different varieties of seeds ranges between 36.66 in PTB.22 to 23.66 days in PTB.33.

In a second experiment all the 29 varieties of seeds have been subjected to infestation by S.cerealella by confining moths on these varieties, to observe more precisely the development period, number, size and fecundity of moths developing in each variety and the results statistically analysed.

Development period of the moth within the different varieties of seeds varies significantly. This period is longest in the varieties PTB.8, PTB.7 and Mo.2 (45.66, 42.00 and 40.33 days respectively). The shortest period of development is seen in the varieties PTB.1, PTB.32 and PTB.27 (range from 27 to 35.33 days). Largest number of moths develop in the varieties Japonica, Co.25 and PTB.27 (220.33, 142.66 and 137.33 moths per 100 g.). Least number of moths emerge from the varieties PTB.7, PTB.2, PTB.34 and PTB.32 (17.33 to 39 moths per 100 g.). Size of moths emerging from the different varieties of seeds differ significantly. The heaviest female moths emerge from PTB.1, PTB.34, Mo.2 and PTB.9 (2.166 to 2.570 mg. per moth), and the lightest moths from GEB.24, PTB.16, PTB.32, PTB.10 and PTB.24 (1.166 to 1.373 mg. per moth). Among male moths heaviest moths develop within Mo.2 (1.963 mg. per moth) and lightest in PTB.10 and GEB.24 (0.8 mg. per moth). Fecundity of moths is the highest in those developing within PTB.9 and Japonica (116.7 and 110.2 eggs per female.). Moths emerging from the varieties PTB.7, PTB.8 and PTB.10 show the least fecundity (31.2 to 39.4 eggs per female).

There is no correlation between development period of the moth on the one hand and size of host grains, number and fecundity of moths developing and size of female moths on the other. Development period and size of male moths are however, correlated.

There is significant positive correlation between number of grains per gramme and number of moths emerging and negative correlation between the former and the size of the moths. Partial correlation studies show that number of grains per gramme ie. size of the grains, has no influence o the other factors under study.

The conclusions are:-

(a) The varieties PTB.2, PTB.7, PTB.32 and PTB.34 show relatively, a high degree of resistance to infestation by S.cerealella.

(b) The varieties Japonica, PTB.27, and PTB.26 are highly susceptible to infestation and damage by the pest.

(c) Grain size does not appear to be a factor gover ing susceptibility of paddy seeds to attack by S.cerealella.

(d) Moths developing in grains showing high suscept bility to attack have higher fecundity than those developing in grains of low susceptibility.

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APPENDICES

APPENDIX I

Developmental period and number of moths emerged of *S. cerealella* developing in different varieties of paddy seeds under godown conditions.

Sl. No.	Variety	Reps.	Number of moths emerging on days after exposure to infestation. 20	22	24	26	28	30	32	34	36	38	40	42	45	64	66	68	Total moth emergence.	Mean moth emergence.	Average developmental period.
1	2	3	4																5	6	7
		a	6	7	6	9	4	1	-	5	-	-	-	2	7	-	-	-	47		
1	PTB. 1	b	14	5	7	-	-	-	-	5	2	-	-	-	-	-	-	-	33	31.6	31.0
		c	1	2	3	-	3	-	-	2	-	-	-	4	4	-	-	-	15		
		a	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
2	PTB. 2	b	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
		a	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	3		
3	PTB. 4	b	-	-	-	-	-	1	-	5	2	-	-	-	-	-	-	-	8	4.33	32.33
		c	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	2		
		a	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1		
4	PTB. 5	b	-	-	-	6	6	-	-	-	-	-	-	-	-	-	-	-	12	9.0	28.00
		c	-	-	-	-	-	-	-	-	5	3	-	6	-	-	-	-	14		
		a	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	—		
5	PTB. 7	b	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	2	1.00	27.00
		c	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	1		
		a	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	3		
6	PTB. 8	b	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.33	27.00
		c	-	-	-	3	-	-	-	-	1	-	-	-	-	-	-	-	4		
		a	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	3		
7	PTB. 9	b	-	-	1	5	-	-	3	-	-	-	-	-	4	-	-	-	13	10.33	30.66
		c	2	8	-	2	-	2	-	1	-	-	-	-	-	-	-	-	15		

