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THE BIOLOGY AND CHEMICAL CONTROL OF CALLOSOBRUCHUS CHINENSIS (LINN.) (COLEOPTERA: BRUCHIDAE[1])

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The biology, host range and natural enemies of Callosobruchus chinensis (Linnaeus) were studied. Topical toxicity of DDT, DDVP, Gardona, lindane and malathion, and the effectiveness of these insecticides as sack treatments at three dosage rates were also investigated for the control of this pest.

Mungo beans when stored for long periods of time invariably suffer from the attack of several stored-product pests. The most common and destructive is the cowpea weevil, *Collosobruchus chinensis* (Linn.). Initial infestation of this pest commences in the field. The female weevils start laying their eggs on fully developed green pods. These eggs are so tiny that they are often unnoticed by the naked eye. Upon hatching, the grubs bore directly through the pod into the seed. The holes through which the larvae enter the seeds are too minute for detection and may heal by the time the seeds have matured. Thus, many seeds that appear outwardly as excellent and in perfect condition actually harbor some concealed larvae. When these seeds are stored, the brubs continue to consume the inner portion until fully grown. The pupal period is also spent within the infested bean. In emerging, the adults cut a circular flap in the seed integument. They continue to breed in stored beans throughout the year. Total loss of the stored beans may occur within three months when no proper control measure is applied.

Callosobruchus chinensis was originally described by Linnaeus in 1758 under the combination, *Curculio chinensis*. In a review of the genera of

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Bruchidae, Pic (1912) transferred the species *chinensis* Linn., and assigned it as the generic type of *Callosobruchus*. The combination, *Callosobruchus chinensis* (Linn.), has been widely used since then.

In addition to these two names, this species has been referred to also under other names enumerated below. These are compiled from the recent taxonomic treatment of economically important species of *Callosobruchus* by Southgate (1958), and of North American Bruchidae by Bottimer (1958): *Bruchus pecticornis* Linnaeus 1967, *B. pectinicornis* Fabricius 1775, *B. rufus* DeGeer 1775, *B. scutellaris* Fabricius 1792, *B. barbicornis* Fabcius 1801, *B. bistriatus* Fabricius 1801, *B. barbicornis* Fabricius 1801 *B. biguttellus* Schoenherr 1833, *Kitorhyni scutelari* F. (as used by Motschoulsky 1874), *K. scutellatus* (as used by Motschoulsky 1874), *Bruchus pectinatus* (as used by Schilsky 1904), *B.* (*Bruchus*) *chinensis* (as used by Sharp 1914), *B.* (*Callosobruchus*) *bistriotus* (as used by Bridwell 1929), *B. quadrimaculatus* var. *barbinicornis* Fabricius (as used by Wolcott 1936).

C. chinensis is commonly known as the bean weevil in the Philippines (Capco 1957; Uichanco 1959). In Japan it is called the adzuki bean weevil (Hatai and Kimura 1956); in Korea, the southern cowpea weevil, (Bang 1963); in Burma, a pulse beetle (Ghosh 1937); and in South Africa, the cowpea weevil (Oosthuizen and Laubscher 1940). This weevil has a cosmopolitan distribution. It is believed to be of Asiatic origin (Hamilton 1894) but is now widely distributed over the entire globe through importation and distribution of dried beans.

The bionomics of the bean weevil has been studied abroad (Miyake 1938; Oosthuizen and Laubscher 1940; Rahman, Sohi and Sopra 1942; Rajak and Pandey 1965; Singh 1965; Skaife 1926; and Zacher 1930). Howe and Curie (1964) investigated the effects of temperature variation on the life history of the species. Comparative studies of development on different hosts were undertaken by Miyake and Odera (1939) and Singh (1962). Zacher (1929) observed the oviposition and feeding habits of the insect while Takasugi (1924) and Okuni (1924) studied female fecundity. Records of host plants have been reported by Gundurao and Majumder (1964) while those of natural enemies were given by many workers (Bridwell 1917; Crawford 1913; Kariya and Kurosawa 1939; Krishna Ayyar 1940; Mani 1939; Nakamura 1963; Timberlake 1926; Utida 1955, and Willcocks 1914).

Although this species is generally recognized as a pest, very little is known of its biology in the Philippines. Uichanco (1959) casually noted its seriousness as pest of stored beans while Dammerman (1929) earlier gave a brief description of the species. Its host plants were recorded by Woodworth (1929) and Capco (1957).

