BIOECOLQGICAL STUDY OF MARUCA TESTULALIS (GEYER)

(LEPIDOPTERA : PYRALIDAE)

IN THE ZARIA **AREA OF** NORTHERN NIGERIA

BY

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TABLE OF CONTENTS

	Page
TABLE OF CONTENTS	i
LIST OF TABLES	iii
LIST OF ILLUSTRATIONS	iv
ACKNOWLEDGMENTS	v
I. INTRODUCTION	1
II. LITERATURE SURVEY	4
Geographical distribution and host range	4
Biology	11
Economic importance	16
Control	16
Mechanical control	17
Cultural control	17
Biological control	17
Chemical methods	18
Integrated control	18
Legislative control	18
III. BIOLOGY	21
Life cycle	26
Natural enemies	38
Seasonal distribution	44
IV. HOST RANGE	51
Survey for wild host plants	51
Host preference	61

Page

V. PEST STATUS 67

Damage to corpse 68
Field cages 69
Intercropping 69

SUMMARY 91

LITERATURE CITED 93

APPENDIX vii

LIST OF TABLES

Table		Page
1	Geographical distribution and host plants of *M. testulalis*	4
2	Biology of *M. testulalis*	11
3	Natural enemies of *M. testulalis*	14
4	Chemicals used to control *M. testulalis*	19
5	Parasites collected from *M. testulalis* larvae	43
6	Flowering cycle of wild legumes from which larvae of *M. testulalis* were collected	57
7	Incidence of *M. testulalis* larvae on cultivated and wild legumes	64
8	Incidence of *M. testulalis* on flowers and pods of cowpea variety Acc. 593	71
9	Incidence of *M. testulalis* on flowers and pods of cowpea variety Farimwake	72
10	Effect of *M. testulalis* on yield of cowpea variety Farimwake grown in cages	73
11	Incidence of *M. testulalis* and thrips on sole and intercropped cowpea	74

LIST OF ILLUSTRATIONS

Figure		Page
1	Seasonal cycle of M. testulalis at Samaru.....	25
2	Total number of moths caught at the ultra violet lamp at different hours	28
3	Characteristic round exit hole made by young caterpillar on a cowpea flower.....	32
4	Characteristic round entry hole made by an older caterpillar on a pod	32
5	Damage to a peduncle by a fourth instar larva	34
6	A fourth instar larva of M. testulalis	40
7	A pupa of M. testulalis without the cocoon	42
8	An adult male M. testulalis	42
9	Possible pattern of movement of M. testulalis at Samaru	49
10	Map of Zaria area showing sampling sites	54
11	Relative abundance of M. testulalis larvae collected from wild leguminous plants.....	59
12	Flowering cycle of two cowpea varieties and the incidence of M. testulalis	76
13	Pattern of pod formation in two cowpea varieties and the incidence of M. testulalis	78
14	Incidence of M. testulalis on flowers of sprayed and unsprayed crops	80
15	Incidence of M. testulalis on pods of sprayed and unsprayed crops	82
16	Average M. testulalis larvae per flower per week	87

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I. INTRODUCTION

The world production of cowpeas Vigna unguiculata (L.) Walp. is estimated to be 1,180,000 tons annually (F.A.O. 1970). About 710,000 tons, that is, 60% of this is produced in Nigeria. The farmers in northern Nigeria grow about 80% of all the cowpeas produced in Nigeria (Caswell, in press).

A wide variety of insect pests are known to attack various stages of cowpea in Nigeria (Booker 1963 and 1965a, Taylor 1963 and 1967b, Raheja 1973 and Raheja in press). Pre-harvest pests can reduce yield of cowpea to less than 10% of the potential (Raheja, in press). This loss is further aggravated in the store by post-harvest pests (Caswell 1956, 1961 and 1968). Of the different insects known to attack cowpea, Maruca testulalis (Geyer) is considered to be one of the most serious pre-harvest pests in Nigeria (Booker 1963 and 1965a; Taylor 1963, 1967b and 1968a; Taylor and Ezedinma 1964; Ayoade 1969 and 1974; and Raheja 1973 and Raheja, in press). Studies in other African and non-African countries have supported this view.

A survey of literature on M. testulalis showed that considerable amount of work on the biology and economic aspects of this insect has been done in the southern part of Nigeria but little is known about this insect in the northern half of the country.

In northern Nigeria this insect is not seen during the dry season from November to May whereas in southern part of Nigeria, it breeds all the year round. There are at least two theories on the whereabouts of M. testulalis during the dry season in northern Nigeria. The first hypothesis is that towards the end of the growing season, adults migrate south where they breed until the commencement of the wet season when the rain bearing winds carry them to the north. Another possibility is that the adults migrate to wild legumes along dams and river banks where they breed slowly during adverse climatic conditions and move back to cultivated legumes when conditions become favourable. Also the possibility that the insect goes into diapause in the dry season cannot be excluded.

Very little information is available on the seasonal distribution, life cycle, time of peak flight activity or its natural enemies. In addition to this, there has never been any study on the wild alternative host plants of M. testulalis in Nigeria except for a single mention by Taylor (1967b) who reported it on Crotalaria juncea. The role played by such wild hosts in the carry-over potential during the dry season is likely to provide a better understanding of the biology of M. testulalis.

This study was undertaken to fill some of the gaps in our knowledge in the biology, behaviour and the bionomics of this

insect in the northern part of Nigeria. Due to limitations of time and traveling facilities, survey work was carried out mainly around Zaria. All the experiments were conducted at the Institute for Agricultural Research farm at Samaru, Zaria.

II. LITERATURE SURVEY

Maruca testulalis was first recorded as a pest of cultivated crops by Dietz (1914) in Indonesia. Since then a number of reports from all over the world have appeared in the literature. There seems to be only one species of the genus *Maruca* that is known to cause damage to crops. One other species not recorded in Nigeria but sometimes referred to in the literature as attacking wild legumes is *Maruca amboinalis* (Feld.) (Andrews 1916, and Gater 1925a and 1925b). Since there have been no reports of this insect after 1925, it is likely that it is the same as *M. testulalis*. In at least one publication, this insect has been reported as *Crochiphora testulalis* (Geyer) (Fennah 1947). However, Bennett (1960) while referring to Fennah's work has clarified this confusion in the literature.

Geographical distribution and host range

A survey of literature on *M. testulalis* shows that it is fairly widely distributed throughout the world. Six families of plants consisting of twenty genera and thirty five species have been recorded as host plants of *M. testulalis*. Twenty three species out of these thirty five are cultivated. Over 80% of all the species of plants from which the moth has been recorded belong to the family Papilionaceae. Amongst the wild plants the genus *Crotalaria* is the most widely distributed whereas most of its cultivated hosts belong to the genera *Phaseolus* and *Vigna*. The names of the host plants and the geographical locations where this insect has been found are shown in Table 1.

Table 1. Geographical Distribution and Host Plants of *M. testulalis*

Host Plant				
Family	Name of Plant	Part attacked	Location	Authority
Papilionaceae	*Arachis hypogea*		Burma	Ghosh (1924a)
"	"		Uganda	Hargreaves (1933)
"	"		Uganda	Jepson (1949)
"	*Cajanus cajan*	Pod	Fiji	Lever (1948)
"	"		Ceylon	Thevasagayam and Ganagasingham (1960)
"	"	Pod	Mauritius	Moutia (1957)
"	*Cajanus indicus*		Ceylon	Hutson (1920)
"	"		Burma	Ghosh (1924b)
"	*Canavalia ensiformis*	Flower & Pod	Puerto Rico	Wolcott (1933)
"	*Canavalia gladiata*	Pod	Australia	Caldwell (1945)
"	*Canavalia maritima*		Puerto Rico	Scott (1940)
"	*Canavalia* sp.		Lesser Antilles	Fennah (1947)
"	*Crotalaria incana*		Puerto Rico	Scott (1940)
"	"		United States of America	Williamson (1943)

Table 1. continued

Family	Name of plant	Part attacked	Location	Authority
Papilionaceae	Crotalaria juncea		India	Andrews (1916)
"	"		Nigeria	Taylor (1967b)
"	Crotalaria mucronata	Pod	Fiji	Lever (1944)
"	Crotalaria sp.		Lesser Antilles	Fennah (1947)
"	Derria sp.	Leaf	Malaya	Gater (1925b)
"	"	Leaf	Malaya	Corbett (1935)
"			Lesser Antilles	Fennah (1947)
"	Dolichos lablab	Pod	India	Krishamurthy (1936)
"	Dolichos sp.		Hawaii	Anonymous (1944)
"	Gliricidia sepium	Flower	Brazil	Mendes (1937)
"	Mucuna huberi		United States of America	Mackie (1931)
"	Phaseolus lunatus		Cuba	Bruner (1931)
	"		Puerto Rico	Leonard and Mills (
"	"	Flower and Pod	Puerto Rico	Wolcott (1933)
"	"	Flower and Pod	Puerto Rico	Bartlett (1937)
"	"		Hawaii	Pemberton (1941)
"	"			

Table 1 continued

Family	Name of plant	Part attacked	Location	Authority
Papilionaceae	Phaseolus lunatus	Stem, flower and pod	Hawaii	Holdaway & Look (1942)
"	"	Pod	Hawaii	Holdaway et. al. (1943)
"	"	Pod	Lesser Antilles	Fennah (1947)
"	Phaseolus mungo	Stem, flower and pod	Indonesia	Dietz (1914)
"	"	Leaf and pod	India	Andrews (1916)
"	"		United States of America	Mackie (1931)
"	Phaseolus radiatus		India	Isaac (1936)
"	Phaseolus sp.		Brazil	Mendes (1937)
"	"		Central America	Lipes (1970)
"	Phaseolus vulgaris	Pod	Cuba	Bruner (1931)
"	"		United States of America	Fleury (1932)
"	"	Pod	Sierra Leone	Hargreaves (1937)
"	"	Petiole, flower and pod	Australia	Caldwell (1945)

Table 1. continued

Family	Name of plant	Part attacked	Location	Authority
Papilionaceae	Phaseolus vulgaris	Pod	Ghana	Forsyth (1966)
"	"		Nigeria	Taylor (1967b)
"	"		Australia	Passlow (1968)
"	Psophocarpus tetragonolobus		Nigeria	Taylor (1967b)
"	Sesbania grandiflora		United States of America	Nakagawa and Yamada (1965)
"	Sphenostylis stenocarpus		Nigeria	Taylor (1967b)
"	Stizolobium sp.		India	Isaac (1936)
"	Tephrosia candida		Ceylon	Hutson (1920)
"	"		Ceylon	Light (1926)
"	Tephrosia purpurea	Flower	Indonesia	Tjoa (1937)
"	Vicia faba		Sudan	Schmutterer (1969)
"	Vigna unguiculata		India	Pillai (1921)
"	"		Puerto Rico	Scott (1940)
"	"	Pod	Fiji	Lever (1944)

Table 1. continued

Family	Name of plant	Part attacked	Location	Authority
Papilionaceae	Vigna unguiculata	Pod	Lesser Antilles	Fennah (1947)
"	"		Pretoria	Phelps and Oosthizen (1958)
"	"		Rhodesia	Whellan (1959)
"	"		South Africa	Sellschop (1962)
"	"	Developing seed	West Africa	Caswell (1962)
"	"	Flower and Pod	Nigeria	Booker (1963 and 1965a)
"	"	Flower, pod and terminal shoot	Nigeria	Taylor (1963, 1967b, 1968a and 1969a)
"	"	Flower and Pod	Nigeria	Taylor and Ezedinma (1964)
"	"	Flower and Pod	Nigeria	Jerath (1968)
"	"	Flower and Pod	Nigeria	Ayoade (1969 and 1974)
"	"	Pod	Sudan	Schmutterer (1969)
"	"		Phillipines	Borroga (1969)
"	"	Stem, leaf, flower and pod	Uganda	Nyiira (1971)

Table 1. continued

Family	Name of plant	Part attacked	Location	Authority
Papilionaceae	Vigna unguiculata	Stem, flower and pod	Ghana	Halteren (1971)
"	"	Flower and pod	Uganda	Koehler and Metha (1972)
"	"	Flower and pod	Nigeria	Raheja (1973) and Raheja (in press)
"	"	Flower and pod	Malawi	Roberts and Chipeta (1973)
"	"	Pod	Sierra Leone	Hargreaves (1937)
"	"		Senegal	Risbec (1950)
Caesalpinaceae	Poinciana sp.	Leaf	Burma	Garthwaite (1940)
Mimosaceae	Xylia dolabriformis		Burma	Braithwaite (1941)
"	"		Nigeria	Libby (1968)
Graminaceae	Zea mays		Belgian Congo	Ghesquiere (ref. Risbec 1950)
Malvaceae	Hibiscus rostellatus		Nigeria	Libby (1968)
Pedaliaceae	Sesamum sp.			

Biology

The first report on the biology of M. testulalis appeared in a paper by Dietz (1914) in Indonesia. There are considerable differences in the biology and life cycle of this insect in reports from different parts of the world. Duration of the whole life cycle has been reported to be between 16 and 42 days. The data from various reports on the biology of the insect is summarized in Table 2.

Two orders of insects including seven families and twenty five species have been reported as natural enemies of M. testulalis. Out of these twenty five species, eleven species are braconids while seven are tachinids. Three species were recorded from family Ichneumonidae. Only one species each is recorded in families Chalcidae, Eumenidae, Muscidae and Ephydridae. Also, of these twenty five species, thirteen are recorded from Africa. In Mauritius, Carribean Islands, North Pacific and Asia, three, six, two and one species respectively have been recorded. The family Braconidae is the most widely distributed. Two helminths are also recorded as natural enemies of M. testulalis. A commercial bacterial preparation was found to be pathogenic to the larvae of this insect. The parasites recorded from this insect are listed in Table 3.

