CHILO TUMIDICOSTALIS HAMPSON—A SERIOUS STEM BORER PEST OF SUGARCANE IN BIHAR

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1. Introduction

Pest survey is conducted in Bihar every year systematically, covering practically the whole of the sugarcane-growing area. During such a survey in 1940, a very severe and characteristic damage to mature canes by a stem borer was noticed in Purnea District. Numerous borer larvæ were found in each affected stalk, damaging a very large length of cane tissues. The species of borer responsible for this damage, though resembled closely *Chilo zonellus* Swinh. was, however, a different one. A detailed examination of larval and pupal characters established the identity of the pest as *Argyria tumidicostalis* or what is now known as *Chilo tumidicostalis* Hmps. This was the first record of the pest in Bihar.

The pest was earlier reported from Bengal and Assam, but unfortunately no work had been conducted on any aspect of this pest except that short descriptions of its adult, larva and pupa were given by Hampson (1919 *a*), Isaac and Rao (1941) and Isaac and Venkataraman (1941) respectively. Fletcher and Ghosh (1919) have also given a brief description of four different forms of its larvæ and pupa, placing the same under *Diatræa* species, which was named by Hampson as *A. tumidicostalis.*

The present paper gives in detail the distribution of the pest in Bihar along with its biology, nature and extent of damage and the natural enemies.

II. Historical

Cotes (1889) was the first who attempted to give specific name to the sugarcane moth borers in India. He erroneously named all the borers as *Diatræa saccharalis* Fb. But being aware of the unsatisfactory systematic position of the Indian species the same were sent to Dr. Riley, who identified these as species of *Chilo* nearing *C. plejadellus* Zinck or *C. infuscatellus* Snell. Hampson (1919 *a* and *b*) described the adult of *Argyria tumidicostalis* recorded from Bengal and *Chilo gemininotalis* recorded from Assam. Kapur (1950) re-examined the material from Assam and Bengal and opined that both these species were synonyms and should be renamed as *Chilo tumidicostalis* Hampson.

III. MATERIAL AND METHOD

A preliminary survey of this borer was conducted in various villages (21–30) of Purnea District for three years, 1939–42. A detailed survey was undertaken during the last three years (1953-56) to record the intensity of the borer in sugarcane-growing areas of Purnea and Darbhanga Districts with a view to studying the distribution of the pest and the trend of its migration. The method of recording pest incidence was adopted after Khanna and Bandyopadhyay (1951).

For studying the biology of this pest, a large number of its larvæ was collected from Purnea and Darbhanga Districts and reared in the laboratory at Pusa during September to February for the last three years (1954–56). The pest was reared on cane pieces which were changed regularly to avoid the infection by fungi.

Permanent slides of larvæ and adults were prepared by treating the specimens with 10% KOH solution, washing under a current of water, dehydrating, staining with eosin in 90% alcohol, clearing in carbo-turpentine, turpentine and cedarwood oil as suggested by Puri (1954) and finally mounting in turpentine-balsam.

IV. DISTRIBUTION

The pest is widely distributed all over Assam and Bengal States from where it was reported as early as 1907 and 1911 respectively. Recently, it has also been recorded in Bihar and Orissa. In Bihar, the pest is common only in Purnea District, though stray cases of its occurrence have also been recorded from North Bhagalpur, North Monghyr, Darbhanga and Muzaffarpur Districts. A detailed survey in Purnea and Darbhanga Districts revealed the spreading tendency of the pest (Plate IV). The concentration of the pest in North-East Bihar with gradual reduction in its intensity as it moves westwards clearly indicate that the pest has migrated from Bengal. This is a case where the pest has entered Bihar in cane supplies coming to the Semapur factory from affected areas and shows the danger of such importations to the industry.

V. INCIDENCE OF PEST

The pest survey during the earlier years showed that the incidence of this borer was very high in the factory plantation at Semapur and in the neighbouring villages. During 1940–41, the infestation in Semapur factory farms was, on an average, 82·18%, 14·34% and 11·98% on stalk, internodal and length basis respectively (Table II). The average infestation of this pest in different localities surveyed, was, in respect of stalk, joints and length bases, 29·76%, 3·53% and 2·57% during 1939–40 (Table I); 53·09%, 8·64%

TABLE I

Incidence of Chilo tumidicostalis *in Purnea District*, 1939–40 (*Co* 213)