This study was conducted to investigate various aspects of the biology of the pest, to study its responses to five selected insecticides, and to evaluate the effectiveness of these insecticides as sack protectants at three different dosages. The work was conducted in the Department of Entomology and the Central Experiment Station of the U. P. College of Agriculture from June, 1970 to October 1971.

MATERIALS AND METHODS

Mass rearing: Mungo seeds heavily infested with *C. chinensis* were collected from the storage room of the Department of Entomology and were placed inside ball jar until the emergence of adults. The emerging adult were transferred to wire screen breeding cages. Mungo seeds which were previously fumigated with phostoxin were exposed on petri dishes inside the cages for oviposition by females. Seeds with eggs were collected daily, transferred to new ball jars with screen cover, and were kept in culture until the adults emerged. The breeding cages were cleaned every two weeks and new stocks of parent weevils were placed each time. This procedure was done throughout the study period to maintain adequate stocks of the insect for various laboratory studies.

Life-history studies: Newly emerged adults were paired and confined for egg-laying in plastic with uninfested seeds. The eggs laid by each female were counted daily. Eggs were transferred to petri dishes where the larvae were reared individually. The incubation period and percentage hatchability of eggs were recorded.

To facilitate history studies, only one larva was allowed to develop on a single seed; the remaining were destroyed. Observations of the immature stages were done under a dissecting microscope. Immediately after hatching, the burrow of the first-instar larva was traced by dissecting the seed daily, from the location of the empty egg shell to that of the first molted skin. Subsequent molts were observed the same way, the duration of the larval stages being determined by the time distance between molting periods. The pupae were observed through the very minute openings made on the seed.

The egg-laying, mating and feeding habits of the weevil were observed also from these individual cultures. The preoviposition, oviposition and postoviposition periods, female fecundity and egg fertility were recorded. Longevity of adults and other similar biological observations of the different development stages were also made. daily rearing temperatures and relative humidities were compiled continuously from hygrothermograph readings.

The duration of the different stages, their means and standard errors were calculated. Similar calculations were made also of other biological data.

Field biological studies: Mungo seeds were drilled in rows with four blocks on January 30, 1971. Rows were set 50 cm apart and measured 6 m long. One-half of he urea fertilizer (45 N) at the rate of 100 kg/ha was drilled two days after planting. The other half was side-dressed just before blooming stage. The plants were irrigated with furrow irrigation at weekly intervals. Two weeks after emergence, the plants were sprayed with ambithion at the rate of 1 kg/active ingredient/ha to control leaf-feeding insects. Soil cultivation was done with a cultivaters mounted on a tractor one month after seed emergence.

The plants were observed everyday from planting to harvesting to study the general behavior of the weevil in the field. Other ecological and biological informations were gathered to supplement storage records.

Pods at five maturity levels were harvested to determine initial field infestation. Pod maturity was classified as follows: immature, fully developed green, yellowish green, brown and black pods. The first set of samples were taken on April 1, 1971 and was continued at weekly intervals for six weeks. Four rows per block were picked at random. Five plants in each row were randomly chosen, and two pods at each maturity level were harvested per plant. The samples were collected into plastic bags and were brought to the laboratory for microscopic counting of the eggs.

Dried pods were harvested and threshed on May 6, 1971. The seeds for each block were thoroughly mixed and three sets of 50 gm-samples were taken. The number of infested seeds at harvest were counted by dissecting the seeds under a binocular microscope.

Host range: Dried seeds of some possible host plants were harvested and brought to the laboratory for examination. In addition, different kinds of stored grains and vegetable seeds were artificially infested in the laboratory to determine their suitability as hosts for the weevil.

Natural enemies: The different developmental stages were collected from the field and storage room and examined for parasites, predators, microorganisms and diseases associated with the pest.

Toxicological tests: Technical grades of insecticides were used in the tests. The insecticides used and their chemical compositions are as follows: DDT pp' 100% (1,1,1-trichloro-2, 2-bis-[p-chlorophenyl] ethane, p-p' isomer); malathion 96% (diethyl mercaptosuccinate S-ester with O-O-dimethyl phosphorothioate); lindane 100% (1,2,3,4,5,6-hexachlorocyclohexane, 99% or more gamma isomer); Gardona 99.5% (2-chloro-1-[2,4,5-trichlorophenyl vinyl

dimetylphosphate); and DDVP 97% (O-O-dimethyl 2,2-dichlorovinyl phosphate).