Table 2. Biology of M. Eestulalis

		Authority
Location of eggs	Flower buds	Dietz (1914), Wolcott (1933), Krishnamurthy (1936), Fennah (1947), Taylor (1967b) and Nyiira (1971)
	Leaf	Fennah (1947) and Wyniger (1962)
	Leaf axil	Taylor (1963)
	Flower	Bruner (1931) and Krishnamurthy (1936)
	Pod	Bruner (1931) and Krishnamurthy (1936)
	Terminal shoot	Taylor (1967b)
Duration of egg stage	2 to 3 days	Taylor (1967b) and Nyiira (1971)
Number of larval instars	5	Taylor (1967b) and Nyiira (1971)
Length of larval period	8 to 13 days	Taylor (1967b)
	10 to 14 days	Nyiira (1971)
Pupation site	In debris	Mackie (1931), Caldwell (1945), Fennah (1947), Taylor (1967b) and Nyiira (1971)
	In the ground	Dietz (1914), Mackie (1931), Krishnamurthy (1936) and Booker (1965a)
	Near the surface of the ground	Caldwell (1945)
	On the ground	Fennah (1947)

Table 2. continued

		Authority
Pupation site	In the pod	Dietz (1914)
	Between two pods	Fennah (1947)
Length of pupal period	6 to 7 days	Taylor (1967b)
	6 to 8 days	Fennah (1947)
	7 to 10 days	Taylor (1963)
	8 to 12 days	Bruner (1931)
	9 to 10 days	Dietz (1914)
Duration of adult life	4 to 7 days	Bruner (1931)
	4 to 5 days	Taylor (1967b)
Duration of life cycle	16 to 25 days	Taylor (1967b)
	30 to 35 days	Booker (1965a)
	35 to 42 days	Dietz (1914) and Swain (1971)

Table 3. Natural Enemies of M. testulalis

Family	Name of parasite	Location	Authority
Braconidae	Agathis sp.	Nigeria	Booker (1965b)
"	Apanteles sp.	Cuba	Bruner (1931)
"	"	Puerto Rico	Leonard and Mills (1931)
"	"	Lesser Antilles	Fennah (1947)
"	Bracon calani (M.)	Mauritius	Moutia (1957)
"	"	"	Bennett (1960)
"	Bracon (Microbracon) hebetor (Say.)	"	Moutia (1957)
"	Braunsia analis (K.)	Nigeria	Booker (1965b)
"	Braunsia sp.	Nigeria	Taylor (1967b)
"	Macrocentrus ancylivorus (Rohw.)	Puerto Rico	Bartlett (1937)
"	Microbracon thuberiphagae (Mues.)	Cuba	Bruner (1931)
"	"	Puerto Rico	Leonard and Mills (1931)
"	"	Lesser Antilles	Fennah (1947)
"	Parachemylus sp.	Senegal	Risbec (1950)
"	Phanerotoma philippinensis (Ashm.)	Indonesia	Tjoa (1937)
"	Phanerotoma sp.	Nigeria	Booker (1965b)
"	"	"	Taylor (1967b)
Ichneumonidae	Cremastus flavoorbitalis (Cam.)	Hawaii	Holdaway and Look (1942)

Table 3. continued

Ichneumonidae	Eiphosoma annulatum (Cress.)	Mauritius	Moutia (1957)
"	"	"	Bennett (1960)
Chalcidae	Brachymeria ovata (Say.)	Cuba	Bruner (1935)
"	"	Lesser Antilles	Fennah (1947)
Eumenidae	Pachodynerus nasidens (Latr.)	Hawaii	Holdaway and Look (1942)
Tachnidae	Argrophylax albincisa (Wield.)	Cuba	Bruner (1931)
"	"	Puerto Rico	Leonard and Mills (1931)
"	"	Lesser Antilles	Fennah (1947)
"	Hemiwinthemia sp.	Nigeria	Booker (1965b)
"	Nemorilla floralis (Fall.)	Cuba	Bruner (1935)
"	Neoplectops nudinerva (M.)	Nigeria	Booker (1965b)
"	Thelairosoma sp.	Nigeria	Booker (1965b)
Muscidae	Musca domestica form calleva (WLK.)	Nigeria	Taylor (1967b)
Ephydridae	Typopsilopa sp.	Nigeria	Taylor (1967b)
Helminths	Hexamermis sp.	Cuba	Bruner (1935)
"	"	Lesser Antilles	Fennah (1947)
"	Nemertines	Nigeria	Taylor (1967b)
Commercial bacterial preparation	Bacillus thurigiensis var. thurigiensis (Berliner)	Nigeria	Taylor (1968b)

Economic importance

The fact that M. testulalis is an important pest of leguminous plants especially cowpea in Nigeria cannot be overemphasized. Booker (1963 and 1965a) and Taylor (1963 and 167b) considered this pyralid as one of the most important pre-harvest pests of cowpea in Nigeria. More recently, Raheja (in press) claimed that the pre-harvest pests of cowpea including M. testulalis can reduce the yield of cowpea to less than 10% of the potential in Nigeria.

Serious damage to cowpea and other legume crops by M. testulalis is not restricted to Nigeria. Nyiira (1971) in Uganda described this insect as being the most serious pest of cowpea. Whellan (1959) in Rhodesia reported M. testulalis and Piezotrachelus ugandanus (Wagn.) as the two species of insect causing wide-spread damage to cowpeas in the field. In Sudan, this moth was observed causing considerable damage to cowpea and Vicia faba by Schmutterer (1969). In Puerto Rico, M. testulalis has been described as the most injurious insect pest of cowpea and Canavalia maritima (Scott 1940).

Control

In view of the seriousness of M. testulalis as a pest, mechanical, cultural, biological, chemical and legislative methods have been used for the control of this insect. A method of integrated control has also been suggested.

Mechanical control - The only means of mechanical control recommended was by Wolcott (1933) in Puerto Rico, who suggested destruction of the larvae by hand.

Cultural control - Fennah (1947) in Lesser Antilles, Carribean Islands suggested the destruction of affected parts of plants. In Nigeria, Taylor (1963 and 1969a) recommended the removal of ratoon crops of cowpea and discing and heavy ploughing of cowpea plots.

Biological control - The work on the biological control of M. testulalis has included the use of insect parasites and a bacterial preparation. All the attempts to control it by parasitic insects have failed.

Bartlett (1937) in Puerto Rico was the first to attempt controlling M. testulalis with a parasitic insect. He introduced 7,284 adults of Macrocentrus ancylivorus (Rowh.) against three insects including M. testulalis. Seven species of parasitic insects were released against two insect pests including M. testulalis by Moutia (1957) in Mauritius. Of these only two, Eiphosoma annulatum (Cress.) and Bracon cajani (Mues.) were later recovered. Bennett (1960) also in Mauritius released six parasitic insects against three insect pests including M. testulalis without any success.

Taylor (1968b) in Nigeria showed that a commercial preparation of Bacillus thuringiensis var. thuringiensis (Berliner) was pathogenic to the larvae of M. testulalis.

Chemical methods - The chemical methods include the use of naturally occurring and synthetic compounds. Fumigants have also been used. Table 4 gives the names of the chemicals used by different workers.

Integrated control - A method of integrated control of this insect was suggested by Taylor (1969a) in Nigeria who recommended the removal of ratoon crops, the use of a bacterial preparation and chemicals for the control of this insect.

Legislative control - The importance of this insect is also indicated by the various quarantine measures that have been enforced to prevent its spread. In fact, as early as 1925, the need to prevent the entry of raw fruits from the Carribean Islands infested with M. testulalis into the United States of America was recognised. The first quarantine law forbidding the import of raw fruits from Puerto Rico to the United States of America to prevent entry of M. testulalis was the Quarantine Law Number 58 of 27th May, 1925 (Anonymous 1925). As a result of this, Bruner (1930) suggested fumigation of Phaseolus lunatus beans meant for export from Cuba with carbon bisulphide.

Table 4. Chemicals Used to Control M. testulalis

Compound	Location	Authority
Aldrin, dieldrin and malathion	Nigeria	Taylor and Ezedinma (1964)
Bleaching powder	India	Krishnamurthy (1936)
Carbon bisulphide	Cuba	Bruner (1930)
Chlorpyrifos, methomyl, monocrotophos, fenitrothion, endosulfan, methidathion, tetrachlorvinphos, carbofuran, abate, serucide and fenthion	Nigeria	IITA (1973)
Chlorpyrifos, methomyl, serucide, monocrotophos, trichlorphon, BHC and phosmet	Nigeria	IITA (1974)
Cryolite	Puerto Rico	Scott (1940)
Cryolite	Hawaii	Pemberton (1941)
Cryolite plus calcium arsenate	Hawaii	Holdaway et. al. (1943)
DDT	Lesser Antilles	Fennah (1947)
DDT	Australia	Anonymous (1948)
DDT	Uganda	Koehler and Metha (1972)
DDT, diazinon and dieldrin	Nigeria	Ayoade (1969 and 1974)
DDT plus BHC	Nigeria	Booker (1963 and 1965a)
DDT plus BHC, endosulfan, dimethoate and tetrachlorvinphos	Nigeria	IITA (1971)
DDT plus BHC, tetrachlorvinphos, pirimiphos-methyl, endosulfan, carbaryl, and iodofenphos	Nigeria	Raheja (in press)
Derris dust	Australia	Caldwell (1945)
Derris and pyrethrum dust	Australia	Anonymous (1942)

Table 4. continued

Compound	Location	Authority
Dieldrin, endrin and malathion	Ceylon	Thevasagayam and Ganagasingham (1960)
Dieldrin and parathion	Australia	Braithwaite (1957)
Dimethoate	Malawi	Roberts and Chipeta (1973)
Fenitrothion	Uganda	Nyiira (1971)
Magnesium sulphate	Cuba	Bruner (1931)
Methomyl, mephosfolan, phosfolan, carbofuran, disulfoton, phorate, acephate, phosalone, Dupont 1410, malathion, tetrachlorvinphos, azinphos-ethyl, and pirimiphos-ethyl	Nigeria	IITA (1972)
Nicotine	Hawaii	Holdaway et. al. (1945)
Parathion and malathion	Hawaii	Sherman et. al. (1954)
Tetramethyl thiuram disulphide	Hawaii	Holdaway et. al. (1941)
Trichlorphon, mevinphos, endosulfan, carbaryl, naled, endrin and methomyl	Phillipines	Barroga (1969)

III. BIOLOGY

Maruca testulalis (Geyer) (Lepidoptera-Pyralidae) was first recorded in Nigeria in 1924 (Taylor 1967b). Since then, it has been reported as a serious pest of cowpeas from different parts of Nigeria (Golding 1935 and 1946; Caswell 1962; Booker 1963 and 1965a; Taylor 1963, 1967b, 1968a and 1969b; Taylor and Ezedinma 1964; Jerath 1968; Ayoade 1969 and 1974; and Raheja 1973 and Raheja, in press).

Almost all the work done on the biology of *M. testulalis* in Nigeria has been in the south. These studies were undertaken in view of its seriousness as a pest of legumes in northern Nigeria where little is known about its biology.

Materials and methods

The biology of this moth was studied in the laboratory and in the field. The laboratory was air conditioned for about seven hours daily and temperature fluctuated between 21°C and 29°C. Adults used for oviposition were obtained from larvae collected from the field and reared on cowpea. Adults caught at the ultra violet lamp during the night were also used. These moths were sexed and males and females were released in different types of cages. The type of cages used include hurricane lamp shades, glass cups, "Dutt" biological cages

and glass vials. All the containers were topped with wire gauze. The insects were fed with 11% sucrose solution on a piece of absorbent cotton wool. Hurricane lamp shade was found to be most suitable for rearing because of its moderate size and the ease with which eggs could be collected from it. Filter papers, wax papers and unopened cowpea flower buds were placed in the cages for egg deposition.

Data on the monthly abundance of the eggs, larvae and pupae of this insect were obtained by taking weekly samples from irrigated and rainfed cowpeas while the monthly population build-up of the adults was determined from monthly mean catches from three conventional light traps. Also from weekly observation using an ultraviolet lamp directed to a white sheet, flight activity of M. testulalis was studied. This observation was taken throughout the night at weekly intervals from December 1973 to March 1975.

One hundred flower buds of cowpea were collected at weekly intervals at random from an unsprayed field and dissected under the binocular microscope for egg counts. Occasionally flower buds of wild plants were collected for dissection. Similarly for larval counts fifty flowers and fifty pods were collected at random from unsprayed cowpea field at weekly intervals. The flowers and pods were enclosed in polythene bags and br[illegible] to the laboratory for dissection, and the larvae found were [illegible]

An area of about 600 sq. m. was marked out in an unsprayed field. The trash and soil around cowpea plants were carefully examined for pupae. These were counted and the number found weekly was recorded. This information was supplemented with the weekly counts of pupae found in trash in field cages where cowpea plants were artificially infested with adult M. testulalis (Chapter IV).

Information on the population build-up of adults was based on the monthly mean of three daily conventional light trap catches from August 1973 to August 1975.

In order to ascertain whether larvae and pupae of M. testulalis would go into diapause towards the end of rainy season, fifth instar larvae and pupae were placed in six desiccators. The relative humidity in three of these desiccators was maintained at 40% using lithium chloride while in the other three, the relative humidity was maintained at 50%. These conditions were provided to simulate the conditions of low humidity that normally exist during early November. The larvae placed in desiccators were supplied green pods as food.

Parasites collected from larvae were reared in the laboratory and identified in the Institute for Agricultural Research, Samaru and/or Commonwealth Institute of Entomology, London.

Results and discussions

The monthly abundance of the larvae, pupae, adults and parasites of Maruca testulalis are summarized in Fig. 1. Daily mean rainfall and relative humidity are also shown. The

and glass vials. All the containers were topped with wire gauze. The insects were fed with 11% sucrose solution on a piece of absorbent cotton wool. Hurricane lamp shade was found to be most suitable for rearing because of its moderate size and the ease with which eggs could be collected from it. Filter papers, wax papers and unopened cowpea flower buds were placed in the cages for egg deposition.

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III. BIOLOGY

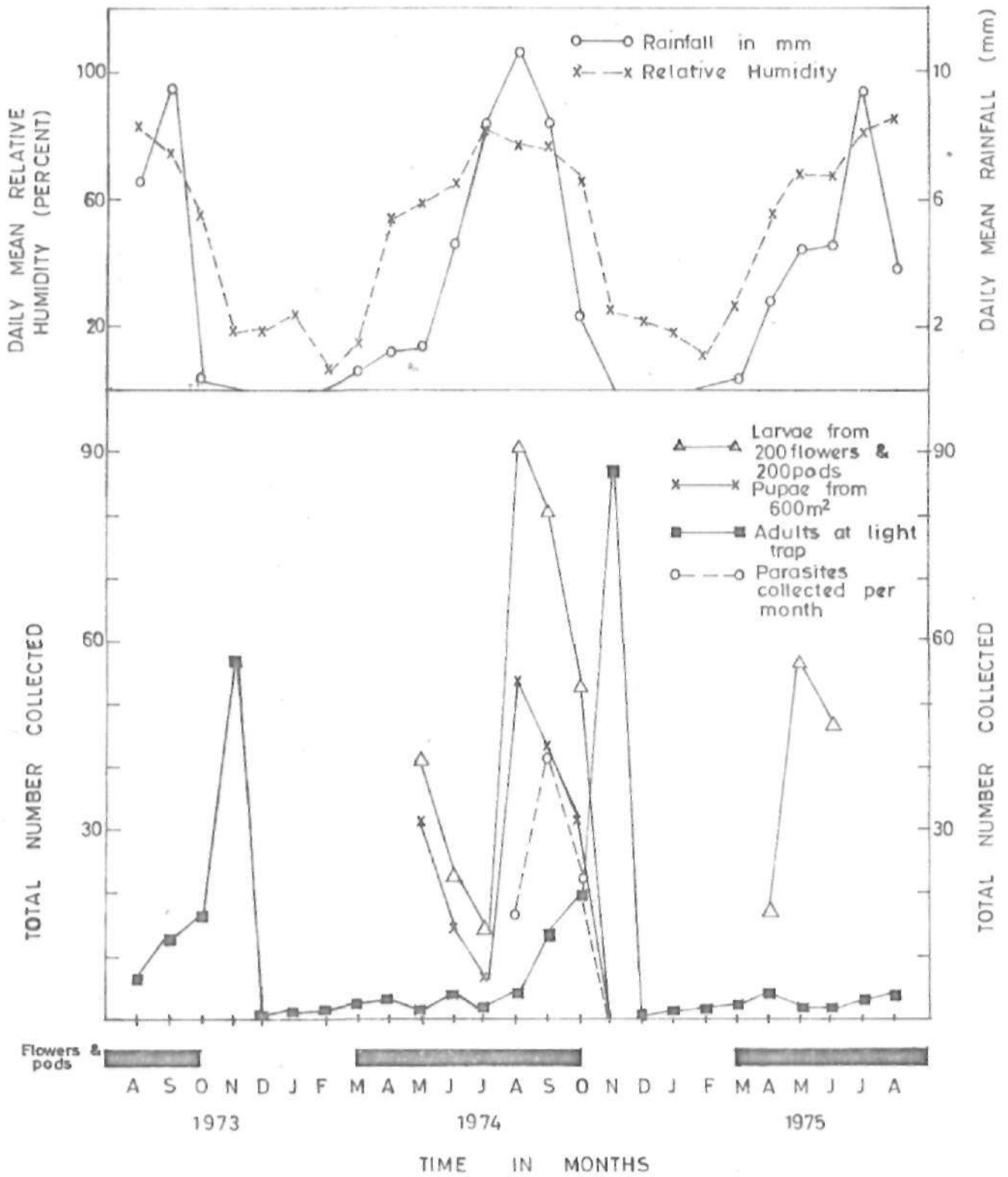
Marasa testulalis (Geyer) (Lepidoptera-Pyralidae) was first recorded in Nigeria in 1924 (Taylor 1967b). Since then, it has been reported as a serious pest of cowpeas from different parts of Nigeria (Golding 1935 and 1946; Caswell 1962; Booker 1963 and 1965a; Taylor 1963, 1967b, 1968a and 1969b; Taylor and Emedianma 1964; Jerath 1968; Ayoade 1969 and 1974; and Raheja 1973 and Raheja, in press).

Almost all the work done on the biology of M. testulalis in Nigeria has been in the south. These studies were undertaken in view of its seriousness as a pest of legumes in northern Nigeria where little is known about its biology.