Sl. No.	Name of villages	Percentage incidence on Stalk basis	Length basis	Joint basis
1	Sakraili ..	41·40±3·09	4·40±0·16	5·80±0·37
2	Binji ..	30·68±2·82	3·50±0·14	4·12±0·32
3	Phulwaria ..	16·38±2·02	1·43±0·13	2·14±0·19
4	Barari ..	29·36±2·95	2·45±0·10	3·30±0·23
5	Sewana ..	23·05±2·54	2·18±0·11	2·83±0·21
6	Santari ..	21·85±2·43	2·57±0·13	3·12±0·26
7	Mednipur ..	36·46±2·97	4·70±0·21	5·66±0·35
8	Baghwara ..	37·41±3·00	4·25±0·18	4·09±0·27
9	Hanswar ..	46·65±3·32	4·62±0·25	6·30±0·41
10	Kishanpur ..	46·20±3·21	2·39±0·12	2·94±0·23
11	Lava ..	50·35±3·54	3·43±0·14	7·68±0·45
12	Lalgunj ..	59·13±3·41	4·54±0·21	2·70±0·18
13	Damka ..	55·20±3·36	6·10±0·32	8·93±0·49
14	Barsauni ..	31·55±2·92	2·72±0·11	3·81±0·25
15	Jalalgarh ..	57·53±3·15	8·24±0·26	11·55±0·55
16	Chilhania ..	31·69±3·01	2·65±0·18	4·46±0·31
17	Ararya ..	25·65±2·75	2·42±0·16	2·98±0·22
18	Dhama ..	2·15±0·82	0·21±0·04	0·44±0·06
19	Banmakhi ..	26·33±2·63	2·32±0·15	3·62±0·24
20	Kajhi ..	13·53±1·97	0·96±0·03	1·15±0·15
21	Mahadeopur ..	8·88±1·63	0·08±0·01	0·67±0·08
22	Barharakothi ..	25·44±2·56	1·16±0·08	2·39±0·18
23	Ramnagar ..	20·28±2·33	1·31±0·09	2·19±0·19
24	Rampur ..	21·82±2·40	1·05±0·06	1·35±0·14
	Overall ..	29·76±0·57	2·57±0·03	3·53±0·05

and 7·37% during 1940–41 (Table II) and 11·95%, 1·35% and 1·31% during 1941–42 (Table III). The incidence of this pest in different localities in Purnea and Darbhanga Districts surveyed variety-wise during 1953–54, 1954–55 and 1955–56 has been presented in Tables IV, V and VI respectively.

VI. VARIETAL RESISTANCE

The behaviour of the borer towards the different varieties was studied during three alternate seasons 1940–41, 1942–43 and 1944–45 and three successive seasons 1953–54 to 1955–56. The mean incidences on stalk basis in respect of different varieties obtained in the samples during the different seasons have been furnished in Tables VII and VIII (*a*, *b* and *c*) which clearly bring out the varietal differences. B.O. 10 is least affected on the three basis of infestation, *viz.*, stalk, joints and length bored while Co 421 is the most

TABLE II

Incidence of Chilo tumidicostalis *in Purnea District*, 1940–41 (*Co* 213)

Sl. No.	Name of villages	Percentage incidence on		
		Stalk basis	Length basis	Joint basis
1	Horprasad ..	60·38±3·09	12·18±0·25	13·43±0·55
2	Mednipur ..	56·38±3·18	6·72±0·18	7·96±0·42
3	Hasina ..	55·55±3·10	8·33±0·21	9·03±0·46
4	Balthi ..	48·28±3·19	5·79±0·18	10·33±0·49
5	Saturi ..	46·98±3·25	4·99±0·15	6·64±0·42
6	Chitabhari ..	43·65±3·11	6·97±0·26	6·31±0·41
7	Kaira ..	51·95±3·01	7·44±0·13	7·22±0·48
8	Mangera ..	43·54±3·88	5·79±0·35	6·82±0·51
9	Semapur (Zirat)	82·18±2·43	11·98±0·22	14·34±0·53
10	Nayatola ..	48·77±3·19	5·83±0·21	6·42±0·39
11	Katilpur ..	56·77±2·98	6·47±0·24	7·52±0·44
12	Lava ..	52·75±2·89	6·22±0·20	7·24±0·38
13	Kumaripur ..	56·40±2·92	8·88±0·28	10·52±0·49
14	Nawabganj ..	35·97±3·05	3·08±0·11	4·40±0·31
15	Noranji ..	64·51±3·11	10·05±0·15	12·42±0·46
16	Sakraili ..	51·03±2·93	7·28±0·17	8·14±0·44
17	Purnea Farm ..	63·60±3·04	8·31±0·26	10·29±0·49
18	Kosha ..	44·98±2·92	5·29±0·23	7·00±0·41
19	Ajampur ..	52·98±3·13	7·85±0·25	8·88±0·45
20	Budhuchak ..	57·08±3·07	8·15±0·15	9·18±0·46
21	Kantakosh ..	39·08±3·12	4·23±0·12	5·65±0·38
	Overall ..	53·09±0·69	7·37±0·04	8·64±0·10

affected, varieties Co 513, Co 356 and B.O. 11 coming near B.O. 10 and varieties Co 313, Co 331, Co 453 and Co 299 that of Co 421. The former group was generally solid-cored while the latter developed considerable pith and cavity in their stalks.

VII. ENVIRONMENTAL EFFECTS

Three effects of different environmental factors, *viz.*, type of soil, its susceptibility to water-logging and flooding and nature of the crop whether ratoon and plant on the activity of the pest were studied in the different villages. The result (Table IX) showed that the incidence of this pest was significantly higher in heavy soil as also under water-logged and flooded conditions suggesting that conditions which afforded more humid environment were more favourable for its multiplication. Further the ratoon crop showed significantly higher incidence than the plant crop.