1	2	3	4																5	6	7
			20	22	24	26	28	30	32	34	36	38	40	42	45	64	66	68			
		a	-	-	-	-	1	-	-	P	-	-	-	-	3	-	-	-	4		
8	PTB. 10	b	-	-	-	-	-	4	6	-	-	-	-	-	-	-	-	-	10	7.33	28.33
		c	-	-	-	-	8	-	-	-	-	-	-	-	-	-	-	-	8		
		a	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	2		
9	PTB. 12	b	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.66	35.00
		c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	—		
		a	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1		
10	PTB. 15	b	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.33	22.00
		c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	—		
		a	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
11	PTB. 16	b	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.66	35.00
		c	-	-	-	-	-	-	-	-	5	-	-	-	-	-	-	-	5		
		a	2	-	2	2	-	-	-	-	-	-	-	6	2	-	-	-	14		
12	PTB. 18	b	-	21	6	-	-	-	-	-	4	-	2	-	2	-	-	-	35	22.00	28.66
		c	5	9	3	-	-	-	-	-	-	-	-	-	-	-	-	-	17		
		a	-	-	1	-	-	1	2	-	1	-	-	-	-	-	-	-	5		
13	PTB. 20	b	6	-	-	4	-	1	7	-	-	-	-	-	-	-	-	-	18	7.66	29.00
		c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
		a	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
14	PTB. 21	b	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	3	1.00	35.00
		c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
		a	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1		
15	PTB. 22	b	-	-	-	8	4	2	-	-	-	-	-	-	-	-	-	-	14	6.00	36.66
		c	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	3		
		a	-	-	-	7	1	5	-	-	-	-	-	-	-	-	-	-	13		
16	PTB. 23	b	-	-	-	-	-	-	9	7	-	-	-	-	-	-	-	-	16	13.66	29.66
		c	-	-	-	3	-	-	9	-	-	-	-	-	-	-	-	-	12		

1	2	3	4																5	6	7
			20	22	24	26	28	30	32	34	36	38	40	42	45	64	66	68			
		a	-	-	-	-	-	-	-	-	1	-	1	-	-	-	-	-	2		
17	PTB. 24	b	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1	2.00	34.00
		c	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	3		
		a	-	-	-	-	-	-	1	-	2	-	-	-	-	-	-	-	3		
18	PTB. 25	b	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.66	34.50
		c	-	-	-	-	-	-	-	7	1	-	-	-	-	-	-	-	8		
		a	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
19	PTB. 26	b	-	-	-	-	-	-	13	9	-	-	-	-	-	2	-	-	24	15.66	41.00
		c	-	-	-	-	-	-	6	6	-	-	-	5	4	2	-	-	23		
		a	7	18	-	5	-	8	-	-	7	3	-	3	10	-	-	-	61		
20	PTB. 27	b	-	25	-	-	-	7	-	-	3	-	-	1	-	-	-	-	36	60.33	33.66
		c	21	14	20	8	2	3	-	-	11	-	-	-	5	-	-	-	24		
		a	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
21	PTB. 31	b	-	-	-	-	-	-	-	-	5	8	-	-	-	-	-	-	13	6.66	35.53
		c	-	-	-	-	-	-	-	4	3	-	-	-	-	-	-	-	7		
		a	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
22	PTB. 32	b	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	--	1.66	32.00
		c	-	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-	5		
		a	-	-	3	13	-	-	-	-	-	-	-	-	-	-	-	-	16		
23	PTB. 33	b	-	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	6	16.00	23.66
		c	-	1	20	2	-	3	-	-	-	-	-	-	-	-	-	-	26		
		a	-	-	1	1	-	-	3	-	1	-	-	-	2	-	-	-	8		
24	PTB. 34	b	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.66	32.00
		c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		