Materials and methods

The biology of this moth was studied in the laboratory and in the field. The laboratory was air conditioned for about seven hours daily and temperature fluctuated between 21°C and 29°C. Adults used for oviposition were obtained from larvae collected from the field and reared on cowpea. Adults caught at the ultra violet lamp during the night were also used. These moths were sexed and Males and females were released in different types of cages. The type of cages used include hurricane lamp shades, glass cups, "Dutt" biological cages

Fig. 1. Seasonal cycle of M. tentulalis at Samaru.

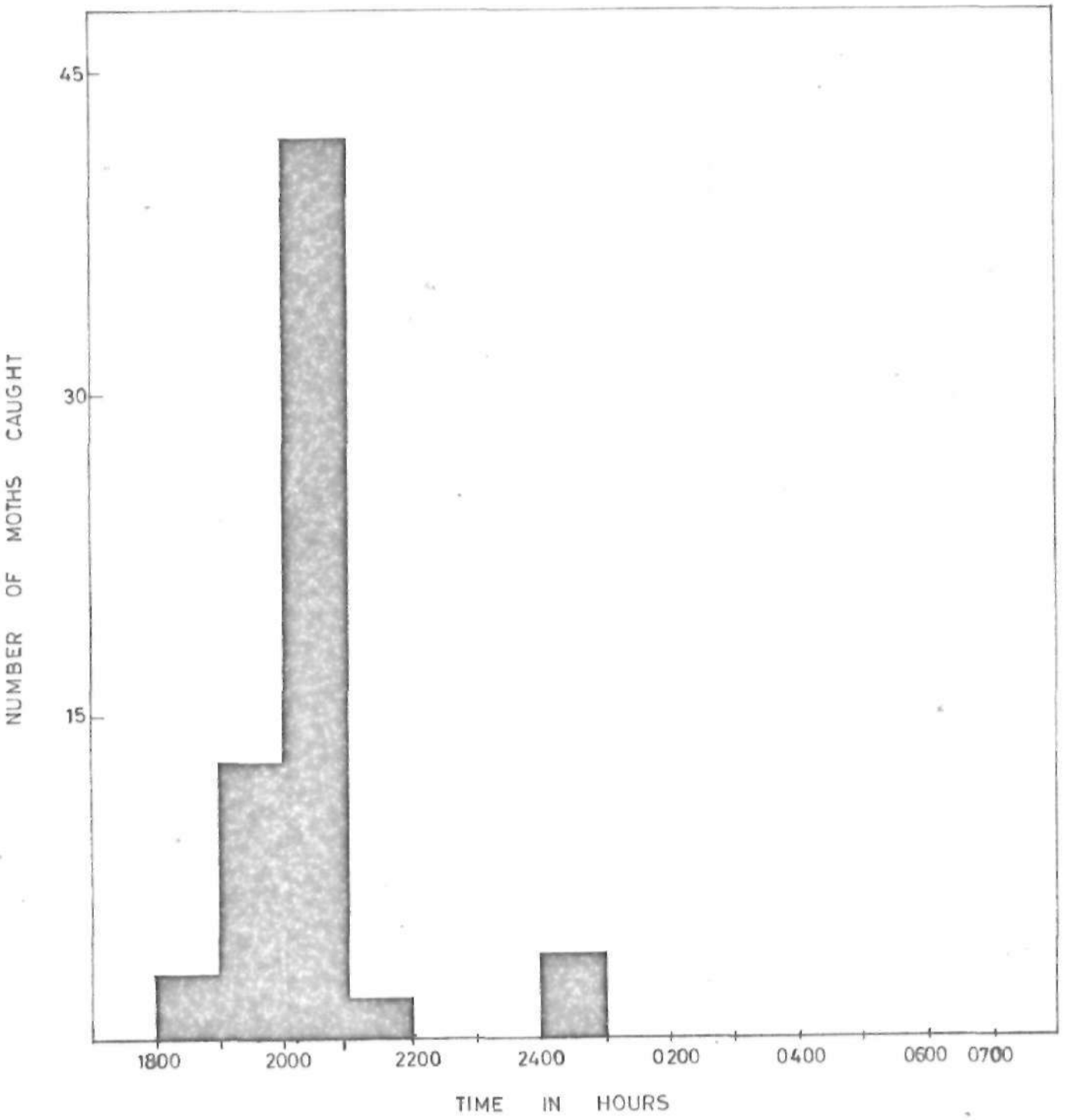

Rainfall in mm
Relative Humidity
DAILY MEAN RELATIVE HUMIDITY (PERCENT)
DAILY MEAN RAINFALL (mm)
100
60
20
10
6
2
Larvae from 200 flowers & 200 pods
Pupae from 600m²
Adults at light trap
Parasites collected per month
TOTAL NUMBER COLLECTED
90
60
30
Flowers & pods
A S O N D J F M A M J J A S O N D J F M A M J J A
1973
1974
1975
TIME IN MONTHS

peaks of larval and pupal populations were obtained in August which was a month characterized by high rainfall and high relative humidity. Also the flowering of rainfed cowpeas commenced during this month. Low larval and pupal populations between April and July were due to the scarcity of suitable hosts. Most of the parasitized larvae were collected in September. The peak of adult catches at the conventional light trap was obtained in November at the onset of the dry season.

Adult M. testulalis were caught between 1840 hrs. and 0045 hrs. at the ultraviolet lamp. The peak of flight activity occurred between 2000 hrs. and 2100 hrs. Fig. 2 shows total number of moths caught at the ultraviolet lamp at different hours during the period from December, 1973 to March, 1975.

Life Cycle - The female moth laid between 6 and 189 eggs which hatched in about three days. There were five larval instars with a total larval period of 10 to 14 days. Prepupal period was one to two days while the duration of the pupal period was on the average of 6 to 7 days. Adults lived for about 4 to 6 days. The complete life cycle of M. testulalis ranged between 22 and 30 days.

Very few eggs were observed on the unopened flower buds of cowpea collected from the field. They resembled tiny water droplets. In addition to this, flowers, pods, leaf axils, terminal shoots and sometimes even leaves have been reported as sites of egg deposition (see literature survey).


NUMBER OF MOTHS CAUGHT
45
30
15
1800
2000
2200
2400
0200
0400
0600
0700
TIME IN HOURS

Eggs were transluscent, oval and creamy yellow measuring about 0.6 mm x 0.45 mm. They were laid singly or in batches with the number in a batch varying from two to sixteen. Six to nine eggs were found laid on the flower buds by a female. On the filter paper the number of eggs laid by a female ranged between seven and eleven. The number of eggs laid on the wax paper by a female varied from seven to nine. A female was found to lay between 6 and 176 eggs on the side of the rearing apparatus. The highest number of eggs laid by a single female was 189.

First instar larvae were whitish, feeding mainly on the androecium and gynoecium of cowpea flowers. An average of 2.83 first instar larvae were collected from a cowpea flower. The maximum number of first instar larvae collected from a cowpea flower was eight. The duration of this stadium was about two days.

Similar to first instar larvae, the second instar larvae also fed mainly on the reproductive organs of flowers. The duration of this stadium varied from one to two days. Fig. 3 shows an exit hole of a larva on a cowpea flower. The flower seen on the peduncle would have fallen soon.

Third instar larvae fed on both flowers and pods. From this stage onwards, only a single larva was found in a flower or a pod. The presence of a single larva in a flower was probably due to increased demand for food by the growing caterpillars and crowding

within the flower. In case of the pods however, the larvae might have means of detecting pods which had been attacked. No cannibalism amongst the larvae was evident. Duration of this instar was about three days.

Fourth instar caterpillars also fed on both flowers and pods. Its duration was about four days.

The fifth instar larvae were similar to the fourth in their feeding habits. The duration of this stadium was about four days.

Only older larvae between third and fifth instars were observed boring into the pods. After gaining entrance, a mass of frass was used to seal the characteristic round hole (Fig. 4). First and second instar larvae appeared incapable of gaining entry into pods because of their weak mouth parts. Larvae were rarely seen in the day but on a few occasions, caterpillars between third and fifth stadia have been observed boring into pods between 0640 hrs. and 0810 hrs.

Besides flowers and pods, older larvae were found occasionally attacking apices of stems and peduncles (Fig. 5). Attack on the stem was also reported by Dietz (1914), Holdaway and Look (1942), Taylor (1967b) and Swaine (1971). Feeding on leaves has also been reported (Holdaway and Look 1942 and Wyniger 1962). Caldwell (1945) observed M. testulalis larvae attacking petioles. In this study however, larvae were never found feeding on leaves or petioles.





Fig. 5. Damage to a peduncle by a fourth instar larva.



Mature caterpillars before pupation measured 16 to 20 mm x 3 mm. They were creamy white with few dark spots on the dorsal side of each segment. In a few cases, larvae were spotless. In these cases, the colour of larvae was greenish yellow instead of the normal creamy white.

The total larval period varied from ten to fourteen days. Taylor (1967b) in Ibadan recorded it as ranging from eight to thirteen days. No diapause was observed. All the fifth instar larvae kept in desiccators at 40% and 50% R.H. pupated and adults emerged from the pupae in about eight days. No cannibalism was observed even under food stress and extreme crowding.

In the field, pupation took place either in cocoons in debris or on the ground slightly covered by the soil to a depth of about 0.5 mm. Just before pupation, larvae moved from cowpea plants to the debris around cowpea plants. Prepupal period ranged from one to two days. In the laboratory pupation took place in cocoons either at the base or suspended across the middle of the vials. On a few occasions, pupation took place vertically in vials. Shortly after pupation, the colour of pupa was pale yellow which gradually turned brown.

Full grown pupae were about 11.5 mm in length and 2.1 mm in width. Duration of the pupal period was between five and eight days with most of the adults emerging between six and seven days.

Similar observations were made by Taylor (1967b). Dietz (1914) recorded pupal period as varying from nine to fourteen days, while Bruner (1931) and Nyiira (1971) reported it to be between eight and twelve days, and six and eleven days respectively. No diapause has been reported. The adults emerged from pupae kept in desiccators at 40% and 50% R.H. in about eight days.

In the field emergence took place mostly at night but in the laboratory, emergence occurred occasionally in the day. At times emerging adults may be caught by their silken cocoons and get killed through exhaustion while trying to escape. Immediately after emergence, adults were observed with their wings parallel to their sides. They remained motionless for some time after which efforts to expand their abdomen ensued. The time taken from emergence until the wings were well stretched varied between seven and twenty minutes.

Adults had a wing span of 20 mm to 25 mm. Forewings were brown with white stripes and many white dots. Hind wings were white with a brown fringe. The adults were occasionally seen from 0700 hrs. to 1800 hrs. resting under cowpea plants. When plants were disturbed, adults flew for only a short distance. The observer has to be sure of the identity of H. testulalis or else he may be misled by the almost identical appearance of Hymenia sp. These two pyralids can be distinguished by the position of their wings when at rest. The

wings of M. testulalis are stretched wide exposing a large portion of the white hind wings with the forewings making an angle of about 160° at rest. In case of Hymenia sp. the forewings make an angle of about 75° without exposing a large portion of the dull hind wings at rest.

In the laboratory, males and females which were released together in lamp shades for mating and fed with 11% sucrose solution lived for four to six days. This is similar to observations made by Taylor (1967b) where adults fed with 10% sucrose solution lived for four to five days. Adults kept singly soon after emergence and fed with 11% sucrose solution survived for ten to twelve days. Taylor (1967b) recorded eight to twelve days for such adults. Mated adults fed with only distilled water lived for about four days and laid an average of seven eggs while unmated adults fed with only distilled water lived for about seven days. Adults denied both mating and feeding facilities lived for about two days. Unmated adults fed on sucrose solution lived longer than those that were allowed to mate.

At the ultra violet lamp, adults either alighted directly on the white sheet provided or on the screened portion of the carton through which a beam of light was reflected from the ultra violet lamp. Between one to three adults were observed alighting at a time.

Occasionally, adults did not fly directly to either the sheet or the screened portion of the carton but first landed on the slightly dark area nearby and after staying there for a few minutes, flew to either the sheet or to the carton.

Most of the adults were caught from mid-August to mid-November. These adults were caught between 1840 and 0045 hrs. The number caught in one night varied from zero to eleven. Peak of flight activity was found to be between 2000 and 2100 hrs. (Fig. 2). The temperature and relative humidity could not be recorded at this time because of limited facilities.

The complete life cycle of M. testulalis ranged between 22 and 30 days. Taylor (1967b) in southern Nigeria found the duration of its life cycle to be between 16 and 22 days while Booker (1965a) found the duration of the life cycle to range between 30 and 35 days. Dietz (1914) and Swain (1971) reported the duration to be between 35 and 42 days. There were four generation in a year and the sex ratio was 1:1 with the female population being slightly higher. The pictures of larva, pupa and adult are shown in Figs. 6, 7 and 8.

Natural Enemies

Ten species of parasites in two orders were recorded from M. testulalis larvae during this study (Table 5). All parasites reared in this study were larval parasites. No egg or pupal parasites



Fig. 7. A pupa of M. testulalis without the cocoon

Fig. 8. An adult male M. testulalis.

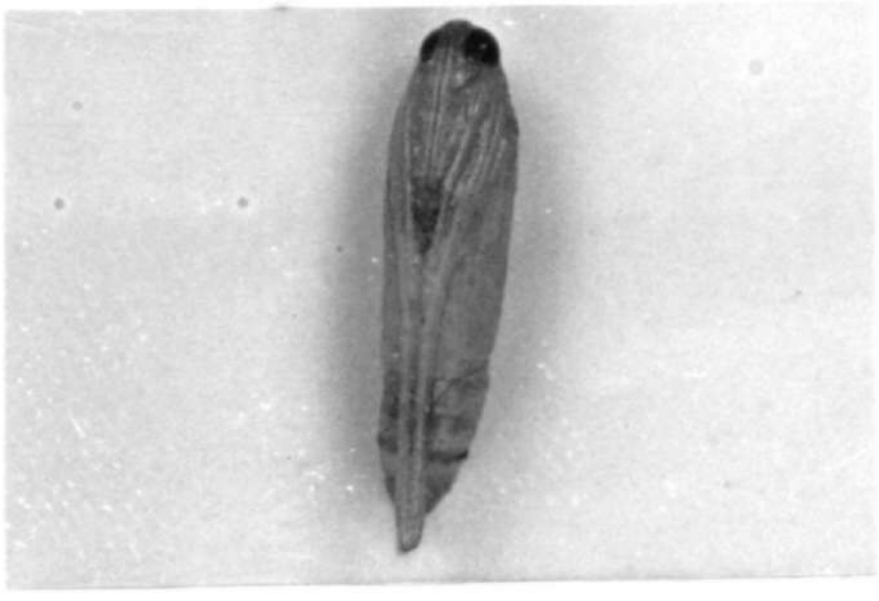




Table 5. Parasites Collected from Maruca testulalis Larvae*

Name	Family	Host stage	No. found	% Parasitization
Braunsia analia (K)	Braconidae	larva	47	2.61
Phanerotoma sp.	Braconidae	larva	7	0.39
Pseudoperichaeta sp.	Tachinidae	larva	7	0.39
Spathius sp.	Braconidae	larva	2	0.11
Spogossia sp.	Tachinidae	larva	2	0.11
Xristomerus sp.	Ichneumonidae	larva	2	0.11
Thelairosoma sp.	Tachinidae	larva	2	0.11
Exoplectops sudinerva (H)	Tachinidae	larva	2	0.11
Macrocentrus near marginator	Braconidae	larva	2	0.11
Agathis sp.	Braconidae	larva	1	0.06

* From 1800 larvae

were found. The role of these parasites in natural control of M. testulalis is uncertain. However, their low number suggests that they were not a major factor in regulating the population of this insect. Only 4.11 percent of the total larvae reared were parasitized; and Braunsia analis (K.) was the most abundant accounting for 63.51 percent of the total parasitisation.