TABLE III

Incidence of Chilo tumidicostalis *in Purnea District*, 1941–42 (*Co* 213)

Sl. No.	Name of villages	Percentage incidence on		
		Stalk basis	Length basis	Joint basis
1	Basalgaon ..	8·30±2·13	0·89±0·09	1·07±0 20
2	Niridhar ..	11·11±1·37	0·50±0·411	0·78±0·26
3	Geradih ..	10·90±1·00	0·87±0·060	1·33±0·28
4	Bilaspur ..	6·90±2·36	0·32±0·020	0·46±0·15
5	Kaushal ..	16·66±2·88	1·66±0·190	1·63±0·35
6	Bawanganj ..	14·30±2·96	0·99±0·100	1·33±0·22
7	Birja ..	0·00	0·00	0·00
8	Sakraili ..	3·60±1·77	0·22±0·010	0·23±0·11
9	Dharhara ..	2·73±4·60	0·21±0·010	0·29±0·09
10	Dhina ..	0·00	0·00	0·00
11	Parhari ..	32·00±3·82	0·17±0·010	0·85±0·30
12	Santari ..	10·00±2·54	0·17±0·007	0·35±0·09
13	Bantori ..	5·50±2·65	0·33±0·070	0·54±0·27
14	Husaina ..	5·30±1·29	0·39±0·080	0·53±0·14
15	Habibganj ..	6·58±2·02	0·35±0·010	0·45±0·17
16	Kursella ..	0·00	0·00	0·00
17	Baghmera ..	23·21±4·01	1·59±0·010	2·65±0·36
18	Mednipur ..	10·17±2·79	0·67±0·008	0·53±0·16
19	Bagahar ..	7·35±3·16	0·64±0·008	1·01±0·20
20	Matihari ..	18·33±3·55	1·98±0·010	2·81±0·39
21	Halbaidi ..	14·52±3·66	1·82±0·010	2·02±0·31
22	Mahadeopur ..	27·63±3·64	3·32±0·010	4·04±0·31
23	Bahadurpur ..	13·51±3·25	1·77±0·010	1·82±0·10
24	Keshopur ..	10·39±2·47	1·09±0·006	1·52±0·09
25	Anta Bigha ..	4·48±2·53	0·21±0·006	0·26±0·06
26	Purnea Farm ..	14·03±1·48	1·16±0·010	1·34±0·02
27	Girsole ..	25·00±5·38	4·36±0·010	4·29±0·45
28	Magura ..	10·81±5·11	1·11±0·010	1·60±0·39
29	Meraji ..	21·31±5·24	2·82±0·010	3·06±0·30
30	Maheshpur ..	21·11±4·30	2·38±0·008	2·30±0·34
	Overall ..	11·95±0·73	1·31±0·03	1·35±0·06

VIII. NATURE AND SYMPTOMS OF DAMAGE

The pest appears early in March when the damage by the first brood is not pronounced. The ravages of the pest really start with the second brood by August-September, when the crop is sufficiently old and have formed internodes. The attack continues till harvest. The larvæ usually prefer the upper half of the stems. A large number of larvæ are often found congregated in a few internodes. In quite a few cases as many as 40–60 larvæ were

TABLE IV

Incidence of Chilo tumidicostalis *in different varieties in Purnea District*, 1953–54

Sl. No.	Name of villages	Percentage infestation on Stalk basis	Joint basis	Length basis
		Variety B.O. 11		
1	Purnea ..	22·22±5·66	3·69±0·59	2·22±0·22
2	Manihari ..	22·50±6·61	2·84±0·59	1·50±0·23
3	Forbesgunj ..	7·69±4·27	0·51±0·25	0·21±0·08
4	Semapur ..	10·13±2·00	8·55±0·40	0·36±0·04
5	Kishangunj ..	12·82±5·35	0·82±0·31	0·36±0·11
6	Jogbani ..	5·00±3·44	0·36±0·21	0·10±0·06
7	Araria ..	4·65±3·14	0·53±0·24	0·86±0·15
	Mean ..	11·60±3·47	4·85±0·39	0·67±0·09
		Variety Co 453		
1	Purnea ..	33·15±3·53	6·96±0·45	4·37±0·17
2	Manihari ..	26·21±3·06	7·07±0·40	4·99±0·17
3	Forbesgunj ..	23·68±6·89	2·05±0·51	1·03±0·19
4	Semapur ..	21·69±2·99	4·04±0·32	3·12±0·14
5	Kishangunj ..	20·69±4·38	2·44±0·39	1·72±0·16
6	Jogbani ..	10·26±1·98	0·90±0·14	0·35±0·04
7	Araria ..	23·91±6·29	4·78±0·75	2·11±0·24
8	Karahgola ..	14·29±5·40	5·11±0·81	3·98±0·35
	Mean ..	21·76±3·38	4·31±0·37	2·87±0·15
		Variety Co 513		
1	Purnea ..	29·41±4·94	4·04±0·52	2·13±0·19
2	Semapur ..	12·40±2·99	2·87±0·37	2·08±0·15
3	Kishangunj ..	14·04±3·25	1·57±0·29	0·71±0·09
4	Jogbani ..	4·43±1·63	0·37±0·11	0·14±0·03
5	Araria ..	13·51±5·62	1·30±0·49	0·42±0·13
6	Karahgola ..	7·14±3·97	0·88±0·36	0·49±0·13
7	Kusiargaon ..	19·05±4·28	3·80±0·50	2·50±0·19
	Mean ..	13·57±3·34	2·08±0·33	1·22±0·12
		Variety Co 313		
1	Manihari ..	29·72±5·31	3·70±0·54	1·38±0·16
2	Forbesgunj ..	35·63±3·47	9·29±0·48	7·59±0·21
3	Semapur ..	33·33±2·00	3·97±0·79	2·25±0·29
4	Jogbani ..	2·06±2·44	1·99±0·57	0·69±0·16
5	Araria ..	21·62±6·77	2·30±0·61	1·05±0·19
	Mean ..	29·75±3·93	6·29±0·54	4·55±0·20
		Variety B.O. 10		
1	Purnea ..	11·71±4·51	0·89±0·28	0·46±0·11
2	Jogbani ..	4·95±2·15	0·30±0·38	0·13±0·04
	Mean ..	7·22±2·94	0·50±0·35	0·24±0·06
		Variety Co 331		
1	Manihari ..	30·18±3·08	9·31±0·54	8·91±0·23
2	Semapur ..	2·60±1·86	3·19±0·48	1·48±0·17
	Mean ..	23·36±2·78	7·80±0·53	7·07±0·22