1	2	3	4																5	6	7
			20	22	24	26	28	30	32	34	36	38	40	42	45	64	66	68			
		a	11	-	1	5	-	-	-	-	-	-	-	-	4	-	-	-	21		
25	MTU. 3	b	-	14	5	3	1	-	-	-	-	-	-	2	-	-	-	-	25	27.00	31.00
		c	-	19	3	-	-	-	2	-	-	-	-	7	4	-	-	-	35		
		a	-	-	-	-	-	4	-	1	-	-	-	-	-	-	-	-	5		
26	GEB. 24	b	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	--	1.66	32.00
		c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
		a	5	7	-	13	8	4	-	-	-	-	-	-	-	-	-	-	37		
27	Japonica	b	-	-	3	18	34	12	2	-	-	-	-	-	-	-	-	-	69	53.33	27.33
		c	-	-	-	14	13	9	13	3	2	-	-	-	-	-	-	-	54		
		a	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
28	Mo. 2	b	-	-	1	-	5	6	3	-	3	-	-	-	-	-	-	-	18	6.00	29.00
		c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
		a	-	-	-	-	-	4	4	-	2	-	-	-	-	-	-	-	10		
29	Co. 25	b	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	--	3.33	32.00
		c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		

APPENDIX II

Number of moths emerged and developmental period of *S. cerealella* when bred on different varieties of paddy seeds under laboratory conditions.

Sl. No.	Variety	Reps.	Date of exposure.	Number of moths emerging on days after exposure														Total No. of moths emerging.	Average moth emergence.	Average developmental period
				20	22	24	26	28	30	32	34	36	38	40	42	44	46-55			
1	2	3	4	5														6	7	8
		a	19-10-63	2	3	2	3	13	5	11	11	11	6	14	-	2	-	83		
1	PTB. 1	b	1-1--64	-	-	-	8	18	21	14	-	8	7	5	3	2	-	86	83.33	31.33
		c	16-2--64	-	-	6	23	23	10	7	7	3	2	-	-	-	-	81		
		a	21-10-63	-	-	-	-	3	1	6	-	9	9	14	9	1	-	52		
2	PTB. 2	b	10-1--64	-	-	-	-	1	-	2	1	10	8	1	1	2	-	26	37.33	33.66
		c	20-1--64	-	6	9	6	10	2	4	3	-	-	-	-	-	2	42		
		a	20-10-63	-	-	-	2	8	15	17	16	10	16	8	1	-	-	93		
3	PTB. 4	b	14-1--64	-	-	-	-	8	-	12	6	8	6	2	5	4	-	51	71.66	34.66
		c	25-1--64	-	-	-	-	4	18	5	-	8	7	13	10	1	5	71		
		a	21-10-63	-	-	-	-	-	11	13	11	11	19	6	4	7	-	82		
4	PTB. 5	b	9--1--64	-	-	-	-	-	-	-	12	-	21	14	25	23	7	102	85.33	33.00
		c	18-2--64	-	5	13	5	6	19	11	-	-	-	12	-	-	1	72		

1	2	3	4	5														6	7	8
				20	22	24	26	28	30	32	34	36	38	40	42	44	46-55			
		a	19-10-63	-	-	-	-	-	-	6	3	7	9	9	4	-	-	38		
5	PTB. 7	b	5--12-63	-	-	-	-	-	-	7	-	8	8	3	4	2	7	39	39.00	42.00
		c	10-1--64	-	-	-	-	-	-	-	-	-	7	6	10	10	7	40		
		a	16-10-63	-	1	-	-	5	11	14	13	10	17	2	2	2	4	81		
6	PTB. 8	b	8--12-63	-	-	-	-	4	11	9	6	6	12	8	11	3	2	72	76.00	45.66
		c	6--1--64	-	-	-	-	-	-	-	12	12	5	8	10	20	8	75		
		a	10-10-63	-	-	-	2	5	9	28	23	21	13	11	7	6	3	128		
7	PTB. 9	b	6--12-63	-	-	-	-	-	-	-	-	-	-	-	15	7	70	92	109.66	37.33
		c	18-1--64	-	-	2	20	27	25	13	18	4	-	-	-	-	-	109		
		a	23-10-63	-	-	-	-	10	17	10	10	8	11	3	4	1	-	74		
8	PTB. 10	b	7--1--64	-	-	-	-	-	9	22	13	6	5	5	-	-	-	60	68.66	33.66
		c	15-1--64	-	-	-	-	-	-	-	10	26	15	11	5	5	-	72		
		a	23-10-63	-	-	-	-	6	2	5	3	15	7	4	5	1	-	48		
9	PTB. 12	b	19--1-64	-	-	-	-	-	-	8	7	2	3	-	13	-	-	53	52.33	35.66
		c	25--1-64	-	-	-	-	14	-	18	12	5	3	4	-	-	-	56		
		a	11-10-63	-	-	-	3	7	11	20	18	17	11	3	4	-	-	94		
10	PTB. 15	b	8--1--64	-	-	-	-	8	3	13	10	10	12	7	3	3	2	71	83.33	36.66
		c	10-2--64	3	25	11	15	12	4	-	-	-	-	6	-	7	2	85		
		a	20-10-63	-	-	-	-	11	11	15	17	14	15	11	5	6	1	106		
11	PTB. 16	b	19-1--64	-	-	-	7	-	37	22	13	3	-	-	-	-	-	82	95.33	32.66
		c	23-2--64	-	-	-		16	28	19	14	9	4	8	-	-	-	98		
		a	20-10-63	-	-	-	3	8	7	17	18	9	5	2	2	-	-	71		
12	PTB. 18	b	8-12--63	-	-	-	-	-	-	-	-	-	-	6	13	20	43	81	81.33	38.33
		c	23-1--64	-	-	-	-	-	-	-	4	39	14	10	8	8	9	92		