Stock solutions with concentrations of 50 mg/ml were prepared for each insecticide, using acetone as solvent. Various test dosages of each insecticide were prepared from acetone dilutions of these stock solution. Ten 1-to 2-day old females of uniform size were used for each test. With the use of an aspirator, test insects were collected into plastic vials and each vial of weevils was weighed on an analytical balance. The average weight of each weevil was calculated from the difference in weight between the vial with the test specimens and the emptied container.

The test insects were anaesthesized, in batches of ten, by passing carbon dioxide for 3 minutes through a 5-inch Buchner funnel with perforated bottom. The anaesthesized weevils were treated on top a 3 in^2 wax paper. One microliter of insecticide solution was gently dropped on the notum of each test insect by means of a calibrated tuberculin syringe mounted on an automatic micro-applicator. Solutions were applied in an ascending order of concentration. Acetone alone was used in the control group. All treatments were replicated ten times except DDVP with only nine. Each replication was done at about the same time at night, from 8:30 P.M. to 2:00 A.M., and under a mean temperature of 79 ± 5.89°F.

Treated weevils were aerated gently to facilitae dying and were kept in petri dishes before motality counts which were made 48 hours after treatment. Moribund individuals were considered dead. The observed mortalities were corrected for natural mortality using Abbot's (1925) formula. The data were statistically analyzed using probit analysis (Finney 1952).

Chemical control studies: Jute sacks, of one-fourth cavan capacity, were dipped in 1 and 2% concentrations of DDT, DDVP, Gardona, lindane and malathion, then air-dried. Control sacks were dipped in water and similarly dried. Two kg of mungo seeds (variety CES 14) were stored inside each sack. Even if no infestation was observed, all grains were fumigated with phostoxin before use to insure freedom from previous insect infestation.

The sacks with seeds were arranged on racks according to a completely randomized design with four replications. The mean temperature of the storage room was 80.93 ± 1.38°F and mean relative humidity was 92.07 ± 7.68%. Initial infestation was provided by placing one-half cavan of heavily infested mungo seeds at the start of the experiment. Two kg. of infested grains were added in the experimental room at forthnightly intervals. The degree of infestation was determined by taking monthly 50-gm-samples of the grains. Before sampling, the seeds inside the sacks were

The data were transformed by means of arc-sine transformation and were statistically analyzed. Differences between means were tested for significance using Duncan's Multiple Range Test.

TABLE 1. Duration of the different developmental stages of *C. chinensis*. (Based on 183 individuals).

Developmental Period	Range (days)	Usual (days)	Mean (days)
Incubation period	3-7	4	4.61 ± 0.03
Total larval period	11-14	12	12.48 ± 0.09
First stadium ..	2-6	3	3.23 ± 0.06
Second stadium	2-5	2	2.07 ± 0.04
Third stadium	2-5	3	2.57 ± 0.05
Fourth stadium	3-7	4	4.56 ± 0.06
Pupal period	2-7	3	3.94 ± 0.10
Egg to adult	19-26	20	21.52 ± 0.13

RESULTS

Mass Rearing: No problems were encountered in rearing adequate numbers of insects using the procedure described above. The environmental conditions were favorable for their rapid development and multiplication. Sufficient female adults of uniform size and age were readily available for toxicological testing.

Life History and Habits

Duration of developmental stages: The duration of the different developmental stages of *C. chinensis* is shown in Table 1. The mean temperature of the storage room where weevils were kept in culture was 83.91 ± 1.66°F while the relative humidity was 67.79 ± 9.68%. The moisture content of the seeds used was 14.7%.

Larva: A few days before hatching the dark head of the embryo can be seen clearly through the egg shell. The embryo has its head withdrawn, leaving one-fourth of the shell hollowed. When ready to hatch, the larva chews directly on the egg shell, exits through the underside of the egg shell, and bores its way through the seed. It takes about six hours from the time the larva begin eating the shell until it is entirely inside the seed. Hatching occurs anytime of the day. Kunhi Kannan (1919b) described in detail the penetration of the larva into the seed.

Once inside the seed, the larva usually feeds near the seed coat for a short while then advances a short distance from its point of entry. It

continues to consume the inner contents of the seed until fully grown. Feeding takes place continuously, ceasing only a few hours before and after molting. Several grubs can develop within a single seed. Up to six larvae were observed successfully completing their life cycle in one seed.