TABLE V

Incidence of Chilo tumidicostalis *in different varieties in Purnea District* 1954–55

Sl. No.	Name of villages	Percentage infestation on		
		Stalk basis	Joint basis	Length basis
		Variety Co 356		
1	Manihari ..	10·80±2·13	1·21±0·15	0·97±0·06
		Variety Co 331		
1	Manihari ..	17·65±4·14	2·69±0·40	1·94±0·17
		Variety B.O. 11		
1	Semapur ..	2·62±1·33	0·19±0·06	0·15±0·03

TABLE VI

Incidence of Chilo tumidicostalis *in Purnea and Darbhanga Districts in* 1955–56

Sl. No.	Name of villages	Percentage infestation on		
		Stalk basis	Joint basis	Length basis
		Variety Co 356		
1	Manihari ..	18·18±1·89	2·13±0·14	2·16±0·08
		Variety Co 513		
1	Sakri ..	10·27±1·78	1·66±0·19	0·93±0·07
		Variety Co 453		
1	Sakri ..	40·00±5·31	7·14±0·64	5·87±0·31
		Variety B.O. 11		
1	Sakri ..	34·89±1·88	5·36±0·18	4·59±0·09

recovered from 2–3 internodes of a single cane, while in majority of canes 5–10 larvæ and pupæ were met with in one cane. The maximum number of pupæ in a single internode was observed to be 14 at Purnea in 1953–54. The larvæ destroy the internodal tissues of the stalk and often reduce it to an almost hollow structure (Plates V and V A).

The damage of this borer may be recognised by the following symptoms: (1) Copious frass of the borer larvæ, looking like saw-dust, is seen sticking to the stem near the borer holes. Very often masses of this excreta are found

TABLE VII

Showing incidence of Chilo tumidicostalis *on different varieties*

Sl. No.	1 Varieties	2 Stalk basis	3 Joint basis	4 Length basis
1	Co 213	31·60±0·67	4·51±0·07	3·75±0·03
2	Co 313	29·75±3·93	6·29±0·54	4·55±0·20
3	Co 331	20·51±3·52	5·50±0·47	4·51±0·19
4	Co 356	14·50±2·01	1·67±0·15	1·57±0·07
5	Co 453	30·83±4·45	5·73±0·52	4·37±0·24
6	Co 513	11·92±2·68	1·87±0·27	1·08±0·09
7	B.O. 10	7·22±2·94	0·50±0·35	0·24±0·06
8	B.O. 11	16·37±2·40	3·47±0·25	1·80±0·08
9	Co 299	36·07±6·15	4·68±0·62	4·06±0·29
10	Co 421	59·26±9·46	7·48±1·05	6·79±0·47

deposited in between the stalk and the sheathing leaves (Plate V A). (2) In cases of severe infestation, the larvæ bore through the stem in such a way that the whole of the peripheral tissue below the rind is eaten up in the form of a ring and hence the portion above the ring gets easily broken by wind (Plate V, Fig. 1). (3) Due to the congregation of larvæ in the plants, several entry and exit holes are made by them and as many as 6–10 holes are not infrequently seen in one internode.

IX. EXTENT OF DAMAGE

Loss in tonnage.—Due to gregarious habit of the boring larvæ the internal cane tissue is almost completely destroyed. The canes often become hollow tubes and lose in weight heavily. In severe cases the upper hollow portions give way to high winds and either break away or hang down becoming dry in due course. The intensity of loss in tonnage has varied in different years and in different localities from 8·2% to 12·6% (Table X). Similarly different varieties have shown (Table XI) distinct variations in the magnitude of loss suffered, Co 419 showing the heaviest loss and Co 213 and Co 331, the least (Table XI). This is rather interesting as the incidence was rather high in both these varieties and the differences seemed due to comparatively harder rind and core compared to Co 419. So far different districts are concerned, losses have been much more pronounced in North Bhagalpur and North Monghyr than in the Purnea District (Table XII).