Amongst the parasites recorded during this study, five are probably the same species as reported by earlier workers. Booker (1965b) recorded Neoplectops nudinerva (M.) (Tachinidae), Thelairosoma sp. (Tachinidae), Agathis sp. (Braconidae), Braunsia analis (K.) (Braconidae), Phanerotoma sp. while Taylor (1967b) recorded Braunsia sp. and Phanerotoma sp. Tjoa (1937) reported Phanerotoma philippinensis (Ashm.).

Natural parasitization of larvae started in August, reached its peak in September and then declined in October. The decline in October was probably due to declining population of M. testulalis larvae in the field at that time. The population of the parasites fluctuated with the population of the larvae in the field. Parasitization commenced in August at the peak of larval population, reached a peak in September and began declining in October (Fig. 1).

Seasonal distribution - Eggs were first collected in the month of

April at the onset of flowering of irrigated cowpea and they were last collected on rainfed cowpea in the field early in October. On the whole very few eggs were collected in the field between April and October. The scarcity of eggs in the field during the favourable weather conditions is difficult to explain. Taylor (1967b) made a similar observation in southern Nigeria. Obviously one possible explanation for this is the lack of our knowledge on sites of egg deposition. It may also be that eggs are washed off by heavy rains.

The population of M. testulalis larvae fluctuated with the availability of cowpea which was found to be its preferred host. The eggs and larvae were first collected in April at the onset of flowering of irrigated cowpeas. During this period the population was low because of the unfavourable climatic conditions. From then, the population fluctuated with a peak in August, a month characterized by high rainfall and high relative humidity. During this month most of the rainfed cowpeas were in blossom (Fig. 1). Larval population declined in September and October. This decline is attributed to low number of flowers and green pods in the field especially late in October.

After the ripening of pods and the harvest of cowpea at the end of the rainy season, caterpillars were collected from wild

leguminous plants until November (Fig. 11, Chapter IV). During this time, all the cowpeas had been harvested (Fig. 1). Occurrence of M. testulalis larvae on wild legumes in October showed that the adults migrated to wild legumes and bred shortly before all the cowpeas had been harvested. Presence of M. testulalis larvae on wild legumes in November indicated the continuance of breeding of this insect on these wild plants where this insect probably survives the long dry season.

The pattern of number of pupae found in the field was similar to that of larvae except that no pupae were collected in debris or on the soil around wild leguminous plants.

Few adults were caught in the light trap between January and July after which the population began to rise steadily, reaching a peak in November and then declining sharply (Fig. 1). The low population between January and July was probably due to adverse climatic conditions coupled with scarcity of suitable hosts.

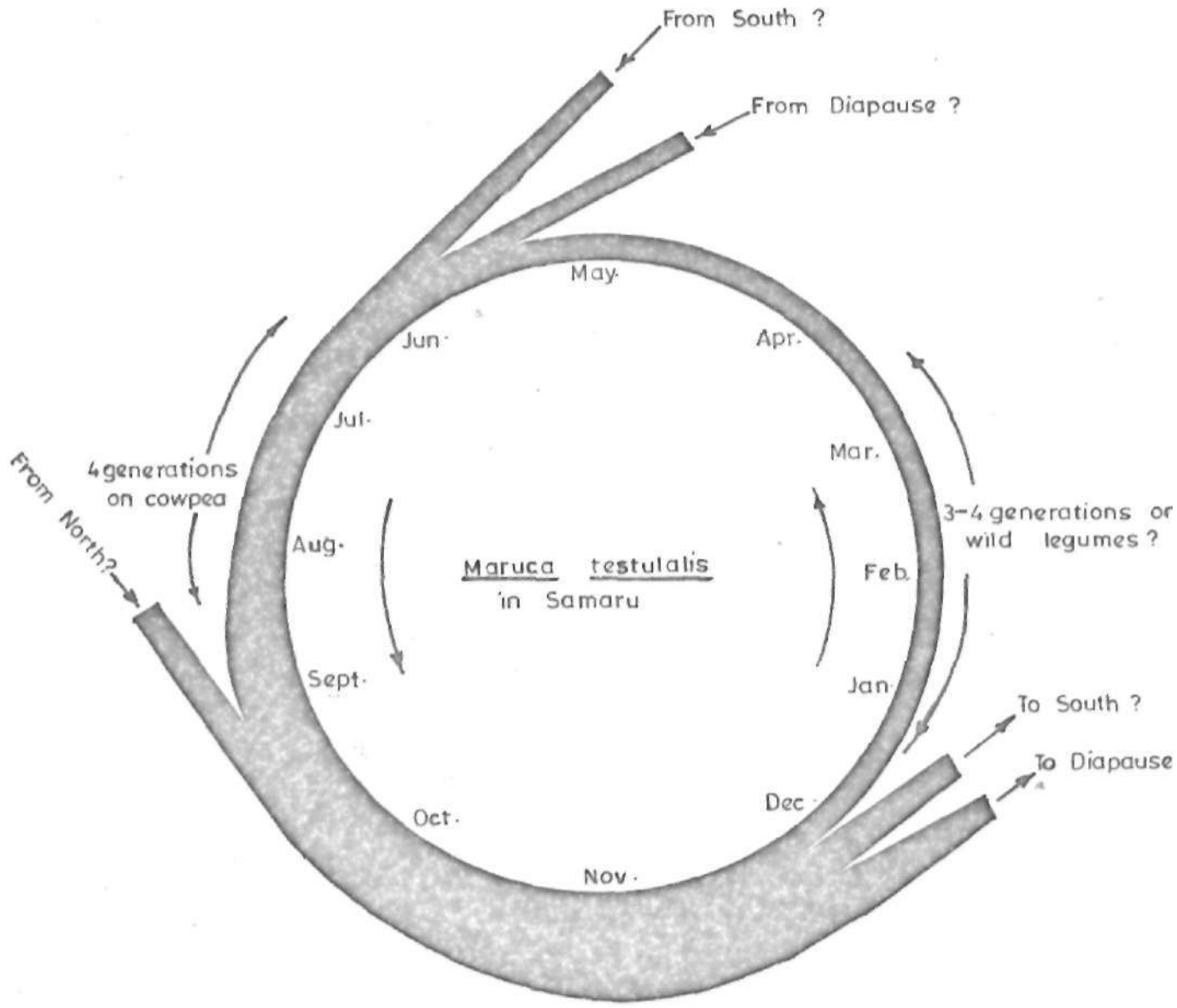
That the greatest number of adults were caught in November may be attributed to migration of adults from cowpea to wild hosts which probably occurred at the end of the rainy season with the possibility of incoming migration from the further north.

Since most of the climatic conditions and food requirements favouring the existence of M. testulalis are met with in August, one would have expected the peak of adult catches in the light trap

during this month. This was certainly the case with larvae and pupae. One possible reason could be that most of the adults are in the cowpea fields and therefore not engaged in extensive flight activities. However, it is more likely that the heavy rains which frequently made the collections from the conventional light traps wet made many small insects like M. testulalis unrecognisable from large numbers of other insects collected from the trap. In the future, traps with small orifices that allow only small insects of the size of M. testulalis into such light traps may be designed.

The decline in the population of the adults collected at the end of November was most likely due to migration of most of the adults to wild hosts around big river banks or to the southern parts of the country where climatic conditions remain favourable (Fig. 9). Even if migration to the south did occur, there was a small resident population in the north. This is indicated by few adults caught in the light trap between January and March before irrigated cowpeas had started flowering. These insects were probably surviving on wild legumes such as Crotalaria lachnosema, Sesbania pachycarpa and Adenodolichos paniculatus. This aspect will be further discussed in the chapter on host range.

The population of M. testulalis was mainly regulated by seasonal changes in climate and the availability of food. The population of this insect was at its lowest during the long dry season


From South ?
From Diapause ?
May
Jun
Apr
Jul
Mar
4 generations on cowpea
From North?
3-4 generations or wild legumes ?
Aug
Maruca testulalis in Samaru
Feb
Sept
Jan
To South ?
To Diapause
Dec
Oct
Nov

when food was scarce and weather conditions were unfavourable whereas the population rose during the short growing season when food was plentiful and climatic conditions were favourable.

High rainfall and high relative humidity favoured rapid population build-up. Temperature did not seem to play any important role in population build-up.

Variations in duration of different developmental stages of M. testulalis reported by different workers may be due to climatic differences under which observations were made. No evidence of diapause has been obtained from these studies. The question of means of its survival during the unfavourable long dry season in northern Nigeria will be discussed further in chapter IV under studies on host range.

IV. HOST RANGE

Maruca testulalis (Geyer) is a polyphagous pest of legumes of agricultural importance throughout Nigeria and in other parts of the world. Availability of food plays an important role in its seasonal abundance. Thirty five species of plants have been recorded as hosts out of which twenty three are cultivated. Its ability to switch over easily from cultivated to wild hosts is perhaps a major factor in its survival during adverse climatic conditions. The first reference in the literature to such a movement from cultivated to wild host appeared in a paper by Williamson (1943) in Texas who reported its movement from string beans (Phaseolus *sp.*) to a wild host Crotalaria incana after all the string beans had been harvested.

This insect does not seem to undergo diapause and little is known about its host range in Nigeria. This information is especially important in northern Nigeria because it may survive on wild plants during the long dry season. A survey of its wild hosts was undertaken with a view to finding an answer to this question.

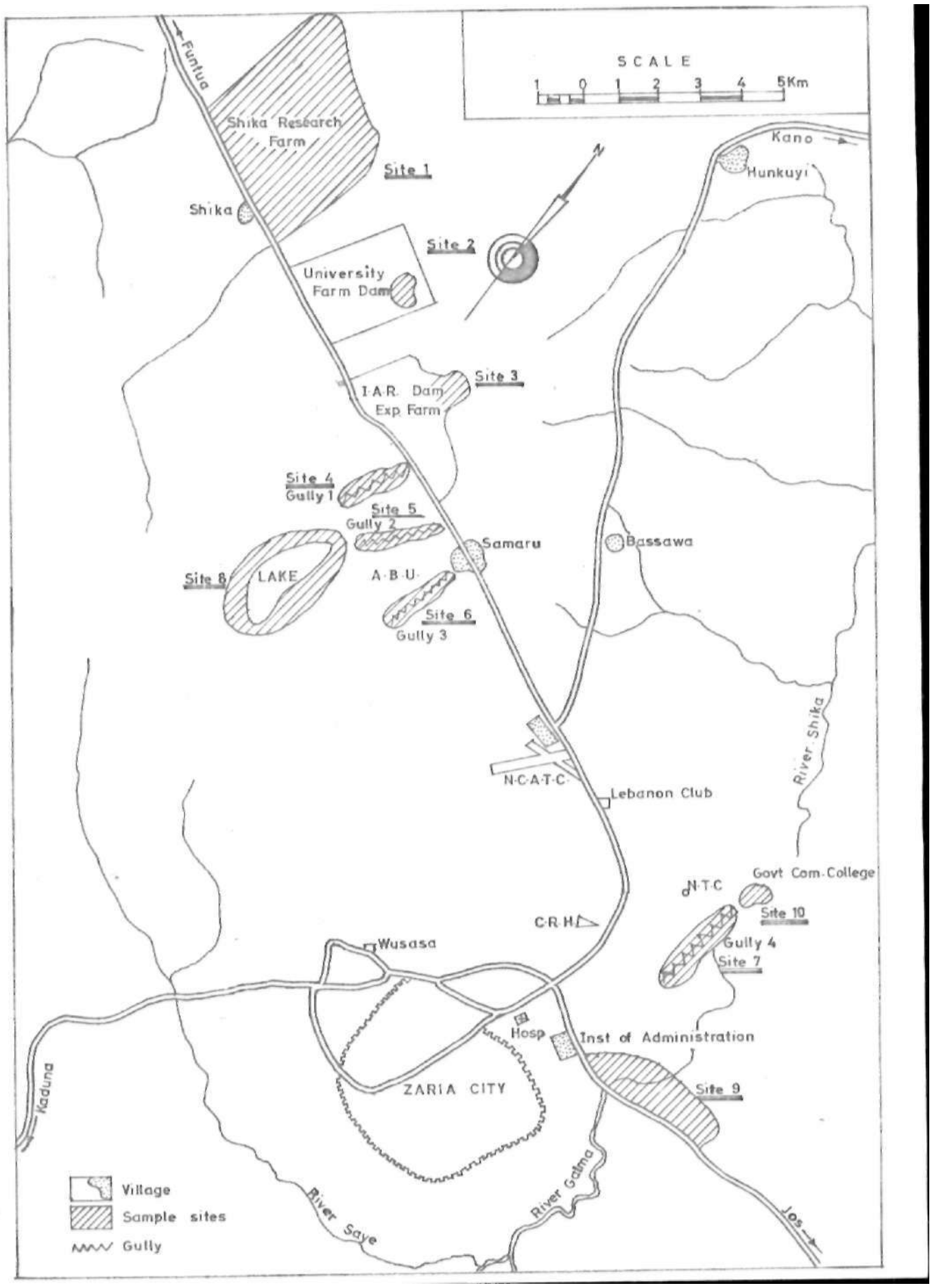
Survey For Wild Host Plants

This was carried out in Zaria area between August 1973 and March 1975. The area of study had to be limited to Zaria and its environs because of lack of time and traveling facilities.

Methods

Ten sampling zones were chosen around Zaria (Fig. 10). These locations were:

1. Shika Research Station and its environs. This site is about 12 km from Samaru on Zaria - Sokoto road.
2. University dam site and its environs. It is located about 10 km from Samaru along Zaria - Sokoto road.
3. Institute for Agricultural Research farm, Samaru, dam site and its surroundings.
4. Gully No. 1. This is situated near the Faculty of Agriculture. It is about 3.5 km in length.
5. Gully No. 2. It is located near Danfodio and ICSA halls of Ahmadu Bello University, main campus, Samaru. Its length is about 3 km.
6. Gully No. 3. Its origin is from the southern part of Federal Industrial Development Centre, Samaru, and it passes through Akenzua hall of Ahmadu Bello University main campus, Samaru. Its length is about 4 km.
7. Gully No. 4. This is located to the east of Sabongari in Zaria City. It is about 2 km in length.
8. Lake and its surroundings. It is a man-made lake located south of the Staff School, Ahmadu Bello University main campus, Samaru. Its length is about 3.5 km.


SCALE
1 0 1 2 3 4 5Km
Funtua
Shika Research Farm
Site 1
Shika
Site 2
University Farm Dam
I.A.R. Dam
Exp. Farm
Site 3
Site 4
Gully 1
Site 5
Gully 2
Samaru
Site 8
LAKE
A.B.U.
Site 6
Gully 3
Kano
Hunkuyi
Bassawa
River Shika
N.C.A.T.C.
Lebanon Club
Govt Com. College
N.T.C.
Site 10
Gully 4
Site 7
C.R.H.
Wusasa
Hosp.
Inst of Administration
Site 9
ZARIA CITY
Kaduna
River Saye
River Galma
Jos
Village
Sample sites
Gully

9. Institute of Administration and its surroundings.

10. Government Commercial College, Zaria and its surroundings.

Each zone was divided into several subzones. Fifty flowers and fifty fruits were collected from each species in each subzone at weekly intervals; brought to the laboratory and examined the same day for presence of M. testulalis larvae. The larvae collected were reared to maturity for definite identification.

In case of grasses, fifty stems were cut at ground level from each species in each subzone, put in a sack and brought to the laboratory for dissection the same day. The larvae found therein were reared to maturity.

At intervals, cracked bark, trash and soil around these plants were carefully examined for possible diapausing larvae and pupae. Leaves and twigs of the wild plants surveyed were pressed and dried after which they were sent for identification to Shika Research Station and/or to the Royal Botanical Garden, Kew, England. Observations were also made on the flowering cycle of all the plants sampled. The names of all the plants sampled are given in appendix 1.

Fruits, leaves and soft stems of the non leguminous wild plants which were most abundant and which were flowering during the growing season were also used for feeding M. testulalis larvae in the laboratory.

Results and discussion

The names, flowering cycle and parts of the plants from which M. testulalis larvae were collected during this survey are given in Table 6. The signs + and - indicate presence and absence of flowers in corresponding months. In Fig 11, the monthly population build-up of M. testulalis on different wild hosts during a period of twelve months, January 1974 to January 1975 is shown.