Pupa: When fully grown, the larva eats out a round hole on the cotyledon directly under the epidermis. It pupates within the larval tunnel.

Adult: After casting its pupal skin, the weevil remains inactive for 2 to 3 days inside the pupal chamber before emerging from the seed. The adult, with the use of its sharp mandibles, cuts a tiny groove in the seed along the edge of the tunnel. Having thus made the groove, pressure is applied on the disk by moving its head and forelegs. With its head out, the beetle waves its antennae and wriggles its body through, enabling it to fully escape from the seed. Emergence usually takes place at night.

The weevils were not observed to feed during the adult stage. Injury on the seed is caused only by larval feeding. The adults do not cause direct damage except for producing holes on the seed during emergence. These observations substantiate those of Zacher (1929) who showed that adults carry sufficient food reserves in the form of large fat bodies accumulated during the active feeding stages. These reserves were found sufficient for the reproductive activities of the adult.

During warm sunny days in the field, the adults are exceedingly active and restless. They fly from plant to plant and roam around the pods. Usually the males make numerous short flights while the females seem to be continuously searching for suitable oviposition sites. When disturbed, the weevils have the habit of folding their legs tightly and feigning death. During cool days or nights, they become sluggish but resume their activities as soon as it gets warm. During rainy days they rest motionless underneath the mungo pods and leaves or under the leaves of surrounding weeds. In the laboratory, the adults crawl continuously during warm periods. They are usually found on the upper surface of the stored seeds and feign death for some time when touched. Kunhi Kannan (1912a) observed that the adults instinctively reach out to the surface of stored seeds to relieve themselves of the weight of the seeds above them.

The females were found to have a longer life span than the males. The females lived from 2 to 22 days ($\bar{x} = 9.14 \pm 0.32$, n = 110) while the males lived only for 2 to 14 days ($\bar{x} = 8.31 \pm 0.30$, n = 135). Comparable durations of 3 to 20 days were reported by Rahman, Sohi and Sapra (1942). Rajak and Pandey (1965) similarly noted that females live longer than males. Seasonal variation in adult longevity was recently reported by

TABLE 2. Numbers[a] of C. chinensis eggs laid on forty pods of different stages of maturity in the field.

Pod Maturity	Block A	Block B	Block C	Block D	Mean
Immature	0.50	0.50	0.17	0.33	0.38 ± 0.16
Fully-developed green	9.50	13.17	15.50	16.00	13.54 ± 2.98
Yellowish-green	8.17	16.67	17.83	22.33	16.25 ± 5.91
Brown, dried	19.00	23.67	30.50	33.00	26.54 ± 6.39
Black, dried	30.67	40.33	37.67	39.83	37.12 ± 4.45

[a] Average at six counting dates

TABLE 3. Percentage[a] field infestation of C. chinensis on mungo seeds at harvest.

	Block A	Block B	Block C	Block D	Mean
Total seeds examined	726	718	729	743	729.00 ± 10.44
Non-infested	664	662	657	671	663.50 ± 3.50
Infested	62	56	72	72	65.50 ± 7.50
Percent infestation	8.54	7.80	9.88	9.69	8.89 ± 0.93

[a] Average of 3 fifty-gram samples taken per block.

Singh (1965). He found that the adults lived from 4 to 10 days during the summer month of April and from 12 to 14 days in November when it is relatively colder.

Based on 384 emerged adults, a sex ratio (male: female) of 1.06: 1.00 was found. The sexes are easily separated on the basis of antennal characters. In the female the antennae are serrate whereas they are pectinate in the male. In addition, the female is slightly larger than the male (Fig.1). Female body length ranged from 2.76 to 3.48 ($x = 3.07 \pm 0.4$) mm. while that of the male ranged from 2.40 to 3.00 ($x = 2.75 \pm 0.03$) mm.

Eggs and oviposition by adults: The first batch of eggs are laid by a female weevil from less than a day to 4 days after emergence ($x =$

Fig. 1. Dorsal view of female (left) and male (right) adults of *C. chinensis*.

1.20 ± 0.23). The egg-laying period extended from 4 to 9 days, occurred mostly at 7 days, and with x = 6.40 ± 0.23 days. Death usually occurred 2 days after the weevil has stopped depositing its eggs.

In the field, the number of eggs deposited on forty pods of differing maturities are shown in Table 2. The female already start laying eggs on fully developed green pods. However, [illegible] to oviposit on dried pods. Eggs were also deposited [illegible] of seeds in split, over-ripened pods. They are [illegible] green pods. The same trend was observed in the [illegible] of different degrees of maturity were exposed for oviposition.