Loss in sugar.—As this borer destroys the storage tissues of the cane, the sucrose percentage of the juice is considerably reduced. From the samples collected in the different localities of Purnea District it was found (Table XIII)

TABLE VIII

Showing relative resistance to C. tumidicostalis *of different varieties*

(*a*) *Stalk basis*

	Co 313	Co 331	Co 356	Co 453	Co 513	B.O. 10	B.O. 11	Co 299	Co 421	Remarks
Co 213	1·85±3·99 N.S.	11·09±3·58†	17·10±2·12†	0·77±4·50 N.S.	19·68±2·76†	24·38±3·01†	15·23±2·50†	4·47±6·19 N.S.	27·66± 9·49†	
Co 313	..	9·24±5·27 N.S.	15·25±4·41†	1·08±5·94 N.S.	17·83±4·76†	22·53±4·90†	13·38±3·07†	6·32±7·29 N.S.	29·51±10·24†	
Co 331	..	..	6·01±4·05 N.S.	10·32±5·68 N.S.	8·59±4·43 N.S.	13·29±4·59*	4·14±4·27 N.S.	15·56±7·09*	38·75±10·09†	
Co 356	..	..	..	16·33±4·89†	2·58±3·35 N.S.	7·28±3·56*	1·87±3·13 N.S.	21·57±6·48†	44·76± 9·67†	
Co 453	..	..	..	..	18·91±5·19	23·61±5·33†	14·46±5·05†	5·24±7·59 N.S.	28·43±10·45†	
Co 513	..	..	..	..	..	4·70±3·99 N.S.	4·45±3·59 N.S.	24·15±6·79†	47·84± 9·83†	
B.O. 10	..	..	..	..	..	..	9·15±3·79*	28·85±6·82†	52·04± 9·91†	
B.O. 11	..	..	..	..	..	..	..	19·70±6·60†	42·89± 9·76†	
Co 299	..	..	..	..	..	..	..	..	23·19±11·28*	

* Significant at 5 % level.

† Significant at 1 % level.

TABLE VIII (*Contd.*)

Incidence (Varietal resistance) in different varieties

(*b*) *Joint basis*

	Co 313	Co 331	Co 356	Co 453	Co 513	B.O. 10	B.O. 11	Co 299	Co 421	Remarks
Co 213	1·78±0·54†	0·09±0·47*	2·84±0·17†	1·22±0·52*	2·64±0·28†	4·01±0·36†	1·04±0·26†	0·17±0·62 N.S.	2·97±1·01†	
Co 313	..	0·79±0·72 N.S.	4·62±0·56†	0·56±0·75 N.S.	4·42±0·60†	5·79±0·64†	2·82±0·59†	1·61±0·82 N.S.	1·19±1·18 N.S.	
Co 331	..	..	3·83±0·49†	0·23±0·70 N.S.	3·63±0·54†	5·00±0·59†	2·03±0·53†	0·82±0·78 N.S.	1·98±1·15* N.S.	
Co 356	..	..	..	4·06±0·54†	0·20±0·31 N.S	1·17±0·38†	1·80±0·29†	3·01±0·63†	5·81±1·05†	
Co 453	..	..	..	..	3·86±0·59†	5·23±0·63†	2·26±0·58†	1·05±0·81 N.S.	1·75±1·17 N.S.	
Co 513	..	..	..	..	..	5·79±0·44†	1·60±0·37†	2·81±0·68†	5·61±1·09†	
B.O. 10	..	..	..	..	..	..	2·97±0·43†	4·18±0·71†	6·98±1·11†	
B.O. 11	..	..	..	..	..	..	..	1·21±0·67 N.S.	4·01±1·08†	
Co 299	..	..	..	..	..	..	..	..	2·80±1·22*	

Incidence (Varietal resistance) in different varieties

(c) Length basis

	Co 313	Co 331	Co 356	Co 453	Co 513	B.O. 10	B.O. 11	Co 299	Co 421	Remarks
Co 213	0·80±0·20†	0·76±0·19†	2·18±0·08†	0·62±0·24*	2·67±0·09†	3·51±0·06†	1·95±0·09†	0·31±0·29 N.S.	3·04±0·47†	
Co 313	..	0·04±0·28 N.S.	2·98±0·21†	0·18±0·31 N.S.	3·47±0·22†	4·31±0·21†	2·75±0·31†	0·29±0·35 N.S.	2·24±0·51†	
Co 331	..	..	2·94±0·20†	0·14±0·30 N.S.	3·43±0·21†	4·31±0·20†	2·71±0·21†	0·45±0·34 N.S.	2·28±0·50†	
Co 356	..	..	..	2·80±0·25†	0·49±0·11†	1·33±0·09†	0·23±0·10*	2·49±0·30†	5·22±0·48†	
Co 453	..	..	..	..	3·29±0·26†	4·13±0·25†	2·50±0·25†	0·31±0·38 N.S.	2·42±0·53†	
Co 513	..	..	..	..	..	0·84±0·11†	0·72±0·12†	2·98±0·30†	5·71±0·48†	
B.O. 10	..	..	..	..	..	..	1·56±0·10†	3·82±0·29†	6·55±0·47†	
B.O. 11	..	..	..	..	..	..	..	2·86±0·30†	4·99±0·48†	
Co 299	..	..	..	..	..	..	..	..	2·73±0·55†	

* Significant at 5% level. † Significant at 1% level.