1	2	3	4	5														6	7	8
				20	22	24	26	28	30	32	34	36	38	40	42	44	46-55			
		a	22-10-63	-	-	-	-	22	12	10	12	7	12	2	-	-	-	77		
13	PTB. 20	b	14-1--64	-	-	-	-	33	18	12	15	2	2	-	-	-	-	82	76.33	33.00
		c	17-2--64	-	-	7	18	15	9	8	8	5	-	-	-	-	-	70		
		a	23-10-63	-	-	-	-	8	12	8	9	19	7	5	6	-	-	74		
14	PTB. 21	b	5--12-63	-	-	-	-	-	1	12	12	7	7	3	13	2	6	63	67.33	35.33
		c	8--1--64	-	-	-	-	-	-	-	10	21	10	13	6	5	-	65		
		a	7--10-63	-	-	-	-	8	1	6	7	-	9	13	1	1	-	36		
15	PTB. 22	b	7--1--64	-	-	-	-	-	-	-	-	8	3	-	17	7	10	45	48.33	37.66
		c	16-2--64	-	-	-	4	8	14	10	18	6	3	1	-	-	-	64		
		a	18-10-63	-	-	-	-	-	-	5	6	9	11	14	11	4	2	62		
16	PTB. 23	b	7--12-63	-	-	-	-	-	-	22	11	12	4	1	-	1	1	52	61.00	37.66
		c	15-1--64	-	-	-	-	3	7	11	12	7	13	8	6	2	-	69		
		a	21-10-63	-	-	-	-	-	7	2	7	8	7	6	5	2	2	46		
17	PTB. 24	b	8--1--64	-	-	-	-	-	-	16	12	7	4	8	3	-	-	50	50.33	36.00
		c	17-2--64	-	-	-	-	11	5	12	8	3	10	6	-	-	-	55		
		a	18-10-63	-	-	-	5	5	11	15	18	8	6	2	-	-	-	70		
18	PTB. 25	b	5--12-63	-	-	-	-	8	9	15	18	14	6	2	1	-	-	73	66.66	34.33
		c	25-1--64	-	-	-	-	6	20	15	4	8	4	-	-	-	-	57		
		a	18-10-63	-	-	-	-	-	16	12	12	7	14	10	6	-	-	77		
19	PTB. 26	b	5-12--63	-	-	-	-	5	11	20	14	11	8	4	1	-	-	72	78.33	34.00
		c	25-1--64	-	-	-	-	6	31	13	20	9	3	4	-	-	-	86		
		a	17-10-63	1	15	24	21	28	27	20	20	3	-	-	-	-	-	159		
20	PTB. 27	b	9--1--64	-	-	-	-	-	25	19	19	10	29	5	4	3	-	114	137.33	27.00
		c	16-2--64	7	35	3[illegible]	15	17	13	2	4	11	-	-	-	-	-	139		