The eggs are laid singly and [illegible] on the outer surface of the pod directly [illegible] seeds, the eggs are deposited anywhere on the [illegible]. The female prefers to lay eggs on seeds with smooth, unbroken and tight seed coats. Tootia and Singh (1966) similarly found that seeds with [illegible], depressed or rough seed coats were less preferred for oviposition.

Fig. 2. Uninfested (A) and infested (B) mungo pods with *C. chinensis*. The small white spots represent egg shells which remain firmly attached even after the adults have emerged, the dark spots represent adult exit holes.

Fig. 3. Uninfested (A) and infested (B) stored mungo beans with *C. chinensis*. Note the egg shells and exit holes on the seeds.

Based on 55 individuals, a female laid from 16 to 73 eggs ($x = 49.08 \pm 2.58$) during its entire span. The heaviest deposition of eggs usually occurred on the first or second day of the oviposition period. This decreased on succeeding days until oviposition stopped. The percentage hatchability ranged from 50 to 100%, with $x = 89.52 \pm 1.83\%$.

Infestation and seasonal abundance: Percentage infestation at harvest time ranged from 7.80 to 9.88%, with a mean of $8.98 \pm 0.98\%$ (Table 3). The infested seeds harbored weevil larvae of varying stages of development. A few days after harvest, the adults started to emerge from the seeds and continued to increase in number under prolonged storage. Stored grains were completely destroyed after three months in storage when no control measure was applied. Infested seeds are totally unfit for human consumption and planting purposes. The nature of damage on pods and seeds are shown in Fig. 2 and 3.

The weevils breed continuously throughout the year in storage whenever host seeds are available. Twelve overlapping generations were observed within a year's time in the laboratory.

HOST RANGE

C. chinensis fed and developed readily on dried seeds of the following legumes: mungo, *Phaseolus aureus* Roxb.; pigeon pea, *Cajanus cajan* (Linn.) Millsp.; garden pea, *Pisum sativum* Linn.; string bean, *Vigna sesquipedalis* Fruw.; cowpea, *Vigna sinensis* (Linn) Savi; and bush sitao, *V. sinensis* X *V. sesquipedalis*.

Fletcher (1917) listed the following leguminous hosts: *Phaseolus mungo*, *P. radiatus*, *P. acontitifolius*, *Dolichos biflorus*, *Lathyrus sativus*, *Cajanus indicus*, *Vigna catjang*, *Pisum sativum* and *Vicia faba*. Wilson (1931) added *Vigna sinensis* and *Cicer arietinum* as food plants.

NATURAL ENEMIES

The common house lizard was observed preying on adults in the laboratory. Only one species of parasite, an undescribed hymenopteran species, was found to attack the larvae. However, several investigators should have reported other parasites of this insect. Mathur and Ramanna (1956) and Utida (1955) attributed population [illegible] of *C. chinensis* to the braconid parasite, *Heterospilus prosopidis* Vier. In [illegible] Mahmoud (1965) found *Neoxorolacrus monocephalus* [illegible] and Hymenoptera. Crawford (1913) and Krishna Ayyar (1940) reported the eulophid, *Bruchobius orientalis* Crawford and *Bruchobius coleman* Crawford parasitizing weevil larvae. Other species of *Bruchobius*, *B. [illegible]* [illegible] Mani (1939) and *B. vagabundus* Timberlake (Timberlake [illegible]) have also been bred

TABLE 4. LD50 values, confidence limits and regression equations of five organic insecticides topically applied on female adults of C. chinensis.

Insecticide	LD_{50} ug/g	Weevil	Confidence Limit (P = 0.05)		Regression Equation
			Lower	Upper	
Gardona	3.030	2.727	3.333	— 1.000 + 6.043X	
Malathion	9.688	9.062	10.312	2.878 + 4.348X	
DDVP	11.818	9.394	13.939	2.870 + 3.020X	
Lindane	14.375	14.375	30.938	3.555 + 1.738X	
DDT	37.879	35.454	40.030	0.339 + 4.252X	

from larvae. Bridwell (1917) found a trichogrammatid egg parasite, *Uscana semifumipennis* Girault. He also listed *Pteromalus calandare* Howard as a serious enemy on this pest. Willcocks (1914), in addition, mentioned a pediculochelid mite, *Peduculoides ventricosus* Newp., destroying larvae and pupae in large numbers.