TABLE IX

Showing incidence of borer under different environments

	Environments	Stalk basis	Joint basis	Length basis
Co 213	Plant	30·43 ±1·02	4·01*±0·10	2·82*±0·04
	Ratoon	36·83 ±2·07	6·05 ±0·25	4·85 ±0·12
	Water-logging	38·01*±1·35	5·49*±0·16	3·80 ±0·06
	Non-water-logging	25·89 ±1·18	3·51 ±0·12	2·66 ±0·05
	Flooding	37·59*±1·55	5·45*±0·18	3·59 ±0·07
	Non-flooding	28·38 ±1·10	3·86 ±0·11	2·97 ±0·05
	Heavy soil	48·39 ±8·97	9·85*±1·36	9·80 ±0·76
	Light soil	31·89 ±0·91	4·45 ±0·10	3·16 ±0·04

* Significant at 5% level.

TABLE X

Showing actual loss % in tonnage due to Chilo tumidicostalis

Variety: Co 213

(*a*) 1939–40

Name of sites	Average weight of healthy cane	Average weight of cane affected by stem borer	% loss in weight due to stem borer
Sakraili ..	13·9	13·5	2·9
Binji ..	13·5	12·8	5·2
Phulwaria ..	11·5	11·7	—1·7
Berari ..	14·6	14·0	4·1
Sewana ..	13·9	14·3	—2·9
Sautari ..	14·4	15·4	—6·9
Mednipur ..	16·8	17·1	—1·8
Baghmara ..	14·1	13·9	1·4
Kishanpur ..	13·8	13·1	5·1
Lalganj ..	14·8	15·2	—2·7
Damka ..	14·2	13·9	2·1
Barsauni ..	9·2	7·3	20·7
Jalalgarh ..	10·4	9·3	10·6
Chilhania ..	12·9	11·7	9·3
Araria ..	10·9	11·5	—5·5
Dhima ..	14·6	12·7	13·0
Banmankhi ..	14·5	11·0	24·1
Kajhi ..	11·3	9·8	13·2
Mahadeopur ..	12·2	7·3	40·2
Barharakothi ..	11·1	11·1	0·0
Ramnagar ..	11·3	9·0	20·4
Rampur ..	15·60	13·1	16·0
Average ..	13·3	12·1	9·0

TABLE X (*Contd.*)

(*b*) 1940–41

Name of sites	Average weight of healthy cane	Average weight of cane affected by stem borer	% loss in weight due to stem borer
Korha ..	8·3	7·6	8·4
Kajra ..	10·6	9·9	6·6
Azampur ..	9·1	7·8	14·3
Mangura ..	9·0	7·6	15·6
Budhuchak ..	11·2	10·8	3·6
Kabilpur ..	11·9	11·8	0·8
Nayatola ..	10·4	9·8	5·8
Amirabad ..	11·6	9·8	15·5
Kantakush ..	9·1	9·7	—6·6
Medhipur ..	13·8	13·7	0·7
Marangi ..	11·5	10·7	7·0
Kumaripur ..	9·3	8·8	5·4
Harprasad ..	10·1	7·8	20·8
Balthi ..	11·1	11·4	—1·8
Nawabganj ..	14·9	11·6	22·1
Average ..	10·8	9·9	8·2

(*c*) 1942–45

Name of sites	Average weight of healthy cane	Average weight of cane affected by stem borer	% loss in weight due to stem borer
Gamitola ..	8·9	8·1	9·0
Chitabari ..	10·6	8·6	18·9
Mangura ..	8·0	7·2	10·0
Marangi ..	12·6	13·4	—6·3
Baghmara ..	14·2	12·8	9·9
Mednipur ..	14·2	11·3	20·4
Baghar ..	12·9	10·6	17·8
Keshopur ..	8·0	6·1	23·8
Ghoradih ..	7·9	6·8	13·9
Bawanganj ..	12·3	11·0	11·3
Binji ..	6·5	3·4	47·77
Dhima ..	12·6	8·0	36·5
Panihari ..	11·1	11·9	—7·2
Sautari ..	14·2	13·7	3·5
Husina ..	11·2	10·2	8·9
Nawabganj ..	15·0	15·5	—3·3
Kursella ..	8·3	5·7	31·3
Average ..	11·0	9·7	12·6

TABLE XI

Showing loss in tonnage in different varieties due to Chilo tumidicostalis

Variety	Average weight of healthy cane	Average weight of cane affected by stem borer	% loss in weight due to stem borer
Co 213	11·37	10·68	6·07
Co 421	27·71	24·33	12·20
Co 331	11·44	10·67	6·73
B.O. 4	16·55	14·22	14·08
POJ 2878	18·05	14·58	19·22
Co 313	10·22	8·99	12·04
Co 210	5·88	5·09	13·44
Co 513	17·08	15·33	10·25
Co 299	9·59	8·79	8·34
Co 419	26·63	17·33	34·92

TABLE XII

Showing actual loss % in tonnage due to Chilo tumidicostalis *in different districts*