1	2	3	4	5														6	7	8
				20	22	24	26	28	30	32	34	36	38	40	42	44	46-55			
		a	17-10-63	-	-	-	-	-	6	11	16	8	6	3	4	-	-	54		
21	PTB. 31	b	10-1--64	1	44	18	4	-	2	-	-	-	-	-	-	-	-	69	64.66	33.00
		c	22-2--64	-	-	4	27	11	6	6	5	2	-	3	3	6	-	71		
		a	15-10-63	-	-	-	-	7	13	-	-	-	-	-	-	-	-	20		
22	PTB. 32	b	24-1--64	-	-	-	-	3	3	4	2	-	-	-	-	-	-	12	17.33	29.66
		c	21-2--64	-	-	3	6	6	4	1	-	-	-	-	-	-	-	20		
		a	9-10-63	-	-	-	-	24	15	23	25	16	9	3	3	-	-	118		
23	PTB. 33	b	10-1--64	-	-	-	-	16	22	20	5	6	2	-	-	-	-	71	97.00	33.00
		c	21-2--64	-	-	19	24	21	10	16	8	1	-	3	-	-	-	102		
		a	8--10-63	-	-	-	-	2	3	4	8	2	5	-	-	-	-	24		
24	PTB. 34	b	5--12-63	-	-	-	-	-	-	4	6	5	4	4	1	1	-	25	26.00	36.66
		c	12--1-64	-	-	-	-	-	2	5	7	6	2	5	2	-	-	29		
		a	12-10-63	-	-	6	1	6	4	5	7	21	3	6	11	3	29	102		
25	MTU. 3	b	21-1--64	-	-	-	-	4	10	8	31	6	13	6	5	13	18	114	113.66	40.33
		c	20-2--64	-	-	-	16	22	17	31	10	12	10	3	4	-	-	125		
		a	19-10-63	-	-	-	17	67	39	42	22	21	17	4	10	-	-	239		
26	Japonica	b	14-1--64	-	-	-	-	10	27	43	14	44	13	17	16	11	23	218	220.33	33.00
		c	18-2--64	-	-	15	10	40	56	41	29	9	4	-	-	-	-	204		
		a	22-10-63	-	-	-	-	-	2	4	9	9	15	9	6	4	7	65		
27	Mo. 2	b	5--12-63	-	-	-	-	-	-	14	14	17	16	8	3	2	15	89	86.66	40.66
		c	3--2--64	-	-	-	-	-	16	13	18	15	5	3	1	20	15	106		
		a	22-10-63	-	-	-	-	22	15	26	31	26	15	4	7	-	-	146		
28	Co. 25	b	4--12-63	-	-	-	-	-	-	15	27	34	38	15	8	2	3	142	142.66	34.00
		c	19-1--64	-	-	-	8	19	28	26	24	24	6	4	1	-	-	140		
		a	20-10-63	-	-	-	-	-	25	14	20	11	15	9	8	-	2	104		
29	GEB. 24	b	23-1--64	-	-	-	-	30	8	13	6	7	11	3	-	-	-	78	84.00	33.66
		c	19-2--64	-	-	-	-	-	12	19	21	16	6	6	-	-	-	80		

APPENDIX - III

Percentage of grains damaged by *S. cerealella* in different varieties of paddy seeds when exposed to natural infestation.