TOXICOLOGICAL TESTS

The median lethal doses (LD50 values) u/g body weight of five organic insecticides topically applied on female adults of *C. chinensis* is shown in Table 4. The relative toxicities of the insecticides tested, in decreasing order, were as follows: Gardona > malathion = DDVP > lindane > DDT. Comparing the LD50 values of the insecticides, Gardona was found to be three times as toxic as malathion, four times DDVP, seven times lindane, and thirteen times DDT.

CHEMICAL CONTROL STUDIES

The mean percentages of infested seeds at different storage periods are shown in Table 5. After 1 to 3 months of storage, all the treatments were significantly better than the control but there were no significant differences among the test chemicals. Significant differences in kind and dosage became apparent only after 4 to 6 months of storage. DDVP at all dosages, and lindane at 0.5% had significantly more infested seeds than the other insecticidal treatments. Effective protection, however, was obtained with lindane at higher concentrations of 2%. Similarly and comparably effective were DDT, Gardona and malathion at all dosages.

TABLE 5. Mean percentages[1] of seed infestation by C. chinensis at different storage periods.

Treatments	MONTHS					
	1	2	3	4	5	6
DDT 0.5%	0.26 a	0.33 a	0.43 a	0.31 a	0.70 a	0.93 a
DDT 1%	0.08 a	0.24 a	0.52 a	0.60 a	0.58 a	0.72 a
DDT 2%	0.19 a	0.41 a	0.32 a	0.60 a	0.80 a	0.86 a
DDVP 0.5%	0.32 a	0.43 a	0.78 a	10.08 c	58.00 d	87.93 e
DDVP 1%	0.26 a	0.30 a	0.56 a	9.10 c	44.04 c	85.40 d
DDVP 2%	0.15 a	0.18 a	1.08 a	16.73 d	58.68 d	86.36 e
Gardona 0.5%	0.11 a	0.17 a	0.41 a	0.56 a	0.83 a	1.14 a
Gardona 1%	0.10 a	0.27 a	0.53 a	0.93 a	1.00 a	1.06 a
Gardona 2%	0.13 a	0.32 a	0.56 a	0.54 a	0.64 a	0.63 a
Lindane 0.5%	0.14 a	0.34 a	0.74 a	7.26 b	23.43 b	71.22 c
Lindane 1%	0.10 a	0.26 a	0.44 a	0.47 a	0.56 a	4,03 b
Lindane 2%	0.26 a	0.35 a	0.50 a	0.57 a	0.55 a	0.60 a
Malathion 0.5%	0.19 a	0.35 a	0.50 a	0.49 a	0.56 a	0.74 a
Malathion 1%	0.32 a	0.19 a	0.23 a	0.53 a	0.64 a	0.70 a
Malathion 2%	0.10 a	0.20 a	0.43 a	0.55 a	0.55 a	0.53 a
Control (Untreated)	40.09 b	67.23 b	86.62 b	96.75 c	100.00 c	100.00 f

[1] Average of our replications. Means not followed by the same letter differ significantly at the 5% level (Duncan's Multiple Range Test).

DISCUSSION

The life history data obtained in this study was relatively shorter than those reported by other workers like Howe and Curie (1964), and Rajak and Pandey (1965) in India. This could probably be attributed to differences in temperature, relative humidity and host plant used during the rearing period. Differences in developmental period at varying temperatures and relative humidities have been established for this species by Goncalves (1939) and Kunnan (1910a). Singh (1962) noted similar differences in the biology of weevils reared on different hosts.

The degree of toxicity of DDT and DDVP when topically applied did not correlate well with their effectiveness as protectants. DDVP, which ranked high in the toxicological tests, was much less effective as a sack protectant. This may be explained by its relatively high volatility. On

the other hand, the effectiveness for sack protection of DDT, which was found to be least toxic, could be attributed to its stability under storage conditions.

Outward appearance of the seed is not a reliable basis in evaluating infestation in the field because the larval entrance hole heals as the seed matures. To minimize infestation from *C. chinensis,* insecticidal application at the onset of pod development is needed as the females start laying eggs at this time. Fumigation, soon after harvest, is recommended for more effective control of the pest. Fumigated seeds should be stored in insecticide-treated sacks (with 0.5% malathion) or in polyethylene-lined sacks to prevent re-infestation of the seeds.

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