All wild plants from which M. testulalis larvae were collected during this survey were legumes. No diapausing larvae or pupae were observed. Over 90% of the larvae were found attacking flowers while others were found in pods (Table 6).

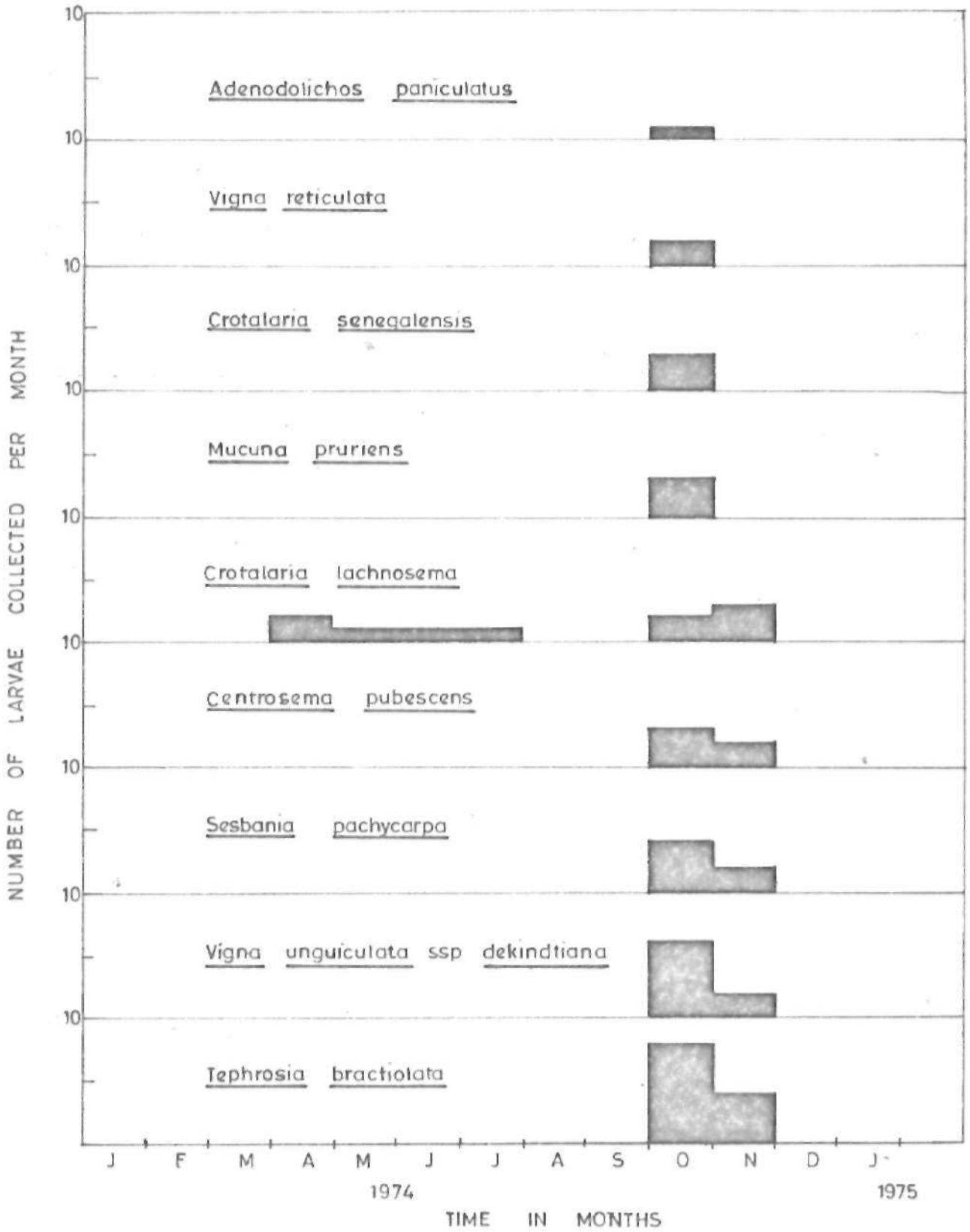
The survey for M. testulalis larvae on wild plants began in August 1973. These larvae were first collected from these wild hosts in October and November 1973. No larvae could be collected in the months December 1973 to March 1974. Very few larvae were collected during the months April to July on Crotalaria lachnosema only. No larvae could be seen on any of the wild hosts during the peak of the rainy season especially August and September. These reappeared on the wild plants again at the end of the rainy season.

Though a large number of wild legumes have been earlier recorded as host plants of this insect (see literature survey) none of the species of wild legumes on which M. testulalis were found feeding

Table 6. Flowering Cycle of Wild Legumes from which Larvae of M. testulalis were Collected

Names	Family	Presence in flowers	Presence in pods	Flowering cycle in months 1974											
				J	F	M	A	M	J	J	A	S	O	N	D
Adenodolichos paniculatus	Papilionaceae	+	-	+	+	+	-	-	-	-	-	+	+	+	+
Centrosema pubescens	"	+	-	+	+	-	-	-	-	-	+	+	+	+	+
Crotalaria lachnosema	"	+	-	+	+	+	+	+	+	+	+	+	+	+	+
Crotalaria senegalensis	"	-	+	-	-	-	-	-	-	-	+	+	+	+	+
Mucuna pruriens	"	+	-	-	-	-	-	-	-	-	+	+	+	+	-
Sesbania pachycarpa	"	+	-	+	+	+	-	-	-	-	+	+	+	+	+
Tephrosia bracteolata	"	+	-	-	-	-	-	-	-	-	+	+	+	+	+
Vigna reticulata	"	+	-	-	-	-	-	-	-	-	+	+	+	+	-
Vigna unguiculata ssp. dekindtiana (Wild cowpea)	"	+	+	-	-	-	-	-	-	-	+	+	+	+	+

+ = Present
- = Absent


NUMBER OF LARVAE COLLECTED PER MONTH
10
Adenodolichos paniculatus
Vigna reticulata
Crotalaria senegalensis
Mucuna pruriens
Crotalaria lachnosema
Centrosema pubescens
Sesbania pachycarpa
Vigna unguiculata ssp dekindtiana
Tephrosia bractiolata
J F M A M J J A S O N D J
1974
1975
TIME IN MONTHS

during this survey have been reported as its wild hosts.

Andrews (1916) and Taylor (1967b) reported Crotalaria juncea as its host. Similarly Williamson (1943) and Lever (1944) recorded M. testulalis on Crotalaria incana and Crotalaria mucronata respectively. In this study the species of Crotalaria found being attacked by this insect were Crotalaria lachnosema and Crotalaria senegalensis. Mendes (1937) recorded this insect on Mucuna huberi. The species found being attacked by this insect during this study was Mucuna pruriens. Sesbania grandiflora was reported as a host plant of this insect by Nakagawa and Yamada (1965). In this study however, Sesbania pachycarpa was found being attacked by this moth. Hutson (1920) and Tjoa (1937) recorded this pyralid on Tephrosia candida and Tephrosia purpurea respectively. The species of Tephrosia found being attacked in this study was Tephrosia bractiolata. The wild plants belonging to genus Vigna found being attacked by this insect in this study were Vigna reticulata and Vigna unguiculata ssp. dekindtiana (wild cowpea). Two other species of wild plants, Adenodolichos paniculatus and Centrosema pubescens found being attacked by M. testulalis during this study have not been reported earlier.

Rate of growth of M. testulalis larvae fed flowers and pods of different wild legumes in the laboratory could not be compared because of the very low population of larvae available at that time. However, observations on the pupal period showed that adults from all the wild

legumes emerged within seven days except those feeding on Adenodolichos paniculatus where the pupal duration was about 8.5 days. The pupal period of insects reared on cowpea flowers ranged between six and seven days. Though this insect can grow well on most of the wild legumes in the laboratory, it is interesting to note that it does not seem to attack these plants when cultivated legumes especially cowpea are available.

Third to fifth instar larvae were also fed on the fruits of Ximenia americana, Butrospermum parkii and Melia azedarch which are non-leguminous plants. Their development was poor when compared to larvae reared on legumes. Only about 3% of all the larvae fed on these plants could be reared to adults from the fruits of X. americana. The pupal period was about nine days and the adults had crumpled wings at emergence. None of the caterpillars fed on the fruits of B. parkii and M. azedarch could be reared to maturity.

In this study, M. testulalis larvae could be found feeding only on legumes. However, at least in one earlier study, a non-leguminous plant was also found to serve as its host. Ghesquiere in Belgian Congo, Africa (ref. Risbec 1950) found this moth infesting Hibiscus rostellatus (Guill.and Per.) (Malvaceae).

Host Preference

A trial to study the preference of M. testulalis for host plants

was conducted during the 1974 growing season at the Institute for Agricultural Research experimental farm, Samaru.

Materials and methods

The cultivated and wild legumes included in this trial are shown in Table 7. Seeds of all wild legumes were scarified prior to sowing. All the varieties were sown in July except Cicer arietinum which was sown in mid-August. Plants were thinned to two per stand two weeks after sowing.

Starting from the first week of flowering, twenty flowers and twenty pods were collected at random at weekly intervals from each variety. Each flower or pod picked was put separately in a polythene bag and brought to the laboratory. These were dissected the same day and the number of M. testulalis larvae found in each flower or pod were recorded.

Results and discussion

Out of the sixteen cultivated legumes included in this trial, eleven were found susceptible to M. testulalis (Table 7). Both flowers and pods of these legumes were attacked except in case of Phaseolus aureus where only the flowers were found infested.

Of the five wild legumes included in this experiment, four were found susceptible to M. testulalis. The flowers of all these four species were infested while the pods of only two of them were

attacked (Table 7). The fifth species of legume did not flower throughout the growing season.

As can be seen from Table 7, the flowers of cowpea variety Acc. 593 were the most susceptible to the attack of M. testulalis while the pods of Ife Brown were found to be most susceptible. Their growth habit may be one of the reasons for their being more susceptible. The peduncles of Acc. 593 and Ife Brown are borne above the canopy because of their semierect habit of growth. This probably encouraged female moths to lay more eggs on the exposed flower buds borne on the peduncles. Unlike Acc. 593 and Ife Brown, the cowpea variety Farinwake, has a trailing habit of growth and many of its peduncles are borne within the canopy of the plants. The hidden position of the peduncles probably made many of the flower buds on the peduncles inaccessible to the female moths for oviposition. Other reasons such as chemical or physical factors that influence preference or non-preference of hosts are of course not ruled out. It is interesting to note that whereas Farinwake has been traditionally grown by the farmers for a long time Acc. 593 and Ife Brown are new varieties. It is very likely that Farinwake has evolved some mechanism for tolerating M. testulalis attack.

Table 7. Incidence of M. testulalis larvae on Cultivated and Wild Legumes

	Number of ridges planted	Spacing (m)	Percent ** flowers with M. testulalis larvae	Percent ** pods with M. testulalis larvae
Vigna unguiculata (Acc. 593)	3	0.3	23.00	11.50
Vigna unguiculata (Ife Brown)	3	0.3	12.00	17.00
Canavalia maritima	3	0.9	8.50	9.50
Vigna unguiculata (Farinwake)	3	0.6	4.50	0.50
Phaseolus lunatus (Scrambling)	3	0.6	4.00	0.50
Phaseolus lunatus (Climbing)	3	0.6	1.00	3.00
*Vigna unguiculata ssp. dekindtiana	3	0.9	2.00	0.50
Phaseolus vulgaris	3	0.6	1.50	0.50
Phaseolus mungo	3	0.6	1.00	0.50
*Crotalaria lachnosema	3	0.3	1.00	0.00
Dolichos lablab	3	0.3	0.50	0.50
Cajanus cajan	3	0.9	0.50	0.50
*Mucuna pruriens	3	0.9	1.00	0.00
*Sesbania pachycarpa	3	0.9	0.50	0.00
Phaseolus aureus	3	0.6	0.50	0.00
Cicer arietinum	3	0.3	0.00	0.00
Glycine max	3	0.3	0.00	0.00
Phaseolus aetifolius	3	0.6	0.00	0.00
Voandzeia subterranea	3	0.3	0.00	0.00
Arachis hypogea	3	0.3	0.00	-
Erythrina senegalensis	3	0.9	-	-

* wild species

** calculated from 200 flowers and 200 pods

General Discussion

The possibility of M. testulalis surviving the long dry season in northern Nigeria has been discussed under the chapter on biology. Though no larvae of this insect were collected from wild legumes between January and March, yet a few adults were caught in the light trap. Wild legumes like Crotalaria lachnosema, which flowers all the year round, Sesbania pachycarpa and Adenodolichos paniculatus which flower till March (Table 6), may serve as sources of food during the long dry season. C. lachnosema, from whose flowers a few larvae of this insect were collected between April and July when all other wild legumes recorded in this study as wild hosts of M. testulalis are not in blossom, may be most important.

A wild species, Gliricidia sepium, has been considered as an important alternative host of this insect in Hawaii (Anonymous 1944). Though this plant was included in this study no M. testulalis larvae were collected from the flowers and pods of this plant. Also in the laboratory, the larvae did not feed on the flowers or pods. It is therefore likely that different M. testulalis strains exist in different geographical regions. In fact, Taylor (1967b) has commented on the complexity and confusion that exists in the literature on the taxonomy of this insect.

The failure of M. testulalis to infest groundnut (Arachis hypogea)

in northern states of Nigeria despite hundreds of hectares under cultivation annually deserves special mention. Ghosh (1924a) in Burma, Hargreaves (1933) in Uganda, Lever (1944 and 1948) and Swain (1971) in Fiji have reported this moth attacking groundnut. Even though M. testulalis larvae were never found attacking groundnut in the field, they did feed on its flowers in the laboratory. The larval and pupal periods were almost the same as of those reared on cowpea flowers. It would seem that though groundnut is ordinarily not a preferred host, the larvae can attack this plant in case of food stress.

V. PEST STATUS

Maruca testulalis (Geyer) is perhaps the most important of all insect pests attacking cowpeas in northern Nigeria. Booker (1965a) attributed 62, 92, and 19 percent loss in yield of June, July and August sown crops respectively in 1961 to the post flowering insects including M. testulalis. The corresponding loss in yield for 1962 was reported to be 55, 75 and 59 percent. Though the damage to flowers was not measured, the damage to pods by M. testulalis alone on June, July and August sown cowpea was 11.3, 4.6 and 7.3 percent respectively, while the corresponding percentages for 1962 were 51.4, 20.3 and 21.

Recently Raheja (1973) and Raheja (in press) in northern Nigeria estimated yield losses due to insect attack on cowpea flowers as being 46, 52 and 48 percent in the years 1971, 1972 and 1973 respectively. He also estimated the damage to crop during pod formation as accounting for 26, 25 and 21 percent in yield in the corresponding years.

Taylor (1963) in southern Nigeria estimated damage done to flowers and green pods of cowpea by M. testulalis to be 50 and 60 percent respectively. In 1967, he estimated the damage to flowers to be 40 to 50 percent and that to pods as being 20 to 40 percent respectively.

Three studies were undertaken during the 1974 growing season: (a) to compare M. testulalis damage on two varieties of cowpeas, (b) to estimate loss in yield due to this insect on plants enclosed in large field cages and (c) to compare the incidence of this moth in sole and intercropped cowpea.

Materials and methods

Damage to cowpea - The two varieties of cowpeas included were, Acc. 593 - an improved selection which is semi-erect and day neutral; and Farinwake - a local variety which is day sensitive and prostrate in its growth habit.

An area of about 0.1 ha was planted with each variety half of which was sprayed with a mixture of 20% DDT and 2% BHC at the rate of 1.21 kg DDT plus 0.112 kg BHC active ingredient in 112 litres of water per hectare. Spraying commenced first week after sowing. All insecticide applications were made with a 'C.P-3' knapsack sprayer.

Data on the pattern of flower and pod formation was obtained by counting the number of flowers and pods on 80 plants at random at weekly intervals starting the first week of flowering or pod formation.