Variety: Co 213

1943–45

Name of sites	District	Average weight of healthy cane	Average weight of cane affected by stem borer	% loss in weight due to stem borer
Sibi	Darbhanga	7·61	6·60	13·27
Maharajganj	,,	12·72	12·08	5·03
Average ..		10·17	9·34	8·16
Morangi	Purnea	11·31	7·81	30·95
Sewana	,,	11·69	10·28	12·06
Bijai	,,	7·88	7·14	9·39
Nathpur	,,	10·00	9·50	5·00
Average ..		10·22	9·43	7·73
Latra	North Bhagalpur	13·12	8·42	35·82
Tulsipur	,,	8·06	7·00	13·15
Parbetta	,,	9·98	5·11	48·80
Ganeshpur	,,	8·64	5·20	39·81
Average ..		9·95	6·43	35·38
Teghra	North Monghyr	8·29	6·80	17·97
Pipra	,,	10·13	8·17	19·35
Average ..		9·21	7·49	18·68

TABLE XIII

Loss in sugar due to Chilo tumidicostalis *in different varieties*, 1940–41

Varieties	Localities	Healthy canes		Unhealthy canes		Difference of sucrose % (H—A)	% loss in sucrose on healthy juice
		Brix %	Sucrose % H	Brix %	Sucrose % A		
Co 213	Sakraili	17·1	14·37	12·7	9·28	5·09	35·42
	Kajra	17·0	14·26	13·0	9·64	4·62	32·47
	Ajampur	17·2	14·48	13·6	10·36	4·12	28·45
	Chitabari	18·3	15·68	13·7	10·48	5·20	33·16
	Mangura	17·7	15·03	12·2	8·68	6·35	42·25
	Budhuchak	17·7	15·03	15·9	13·03	2·00	13·57
	Kabilpur	17·2	14·48	13·0	9·64	4·84	33·43
	Nayatola	17·1	14·37	12·6	9·16	5·21	36·25
	Lava	18·7	16·11	14·9	11·88	4·23	26·28
	Amirabad	18·1	15·47	15·9	13·03	2·44	15·72
	Kantakush	17·3	14·59	15·3	12·34	2·25	15·42
	Madnipur	17·8	15·14	15·5	12·57	2·57	16·97
	Marangi	17·7	15·03	15·2	12·23	2·80	18·63
	Kumaripur	17·0	14·26	15·0	12·00	2·26	15·83
	Harprasad	17·2	14·48	15·0	12·00	2·48	17·13
	Purnea Farm	18·1	15·47	16·4	13·59	1·88	12·15
	Sautari	16·5	13·70	13·7	10·48	3·22	23·50
	Husina	17·3	14·59	14·9	11·88	2·71	18·57
	Balthi	17·7	15·03	14·0	10·83	4·20	27·94
	Nawabganj	18·5	13·90	13·5	10·24	5·66	35·59
	Korha	16·1	13·25	11·8	8·10	5·15	38·87
	Average ..	17·5	14·81	14·2	11·07	3·74	25·25
Co 313	Nawabganj	17·8	15·14	13·2	9·88	5·26	34·74
	Semapur zirat	17·1	14·37	12·6	9·16	5·21	36·26
	Nayatola	18·5	15·90	14·3	11·18	4·72	29·68
	Lava	19·1	16·54	16·5	13·70	2·84	17·17
	Kantakush	17·1	14·37	15·2	12·23	2·14	14·89
	Mednipur	19·2	16·65	16·7	13·92	2·73	16·39
	Marangi	18·5	15·90	16·5	13·70	2·20	13·84
	Kumaripur	17·4	14·70	15·6	12·68	2·02	13·74
	Purnea Farm	19·5	16·96	17·8	15·14	1·82	10·73
	Harprasad	16·8	14·04	13·9	10·71	3·33	23·72
	Average ..	17·9	15·25	15·20	12·23	3·02	19·80
Co 513	Semapur zirat	17·9	15·25	13·4	10·12	5·13	33·64
B.O. 4	Semapur zirat	17·9	15·25	12·3	8·80	6·45	42·30
POJ 2878	Semapur zirat	17·3	14·59	12·6	9·16	5·43	37·22
Co 299	Semapur zirat	17·2	14·48	11·2	7·45	7·03	48·55
	Mangura	17·4	14·70	12·7	9·28	5·42	36·87
Co 421	Purnea Farm	19·6	17·07	15·9	13·03	4·04	23·73
Co 331	Purnea farm	19·3	16·75	14·6	11·53	5·22	31·16

that the sucrose percentage in the juice of healthy canes of Co 213 was reduced on an average by 3·74 units due to the attack of this pest. The variation in the reduction of sucrose percentage ranged from 1·82 to 7·03 units. The average reduction in all the localities (3·74) when worked out on the basis of the sucrose percentage of pest-free juice came to be 25·25% in the area as a whole. In Co 313 the reduction varied from 1·82 to 5·26 with an average of 3·02 and percentage loss of 19·80. This pest thus constitutes a serious menace to the industry as it appears and damages the crop at a time when it is entering its maturation phase.