Sl No.	Vaeity	Mean no.of grains damaged out of 200 R1	R2	R3	Percentage Recorded values	After transformation.
I	PTB.1	3.0	4.0	3.0	1.33	1.2879
2	PTB.2	-	-	-	-	-
3	PTB.4	2.0	1.0	6.0	1.50	1.1464
4	PTB.5	0	5.0	6.0	1.83	1.1044
5	PTB.7	0	1.0	1.0	0.33	0.4714
6	.TB.8	2.0	0	0.50	0.41	0.5000
7	PTB.9	3.0	3.0	4.0	1.33	1.2879
8	PTB.10	0.2*	2.0	4.0	1.03	0.8381
9	PTB.12	2.0	0	0	0.33	0.3333
10	PTB.15	0.4*	0.0	0	0.06	0.1491
11	PTB.16	0	0	2.0	0.33	0.3333
12	PTB.18	2.0	4.5	2.0	1.416	1.6666
13	PTB.20	6.0	11.0	0	2.830	1.3591
14	PTB.21	0	2.0	0	0.333	0.333
15	PTB.22	1.0	7.0	0.4*	1.410	1.0084
16	PTB.23	3.0	7.0	2.0	2.000	1.3651
17	PTB.24	4.0	1.0	3.0	1.333	1.1150
18	PTB.25	1.0	0	3.0	0.666	0.6439
19	PTB.26	0	14.0	15.0	4.830	1.7948
20	PTB.27	6.0	4.0	20.0	5.000	2.0128
21	PTB.31	0	6.0	2.0	1.333	0.9107
22	PTB.32	0	0	2.0	0.333	0.333
23	PTB.33	3.0	3.0	12.0	3.000	1.6329
24.	PTB.34	3.0	0	0	0.500	0.4082
25	MTU.3	5.0	1.0	4.0	1.666	1.2341
26	GEB.24	0.1*	0	0	0.016	0.0230
27.	Japonica	3.0	20.0	18.0	6.830	2.4620
28.	Mo.2	0	5.0	0	0.830	0.5270
29.	Co.25	0.20*	0	0	0.030	0.3333

* Damage estimated from 1000 grains.

APPENDIX IV (4)

Fecundity of moths of *S. cerealella* reared on different varieties of paddy seeds under laboratory conditions.

Sl. No.	Variety	Number of eggs laid per moth									Average
		Rep. I			Rep. II			Rep. III			
		1	2	3	1	2	3	1	2	3	
1	2	3									4
1	PTB. 1	82	87	56	73	81	91	65	54	93	75.8
2	PTB. 2	77	79	74	72	76	79	72	70	82	75.8
3	PTB. 4	49	51	56	46	59	40	39	47	69	50.8
4	PTB. 5	85	57	56	39	54	35	79	82	36	58.0
5	PTB. 7	30	26	31	39	30	20	19	32	53	31.2
6	PTB. 8	40	46	50	25	40	39	34	40	17	37.0
7	PTB. 9	127	120	101	178	91	107	85	98	140	116.75
8	PTB. 10	40	50	37	34	36	40	54	38	25	39.00
9	PTB. 12	95	110	70	92	83	95	90	79	96	90.00

1	2	3									4
		1	2	3	1	2	3	1	2	3	
14	PTB. 21	50	74	49	40	56	61	70	35	51	54.20
15	PTB. 22	58	60	49	40	39	70	79	63	55	57.00
16	PTB. 23	56	60	61	55	58	62	56	58	54	57.80
17	PTB. 24	46	68	46	66	59	36	58	74	50	57.00
18	PTB. 25	45	46	51	54	41	20	61	50	58	47.40
19	PTB. 26	115	105	85	80	90	102	108	80	90	95.00
20	PTB. 27	78	70	87	62	70	82	90	77	54	74.40
21	PTB. 31	46	90	79	64	62	89	74	60	49	68.20
22	PTB. 32	45	37	51	46	38	45	50	39	40	43.40
23	PTB. 33	61	91	89	62	72	69	58	49	88	71.00
24	PTB. 34	41	54	63	48	61	36	65	62	50	53.40
25	MTB. 3	60	65	70	50	65	79	53	60	58	62.00
26	GPB.24	53	51	57	41	51	64	59	62	37	50.60
27	Japonica	122	127	68	119	115	134	112	102	91	110.00
28	Mo. 2	84	61	94	68	84	75	69	84	85	78.20
29	Co. 25	80	70	76	86	60	85	74	30	99	74.40

APPENDIX IV (B)

Weight of moths of S. cerealella bred on different varieties of paddy seeds under laboratory conditions.