160 flowers and 160 pods were picked at random from sprayed and unsprayed plots at weekly intervals starting from the first week of flowering or pod formation. Each flower or pod picked was put in a polythene bag, brought to the laboratory for dissection

the same day. M. testulalis larvae found in each flower or pod were recorded.

The unsprayed plots of cowpea were subdivided into two halves and every week beginning the first week after flowering, all the dropped flowers in one of these sub-plots were carefully removed. Twenty four hours later all the flowers which had fallen within this area were removed. Each flower removed was put in a polythene bag, brought to the laboratory for dissection the same day. M. testulalis larve found were recorded.

Field cages - Two cages each measuring 2.5 m x 1.9 m were placed two weeks after sowing in three sites in the plots where cowpea variety Farinwake was planted. When the flower buds were well formed ten pairs of newly emerged male and female M. testulalis were introduced into one of the two cages with the other cage serving as control. The number of eggs or larvae in the cages were not counted. However, after the release of the adults, the trash around the caged cowpea plants was carefully examined every eight days for pupae.

At the end of the season, pods from each cage were picked separately after which they were shelled and weighed. The weight of cowpea seeds obtained from each cage is given in Table 10.

Intercropping - These observations were taken on the trial designed by the cotton entomologist. Farmers in northern Nigeria sow various combinations of crops. Because of the time scale it is not possible to sow cotton after an early cereal unless the cereal is harvested before maturity or unless the cotton is sown much later than optimal. This latter

is often normal practice amongst farmers, and, because lower yields are obtained, spray regimes may be uneconomical. This experiment was designed to determine whether cotton could be sown earlier within cereal, so as to obtain the benefit occurring from early sowing and whether spraying with insecticide would then be economical. Further, since farmers often grew cotton and cowpea mixed, both cowpea alone and mixed with cotton were included as relay treatments. There were three main treatments: either millet or maize as the early crop, or no cereal sown at all. Details of the experiment relevant to the study of M. testulalis are shown in Table 11.

Treatment effect was assessed by picking five flowers and five pods at random at weekly intervals from each plot. Each flower or pod picked was enclosed in a polythene bag, brought to the laboratory and put in a refrigerator in order to immobilise the thrips. The flowers were later dissected and the dissected parts were washed in alcohol for thrips count. Number of M. testulalis larvae and thrips found were recorded.

Results and discussion

The flowering cycle and the pattern of pod formation in relation to M. testulalis attack are shown in Figs. 12 and 13. In Figs. 14 and 15, the incidence of M. testulalis in the flowers and pods of sprayed and unsprayed cowpea varieties, Acc. 593 and Fariwake is shown. The number of flowers and pods dissected at weekly intervals and the percentage of flowers and pods damaged in these two cowpea varieties are shown in Tables 8 and 9.

Table 8. Incidence of M. testulalis on flowers and pods of cowpea variety Acc. 593

Weeks after planting	Number of flowers picked	Number of dropped flowers	Total number of flowers dissected	% of flowers damaged	Number of pods dissected	% of pods damaged
6	160		160	22.50		
7	160		160	42.50		
8	160	225	385	45.56	160	13.75
9	160	301	461	21.91	160	23.13
10	160	160	320	7.19	160	21.88
11	160	139	299	11.04	160	8.13
12	160	43	203	10.34	160	1.25
13	160	64	224	2.68	160	3.13
14	160	80	240	0.00	160	0.00
15	160	157	317	0.00	160	0.00

Table 9. Incidence of M. testulalis on flowers and pods of cowpea variety Fariwaka

Weeks after planting	Number of flowers picked	Number of dropped flowers	Total number of flowers dissected	% flowers damaged	Number of pods picked	% pod damaged
8	160		160	5.00		
9	160	65	225	7.11		
10	160	42	202	5.94	160	1.25
11	160	85	245	3.27	160	0.63
12	160	21	181	0.55	160	0.00
13	160	9	69	0.00	160	0.00
14	160	3	163	0.00	160	0.00

Table 10. Effect of M. testulalis on yield of cowpea variety Farinwake grown in cages

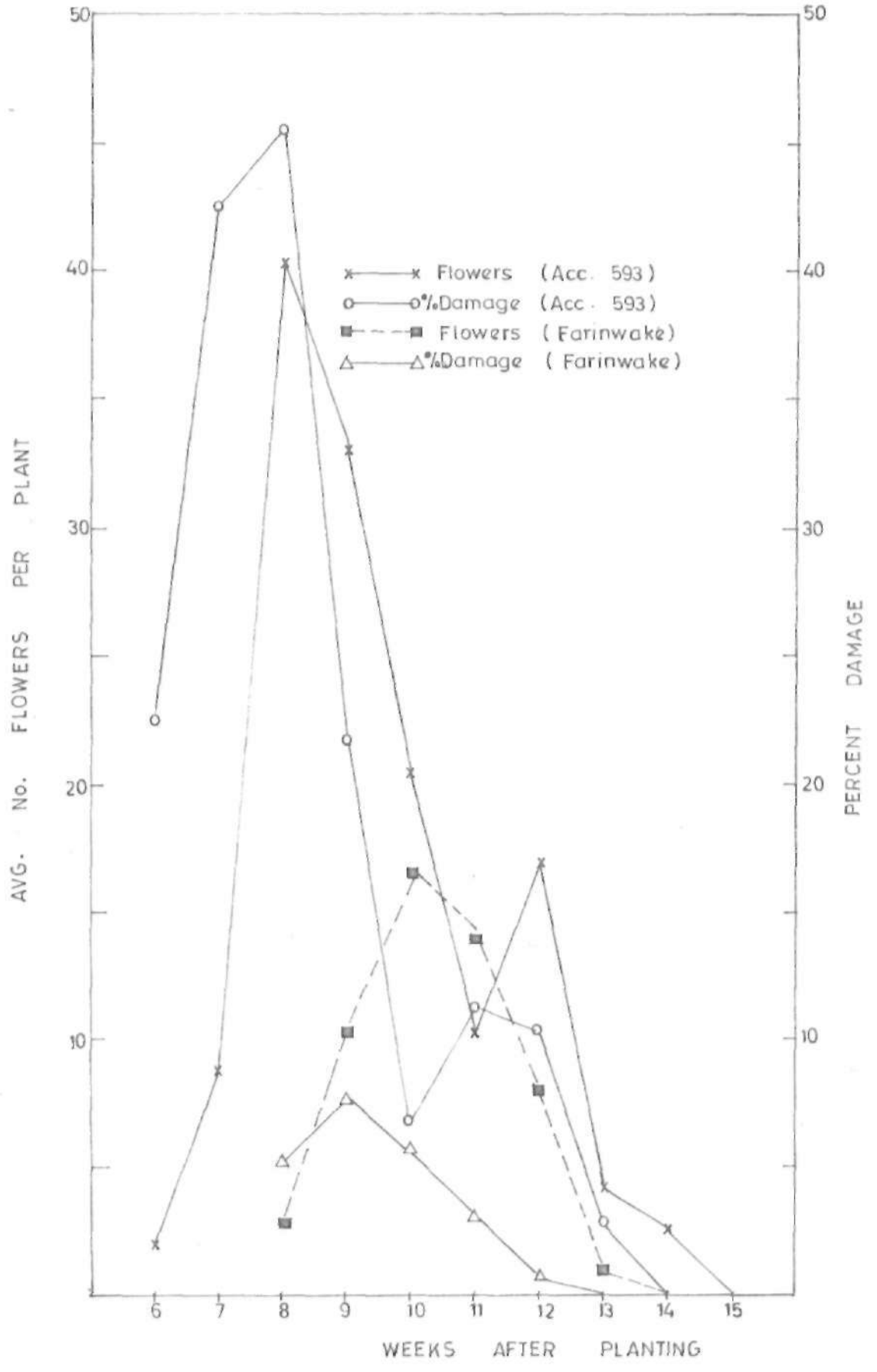
Site	Total yield (gm) Without Maruca	Total yield (gm) With Maruca	Yield per plant (gm) Without Maruca	Yield per plant (gm) With Maruca	% loss in yield per plant	No. of pupae collected in cages with Maruca
Field W5	455	272	56.8	34.1	39.9	17
Field S11	499	454	62.4	56.8	8.9	5
Field W3	545	227	68.1	28.4	58.3	26

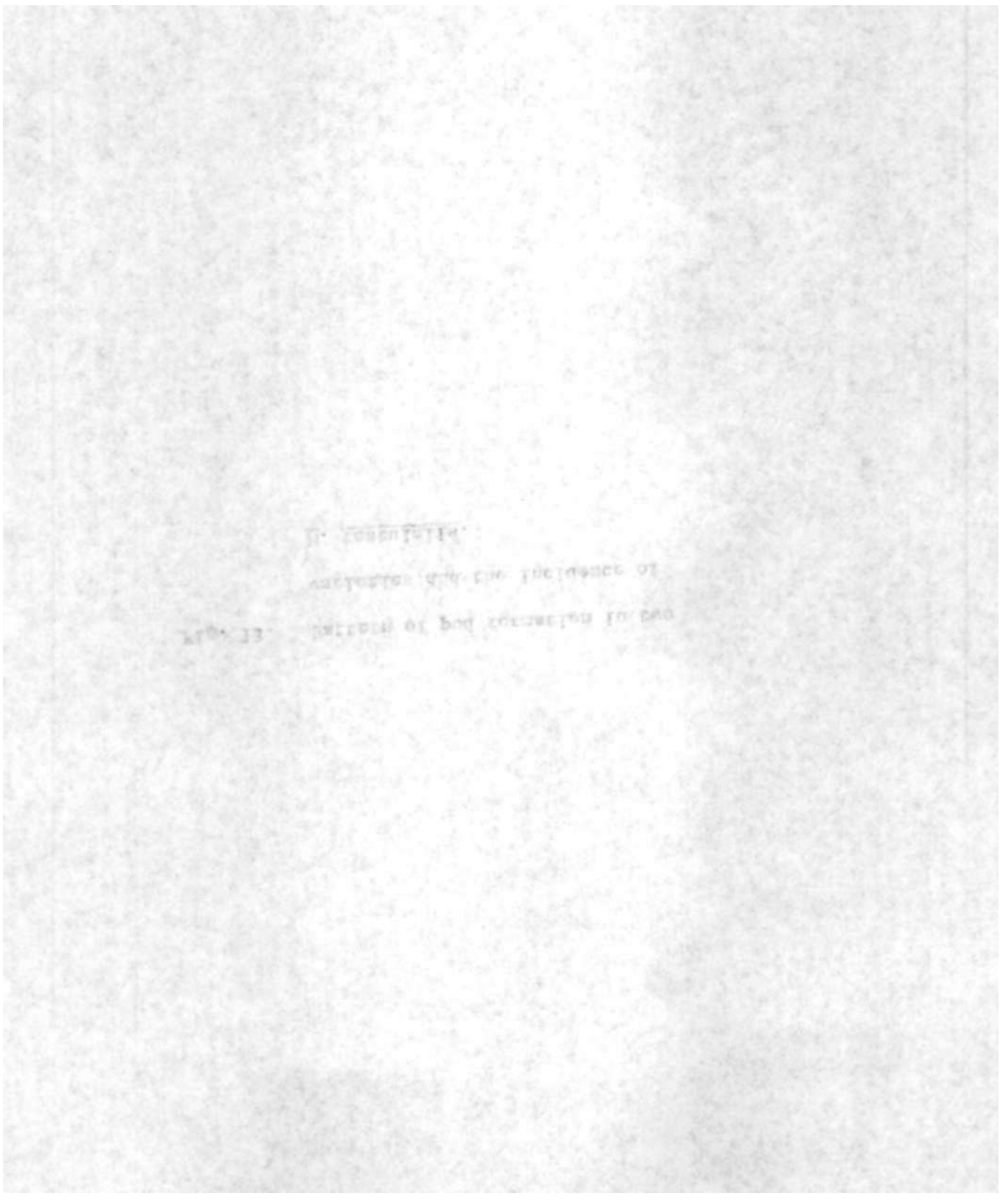
Table 11. Incidence of M. testulalis and thrips on sole and intercropped cowpea

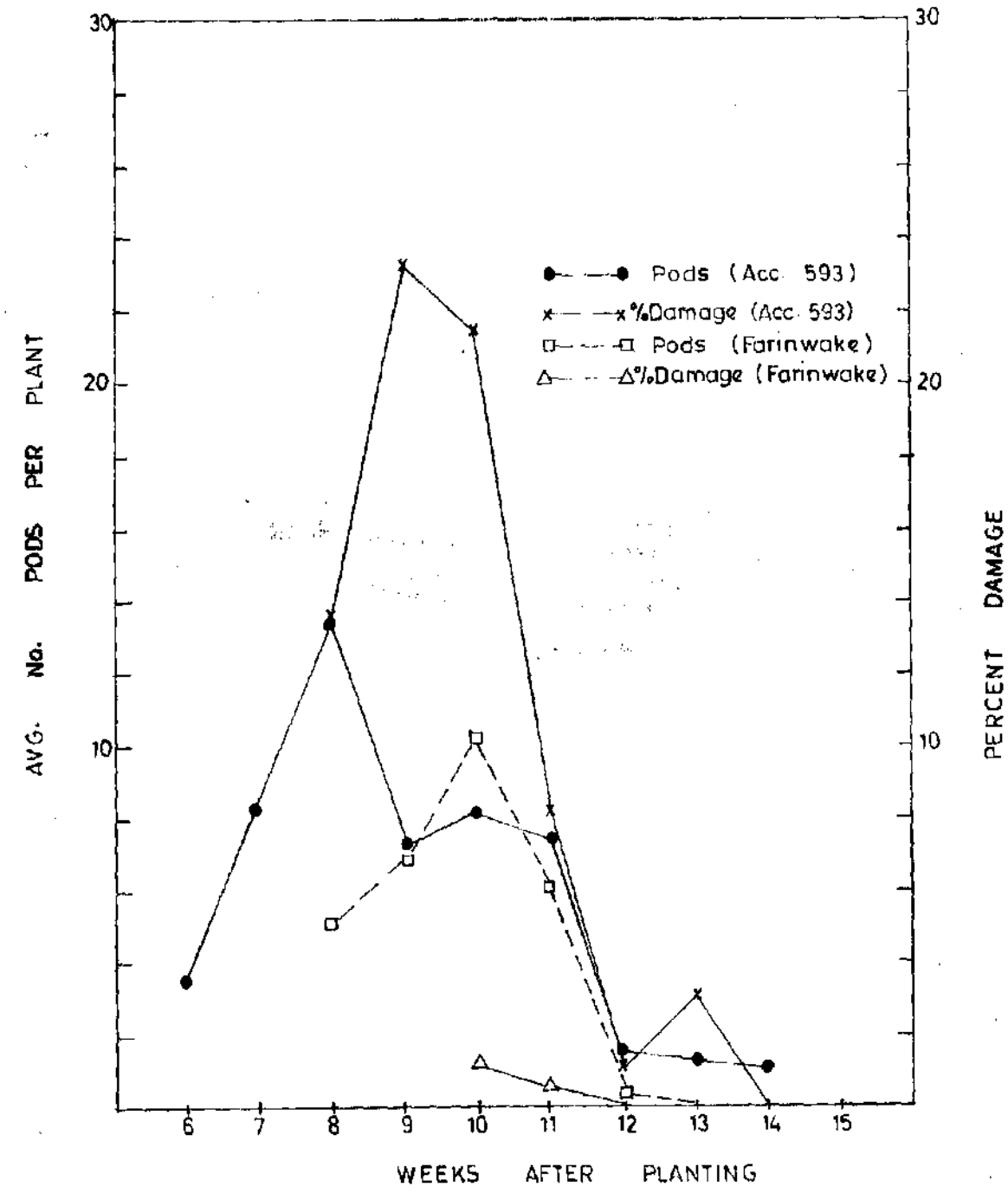
Treatment number	Early crop	Relay intercrop	Ratio* Cotton	Ratio* Cowpea	M. testulalis larvae/flower/wk.**	Thrips/flower/wk.**
1	Millet	Cotton/cowpea	2	1	0.09	0.96
2	Millet	Cotton/cowpea	1	2	0.03	1.38
3	Millet	Cowpea	0	3	0.01	1.69
4	Maize	Cotton/cowpea	2	1	0.05	0.88
5	Maize	Cotton/cowpea	1	2	0.07	1.06
6	Maize	Cowpea	0	3	0.06	1.40
7	Nil	Cotton/cowpea	2	1	0.10	1.49
8	Nil	Cotton/cowpea	1	2	0.03	1.43
9	Nil	Cowpea	0	3	0.17	2.95

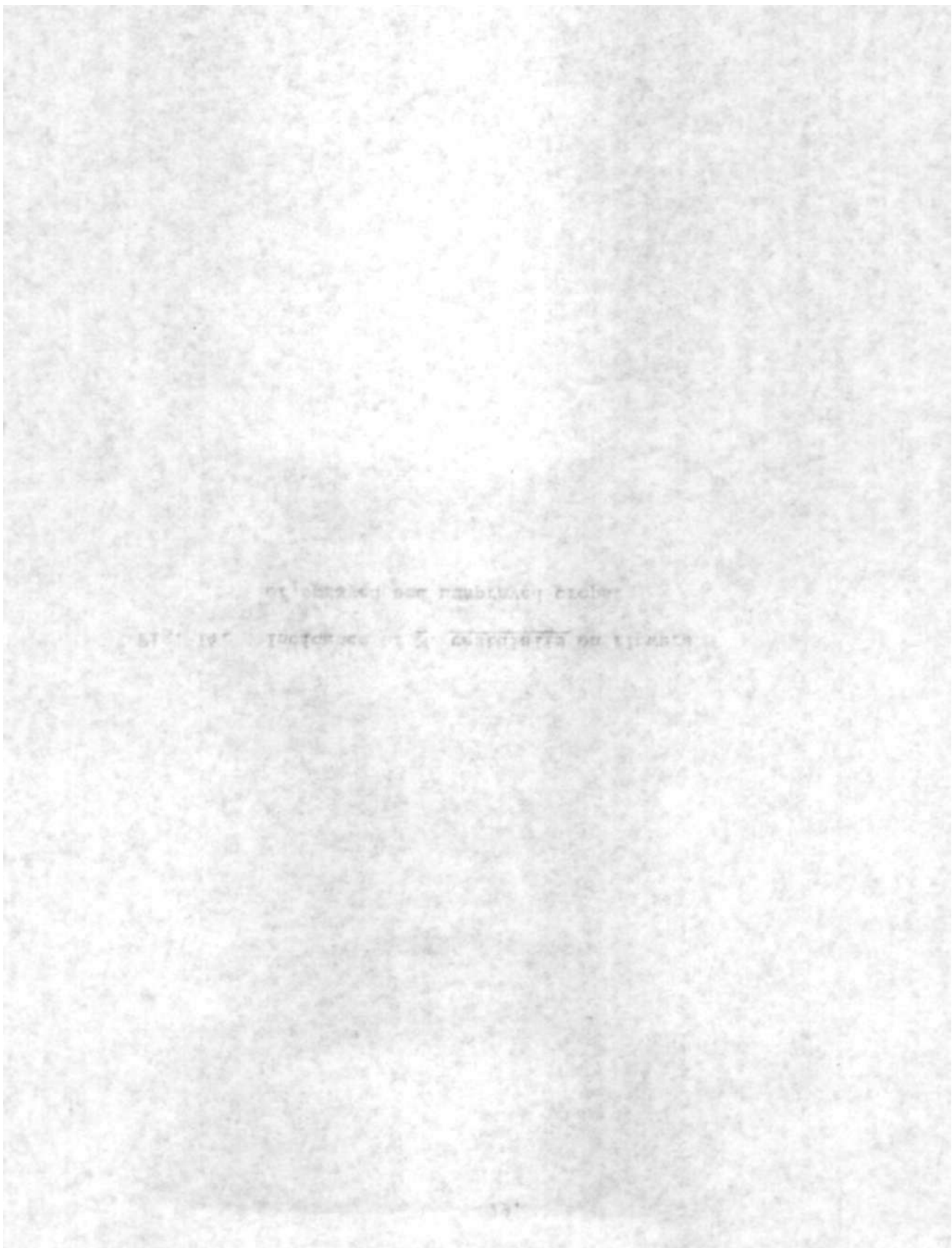
* Cotton - Variety Samaru 71
Cowpea - Variety Fariwake

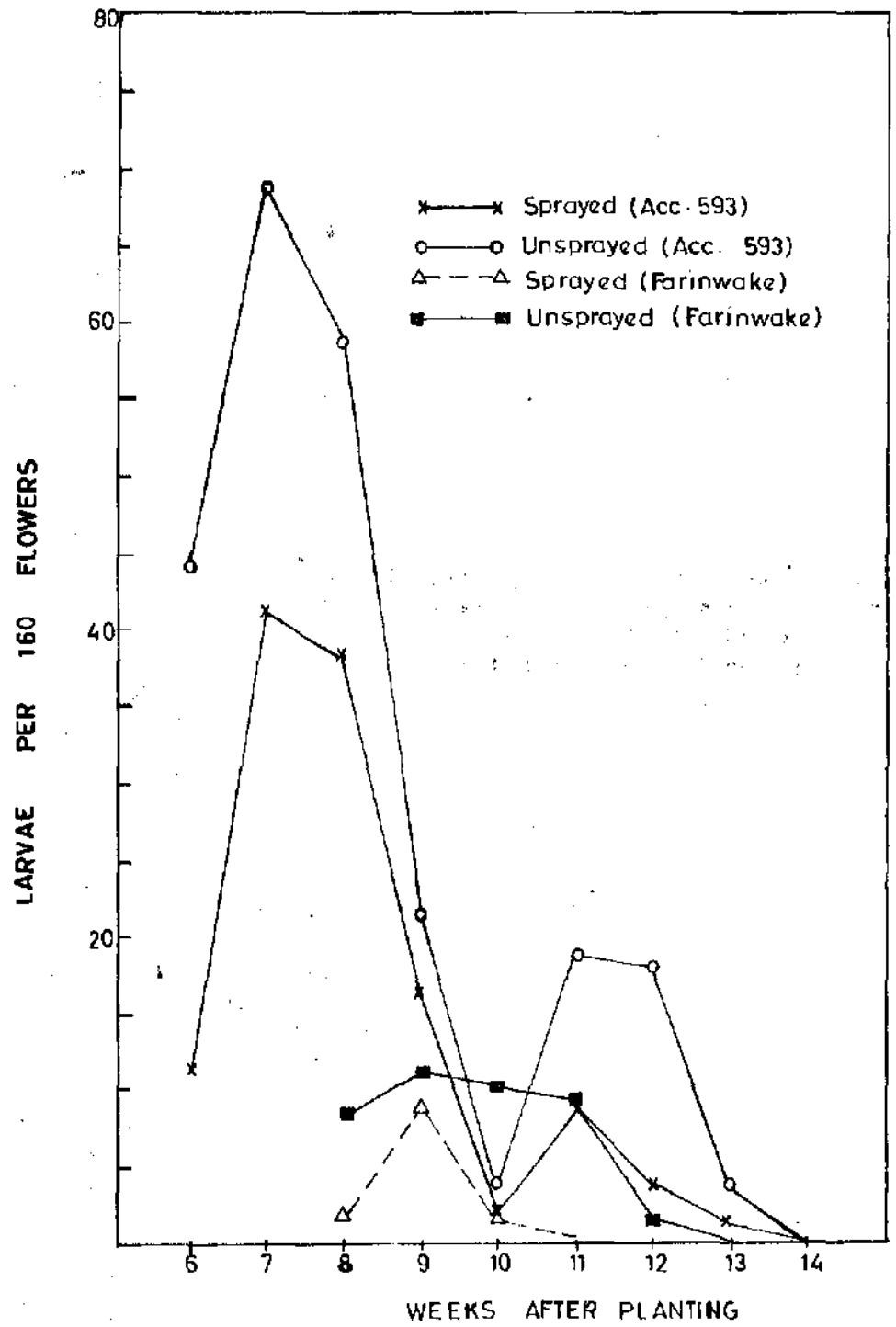
** 5 flowers dissected every week. Average calculated from 30 flowers over a six week period.

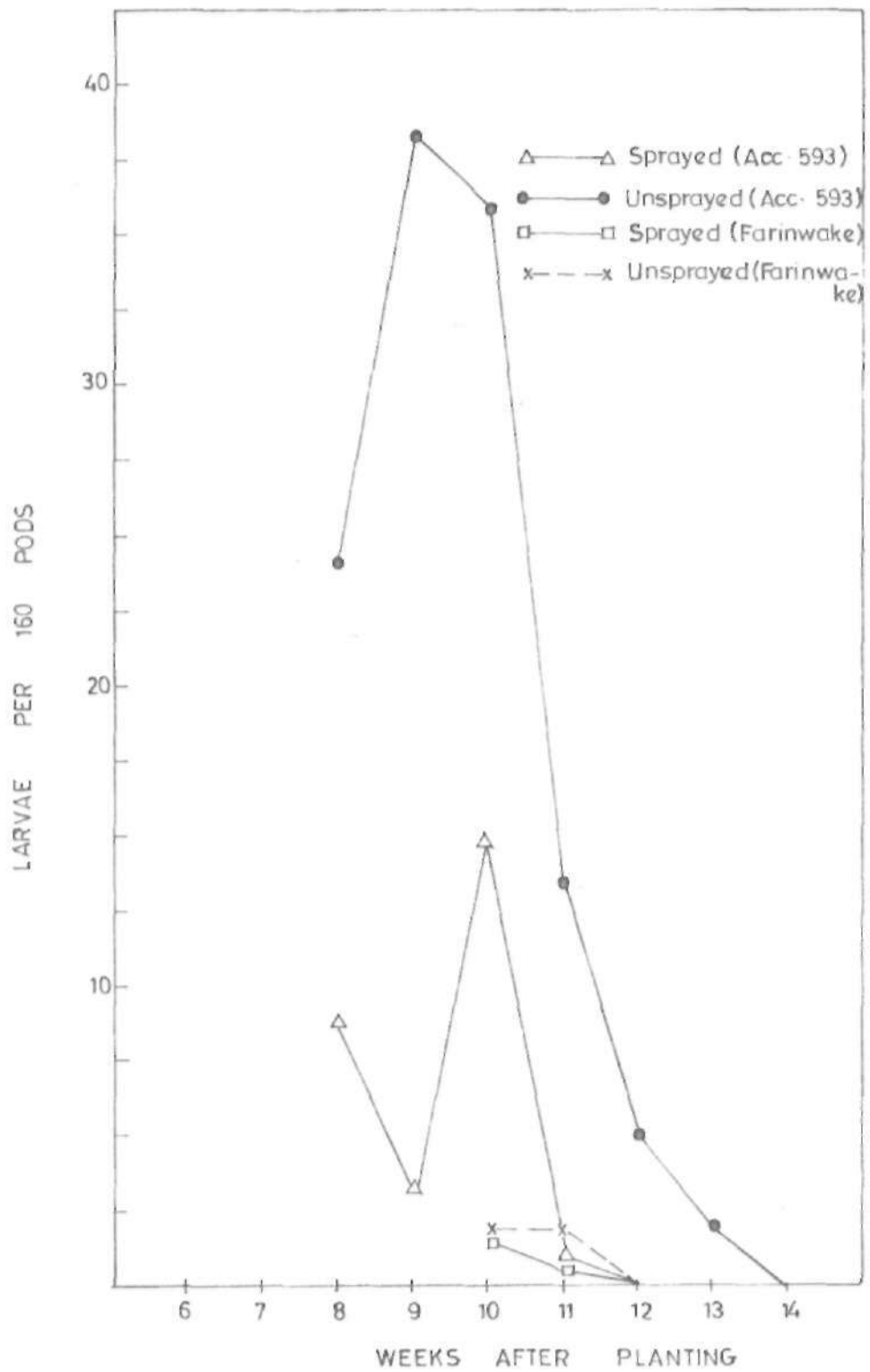

Flowers (Acc. 593)
%Damage (Acc. 593)
Flowers (Farinwake)
%Damage (Farinwake)
AVG. No. FLOWERS PER PLANT
PERCENT DAMAGE
WEEKS AFTER PLANTING
50
40
30
20
10
6
7
8
9
10
11
12
13
14
15




Pods (Acc. 593)
%Damage (Acc. 593)
Pods (Farinwake)
%Damage (Farinwake)
AVG. No. PODS PER PLANT
PERCENT DAMAGE
WEEKS AFTER PLANTING
30
20
10
6
7
8
9
10
11
12
13
14
15




Sprayed (Acc. 593)
Unsprayed (Acc. 593)
Sprayed (Farinwake)
Unsprayed (Farinwake)
LARVAE PER 160 FLOWERS
80
60
40
20
6
7
8
9
10
11
12
13
14
WEEKS AFTER PLANTING


40
30
20
10
LARVAE PER 160 PODS
Sprayed (Acc 593)
Unsprayed (Acc. 593)
Sprayed (Farinwake)
Unsprayed (Farinwake)
6
7
8
9
10
11
12
13
14
WEEKS AFTER PLANTING

Flowering began in cowpea variety Acc. 593 six weeks after sowing. There were two flowering peaks at the 8th and the 12th week after sowing. The rate of flower production rose steadily and declined from 13th to 15th week. In variety Farinwake, flowering commenced eight weeks after sowing and the number of flowers per plant rose steadily with a peak on the 10th week and then declined from 11th week to the 14th week (Fig. 12).

Pod formation followed the pattern of flowering with a flower giving rise to a pod about a day after opening (Fig. 13).

Infestation of M. testulalis on the flowers of Acc. 593 began as soon as flowers first appeared, that is, the sixth week after sowing. The percentage of flowers damaged reached a peak on the 8th and then declined on the 9th week. In cowpea variety Farinwake, infestation of flowers commenced the eighth week after sowing, reached a peak on the ninth week and then declined from the tenth week (Fig. 12 and Table 8).

Attack on Acc. 593 pods commenced about two weeks after flowering, reached its peak on the 9th week and then declined from the 10th week. Similarly on Farinwake, pods were first infested about two weeks after flowering, reached a peak on the 11th week and then declined from the 12th week (Fig. 13 and Table 9).

As it was expected, the incidence of M. testulalis was higher in the crops which were not protected by spraying (Figs. 14 and 15).

There seemed to be a definite correlation between population build-up of this insect and the flowering cycle of cowpea. This was indicated by the presence of first instar larvae on the field. The first batch of these larvae were collected between April and May on irrigated cowpeas. This was followed by the second batch between the end of June and early July. Thus it was the third generation which attacked the early maturing varieties of rainfed cowpea in August. The fourth and the last batch of first instar larvae were collected in October. Some female moths at this time laid their eggs on cowpea while others laid them on wild leguminous plants (Chapter III).