Sl. No.	Variety	Weight of 10 moths in mgm.						Average weight of 10 moths (mgm).	
		R I		R II		R III			
		Male	Female	Male	Female	Male	Female	Male	Female
1	2	3						4	
1	PTB. 1	11.4	27.3	10.0	24.2	12.8	25.6	11.40	25.70
2	PTB. 2	10.0	15.0	11.0	13.0	9.0	14.0	10.00	14.00
3	PTB. 4	12.0	16.0	10.0	14.0	11.0	16.0	11.00	15.30
4	PTB. 5	9.0	17.0	11.0	18.0	14.0	18.0	11.00	17.66
5	PTB. 7	10.0	22.0	11.0	20.0	9.0	18.0	10.00	20.00
6	PTB. 8	9.0	15.0	8.0	13.0	10.0	14.0	9.00	14.00
7	PTB. 9	12.0	22.0	10.0	23.0	12.0	20.0	11.33	21.66
8	PTB. 10	9.0	13.0	8.0	10.0	7.0	12.0	8.00	11.66
9	PTB. 12	10.2	14.5	11.0	15.0	11.1	13.0	10.76	14.16
10	PTB. 15	9.3	14.5	10.1	12.3	7.9	11.9	9.10	12.90
11	PTB. 16	10.0	12.3	11.0	11.9	11.2	14.0	10.73	12.73
12	PTB. 18	9.8	18.2	11.2	18.9	10.4	16.3	10.46	17.80
13	PTB. 20	16.4	20.1	16.1	18.3	15.4	20.0	15.96	19.46

1	2	R I		R II		R III			
		Male	Female	Male	Female	Male	Female	Male	Female
				3				4	
14	PTB. 21	16.6	19.3	15.0	18.5	17.0	19.1	16.20	18.96
15	PTB. 22	12.5	15.3	13.0	16.5	11.4	15.0	12.30	15.60
16	PTB. 23	10.0	16.1	12.1	16.1	11.0	17.1	11.03	16.43
17	PTB. 24	8.3	13.5	8.0	14.1	9.0	13.6	8.43	13.73
18	PTB. 25	14.0	18.0	13.5	17.0	14.6	18.5	14.33	17.83
19	PTB. 26	9.5	15.4	10.4	17.3	12.0	14.9	10.63	15.86
20	PTB. 27	12.0	13.9	11.0	13.0	13.1	14.9	12.33	13.93
21	PTB. 31	12.0	13.3	11.0	14.0	12.9	14.5	11.96	13.93
22	PTB. 32	11.5	13.2	9.4	11.0	12.8	11.3	10.56	11.83
23	PTB. 33	17.7	20.0	16.9	21.5	11.5	19.0	15.36	20.16
24	PTB. 34	15.0	25.0	18.3	24.5	17.0	20.9	16.66	23.46
25	MTU. 3	16.0	20.1	15.5	21.0	14.7	18.9	15.40	20.00
26	GEB. 24	6.6	13.8	8.0	14.0	9.4	12.9	8.00	13.56
27	Japonica	12.3	19.0	13.0	17.5	13.5	20.5	12.93	19.00
28	Mo. 2	19.0	23.0	21.2	23.0	18.7	22.0	19.63	23.33
29	Co. 25	10.0	18.2	11.5	18.0	9.8	17.4	10.43	17.86

A P P E N D I X - V

RECORD OF TEMPERATURE & HUMIDITY (OCTOBER 1963 to MARCH'

Month	Week	Temperature		Humidity	
		Maximum	Minimum	Maximum	Minimum
1963 October	1	86	81	84	56
	2	86	82	83	62
	3	85	81	90	64
	4	84	79	94	65
November	1	85	80	92	68
	2	84	80	88	55
	3	86	81	89	62
	4	85	80	90	64
December	1	84	80	89	64
	2	86	80	79	54
	3	88	82	79	50
	4	86	80	82	52
1964 January	1	86	80	84	62
	2	84	81	85	56
	3	84	80	85	60
	4	84	78	88	60
February	1	80	86	81	54
	2	80	85	60	45
	3	84	88	87	60
	4	84	87	90	60
March	1	87	84	87	58
	2	90	80	72	48
	3	92	89	88	62
	4	88	85	86	68

FIGURES

FIGURE I. Oviposition chamber.

FIGURE II. Moth introduction tube.

FIGURE I

FIGURE II

FIGURE III. *Sitotroga cerealella* Olivier male moth.

FIGURE III

FIGURE IV. *Sitotroga cerealella* Olivier

female moth.

FIGURE IV