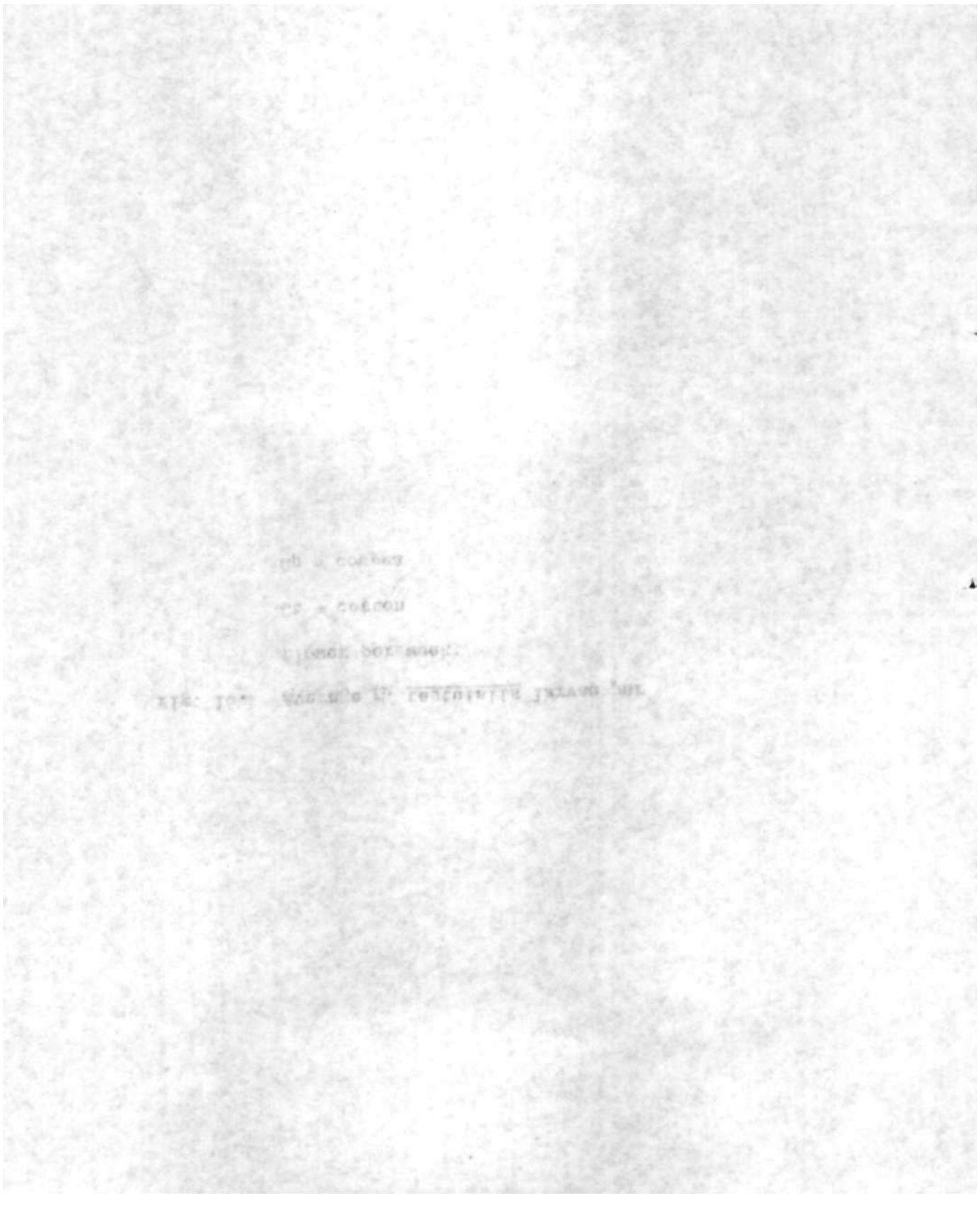
The total yield and percentage loss per plant in cages artificially infested with M. testulalis adults are shown in Table 10. The total number of pupae collected from each cage is also shown. Third instar larvae were first observed in dropped flowers in the cage after nine days. 39.9, 8.9 and 58.3 percent were the recorded losses in yield in fields W5, S11 and W3 respectively. By putting a cage on the cowpea plants it was possible to eliminate all the insects except thrips. Since the thrips were equally abundant in all cages it is reasonable to assume that this difference in yield is mainly

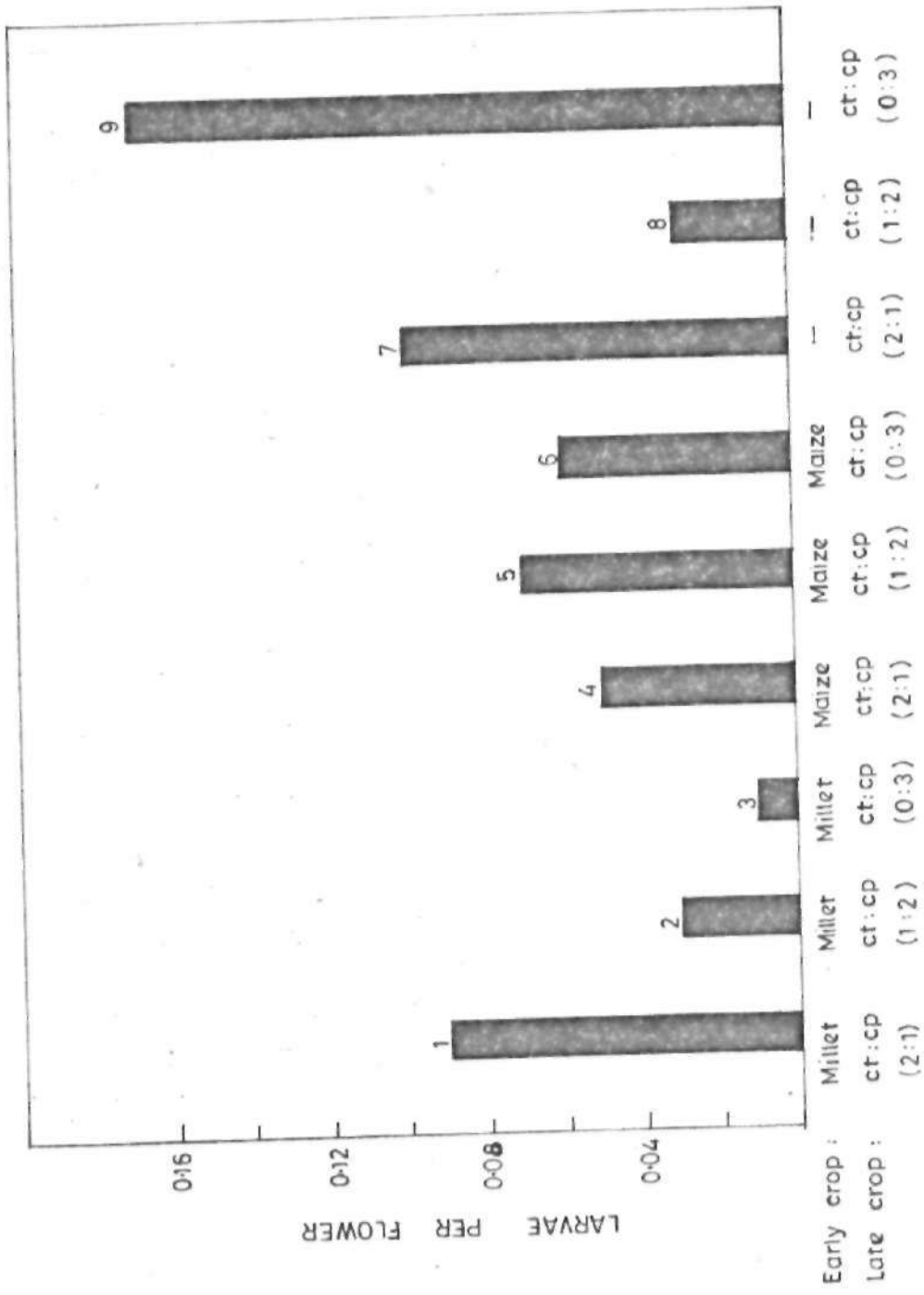
due to M. testulalis. The small difference in yield in the cages at site S11 where only 8.9 percent loss in yield per plant was recorded was most probably due to the death of some of the released adults. This field is located near cowpea and cotton fields which were sprayed weekly. It is therefore likely that spray drifts killed some of the adults. The number of pupae recovered from this cage was five as compared to 17 and 26 in other cages. This is only a preliminary study. The scope of this work had to be limited due to lack of time and facilities.

Table 11 shows the design of the intercropping experiment. The average number of M. testulalis larvae and thrips found per flower in each week are also shown. The average of M. testulalis incidence on cowpea flowers in different treatments is shown in Fig. 16.

Incidence of M. testulalis was highest in treatment number 9, that is, monocropped cowpea, while the incidence was lowest in treatment number 3 where millet was intercropped with cowpea. The population of thrips did not seem to fit any single pattern. Nevertheless it was highest in monocropped cowpea.

In intercropping experiments conducted at the Institute for Agricultural Research, Samaru, it has been shown that the incidence of various insects including M. testulalis is much lower on




LARVAE PER FLOWER
0·16
0·12
0·08
0·04
1
2
3
4
5
6
7
8
9
Early crop : Millet Millet Millet Maize Maize — — —
Late crop : cr:cp cr:cp cr:cp cr:cp cr:cp cr:cp cr:cp cr:cp
(2:1) (1:2) (0:3) (2:1) (0:3) (1:2) (2:1) (0:3)
T R E A T M E N T S

intercropped cowpea (I.A.R. Report to the Board of Governors 1970, 1972, and 1975). While this was also the case with intercropped cowpea in this study, it is interesting to note that in all treatments where cowpea was intercropped with either millet or maize the early crop of millet or maize had been harvested by the time cowpea began to blossom. Thus cowpea in effect was a monocrop when M. testulalis infestation of the flowers began. Thus it would seem that intercropped cowpea plants were less attractive to M. testulalis than monocropped cowpea plants. These plants were shaded under the cereal crops and had stunted growth thus making them less attractive to insects especially M. testulalis. Also widely spaced plants in intercropped treatments may be less attractive to M. testulalis than the closely spaced plants.

Conclusion

M. testulalis is a serious pest of flowers and pods of cowpea. Infestation on flowers could be seen as soon as flowering began. Infestation was carried to pods and continued until no more green pods were available on the field. Damage done by the first and second instar larvae which fed mainly on the reproductive organs of cowpea flowers seemed to be mild when compared to the later instar larvae. Whereas a number of young larvae may be seen feeding in a single flower, only a single larva was found once the caterpillars

were third instar or older. Only older larvae attack the pods and a single larva was found to damage one to four seeds from a single green pod. The assessment of damage to flowers by M. testulalis is complicated by the simultaneous infestation by thrips of the species Taeniothrips sjostedti (Tryb.). Cowpea flowers were seen heavily infested with thrips. As many as 44 thrips per flower were seen. It was not too uncommon to find the same flower infested with both insects. In fact, thrips were found in practically every flower.

Unlike M. testulalis larvae, thrips were not found feeding on green pods but only on reproductive parts of flowers. The status of this insect as a pest is uncertain. Fagade (1966 ref. Taylor, 1969b and 1974) recorded as many as 350 thrips per flower with a mean of 96. Taylor (1969b) reported that the mean number of adults and nymphs on flowers of a local cowpea variety (Mezed) and an improved variety (New Era) reached 54 and 63 per flower on the early and late season crops respectively. The average number of thrips per flower recorded in this study was 11 with the highest as 44.

The cowpea variety Acc. 593 flowered early and flowering period was longer than in Fariwake. It was therefore attacked by two generations of M. testulalis. The flowers of Fariwake partially escaped the third generation of M. testulalis. Flowering in this variety began two weeks after Acc. 593 had started flowering. It was the fourth

and the last generation of this moth which attacked Farinwake. As can be seen in Fig. 14, the incidence of M. testulalis on unsprayed Acc. 593 was higher than that of Farinwake from the 8th to the 12th week after sowing. During these weeks both varieties were in blossom. Variety Farinwake which is indigenous to northern Nigeria, apart from partially escaping attack of the third generation of M. testulalis would also seem to be less susceptible to damage by this insect.

It is worth noting that cowpea variety Acc. 593 which bears most of its flowers above its canopy suffers the heaviest infestation of M. testulalis, whereas in cowpea variety Farinwake where most of the flowers are borne within the canopy lower infestation was recorded. M. testulalis infestation was still lower when the crop was grown as intercrop.

Thus, the choice of a cowpea variety such as Farinwake as a component out of a mixture of crops grown by the farmers in northern Nigeria who cannot afford to spray is interesting. This variety appears to have acquired the ability to withstand M. testulalis attack. Besides, the other crops with which this variety is planted also provide some measure of protection.

SUMMARY

Studies on the seasonal biology, host range and the incidence of M. testulalis in relation to cowpea crop in northern Nigeria were carried out.

Eggs were deposited on flower buds in the field. Incubation period for the egg in the laboratory was found to be 2 to 3 days. There were five larval instars with a total larval period of 10 to 14 days. Prepupal period ranged between 1 to 2 days while the duration of the pupal period was on the average 6 to 7 days. Adults lived for 4 to 6 days. The peak of flight activity of adults was found to be between 2000 and 2100 hours. The complete life cycle ranged between 22 and 30 days. There were at least four generations in the wet season. Two orders of insects including three families and ten species were recorded as larval parasites of this moth. Braunsia analis (K.) (Hymenoptera - Braconidae) was found to be the most abundant accounting for about 64 percent of the total parasitization. These parasites did not seem to play a significant role in natural control.

Larvae and pupae were first collected on the cultivated cowpea in April. They were last collected in October. Their number was highest in August. Adults were caught in the light trap throughout

the year except in the month of December. The peak of population build-up of the adults was found to be in November. All parasitized larvae were collected between the months of August and October. Parasitization reached its peak in September.

Amongst all the cultivated and wild legumes included in this study, cowpea was found to be the most susceptible to M. testulalis attack. Nine species of wild plants belonging to family Papilionaceae were recorded as alternative hosts of this moth. A small resident population of M. testulalis survives the dry season on some of these plants. Crotalaria lachnosema which flowers all the year round may be the most important. There was no evidence of diapause.

Incidence of M. testulalis was found to be higher in unprotected cowpea crop. Damage by this insect may account for between 9 to 58 percent loss in yield. Its incidence was higher on monocropped cowpea as compared to cowpea grown as an intercrop.

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Appendix 1 List of Wild Plants Sampled

Name	Family
Annona senegalensis Pers.	Annonaceae
Cassia siamea Lam.	Caesalpinaceae
Cassia singuena Del.	"
Delonix regia (Boj. ex Hook. f.) Raf.	"
Isoberlinia doka Craib & Stapf.	"
Piliostigma thonningiis (Schum) Milne-Redhead	"
Guiera senegalensis Lam.	Combretaceae
Aspilia africana	Compositae
Ipomea aquatica Frsk.	Convolvulaceae
Luffa aegyptica Mill.	Cucurbitaceae
Cyprus gigantica	Cyperaceae
Securinega virosa (Roxb.) Baill.	Euphorbiaceae
Andropogon gayanus Kunth.	Graminaceae
Echinochloa pyramidalis (Lam.) Hitchc. & Chase	"
Hyparrthelia dissoluta (Nessex Steaud) C. E. Hubbard	"
Pennisetum pedicellatum (Trin.)	"
Rottboellia exaltata Linn. f.	Graminaceae
Hoslundia opposita Vahl.	Labiatae
Urena lobata Linn.	Malvaceae

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Name	Family
Melia azedarch Linn.	Meliaceae
Acacia ataxacantha DC.	Mimosaceae
Albizzia zygia (DC) J. F. Macbr.	"
Entada africana Guill.& Perr.	"
Parkia clappertoniana (Keay)	"
Ximenia americana L.	Olacaceae
Adenodolichos paniculatus Hutch & J. M. Dalz.	Papilionaceae
Centrosema pubescens Benth.	"
Crotalaria confusa (Hepper)	"
Crotalaria lachnosema Stapf.	"
Crotalaria naregutensis Hutch.	"
Crotalaria senegalensis (Pers.) Bacle ex. DC.	"
Dalbergia latifolia Roxb.	"
Desmodium triflorum (L.) DC.	"
Desmodium velutinum (Willd) DC.	"
Eriosema psoraleoides (Lam.) Don.	"
Erythrina senegalensis DC.	"
[illegible]a sepium (Jacq) Walp.	"
[illegible]ra hirsuta L.	"
[illegible]ra pulchra Willd.	"

Appendix 1 continued

Name	Family
Macuna pruriens (L.) DC.	Papilionaceae
Pseudarthria hookeri Wight & Arn.	"
Sesbania pachycarpa DC.	"
Sphenostylis schweinfurthii Harms	"
Tephrosia bractiolata Guillem and Perrott	"
Tephrosia linearis (Willd.) Pers.	"
Vigna reticulata Hook. f.	"
Vigna unguiculata (L.) Walp. ssp. dekindtiana Harms Verdc.	"
Securidaca longepedunculata Fres.	Polygalaceae
Nauclea latifolia (S.)	Rubiaceae
Butyrospermum parkii (G. Don) Kotschy	Sapotaceae
Tacca involucrata Schum & Thonn	Taccaceae
Clerodendron capitatum Schum & Thonn	Verbenaceae
Vitex doniana Sweet.	"