X. BIOLOGY

Adult (Plate VI, Figs. 6 and 7).—In September-October, freshly emerged moths from the field-collected pupæ copulated one day after their emergence and the females laid 3–4 egg clusters on the same day. The emergence of moths generally took place either between 5 P.M. and midnight or from 4 A.M. to 8 A.M. Under laboratory conditions, the copulation took on an average 45 minutes. Wing expanse of male and female were 21–26 mm. and 28–31 mm. respectively. The percentage of successful rearing from field collected larvæ upto adult stage was very low (6% only).

Egg (Plate VI, Figs. 1 *a* and 1 *b*).—Egg-masses consist of 3–4 rows of overlapping eggs, like the tiles of a roof. Eggs are flattened and whitish in colour when fresh. Next day, a blackish streak appears which deepens in colour and becomes prominent on the 4th day. It becomes very conspicuous on the 6th day and disappears on the 7th day, when a broad black spot develops which demarcates the head of the developing embryo. Each egg measures on an average 0·5 mm. in diameter. Most of the eggs, during the first fortnight of October, hatched after 8 days. The hatching usually took place in the morning hours and continued for 2–3 days in the same cluster. The incubation period varied from 8–11 days.

Larva (Plate VI, Figs. 2, 3 and 4).—Unlike the larvæ of other stem borers, the freshly hatched larvæ of this species are gregarious in habit and are very sluggish and inactive in movements. After hatching, they remain assembled in groups of 20–30 for a few hours, feeding upon the leaf surface and move away slowly towards the base of the leaf-lamina till they reach the inner portion of the leaf sheath and enter the central stalk from the side. They often come out, re-enter the other internodes and bore into the core of the stem making it almost hollow, in serious cases as shown in Plate V. The newly hatched larva is very hairy and presents a deep grey general appearance with a broad brown head, deeper in colour than the rest of the body. It measures on an average 1·5 mm.×0·5 mm. Four indistinct rows

of blackish spots or warts run longitudinally on the body almost parallel to one another. As the larva grows, these warts grow deeper in tinge and broader in size, making the rows very prominent. A full-grown larva measures on an average 25–27 mm.×2–3 mm. The spiracles (Plate VI, Fig. 11) are open with a clear space in the centre and a black rim all round. The larvæ undergo 5–6 moults before pupation. During October and November the 1st, 2nd and 3rd moults were shed, each after a lapse of 3-5 days, whereas the 4th and the 5th moults were shed after a lapse of 2–3 weeks or even longer. The full ground larvæ hibernated during December to January, pupating in the first fortnight of February, when it resumed its activity. Some of the larvæ did not become active even upto March and died. The larval period varied from 61–121 days.

The larvæ exhibit a marked variation in their forms as reported earlier by Fletcher and Ghosh (*loc. cit*). These variations might be due to the climatic variations and have been observed to be exhibited by almost all the larvæ during the course of their development under laboratory and natural conditions. There are four different types of variations (Plate VI A). In one type, all the four longitudical stripes are distinct and pinkish-brown in colour resembling closely *Chilo zonellus* and *Chilotræa auricilia.* This form was collected in 1953–54 from Kishanganj area. The second type, which is the most common one, has the stripes very indistinct but the warts are prominent. These warts are brown in colour arranged in parallel rows on the indistinct stripes. Such a form has also been observed in the larvæ of *Chilo zonellus*, but the colour of the warts in the case of the latter is pinkish-brown. This form was collected from Purnea in 1953–54 and Sakri area in 1954–55. The third type has both warts as well as stripes indistinct. The proportion of this form is much less. The fourth type, as described by Fletcher and Ghosh (*loc. cit.*), possesses dark shining warts on the stripes, but the observations recorded by the present authors show that the stripes are arranged in the form of lateral brackets on each segment and are provided with minute warts on them. Such type of forms are the ones provided with deep brown-coloured warts are either parasitised or are those of the hibernating larvæ which never pupate but die away ultimately. The larvæ of *Chilo tumidicostalis* can be distinguished by the presence of open spiracles and triordinala crochets on the prolegs arranged in a complete circle (Plate VI, Fig. 10). The chætotoxy of the full-grown larvæ (Plate VI, Fig. 8) is more or less similar to that of *Chilo zonellus* as described by Trehan and Butani (1950).

Pupa (Plate VI, Figs. 5, 9 *a* and 9 *b*).—Freshly formed pupa is light-brown in colour, becoming darker after 4–5 days. The male and the female

XII. Discussion

Chilo tumidicostalis—a serious pest of sugarcane had a limited distribution, being confined only to Bengal and Assam. When the Seemapur factory in Purnea District of Bihar was established in the early thirties and started getting part of its supplies from the adjoining areas of Bengal, this borer came along with them and in a matter of 3–4 years established itself in the sugar factory area. All sugarcane-growing villages in the district showed varying incidence of the pest as also damage to crop tonnage and quality of juice. Further its movement westward has been noticed in the northern parts of Bhagalpur, Monghyr and Darbhanga Districts. The magnitude of damage caused by this pest can be easily judged from the fact that it served as the chief cause of closure of the Seemapur factory in 1942. It is, therefore, a matter of importance to keep strict vigilance and check the spread of this pest by creating a buffer zone where no cane is cultivated as also to stop movement of cane not only from Bengal to Purnea but also from Purnea to the heavily concentrated cane districts of the Tirhut Division, where the burden of the sugar industry in Bihar lies. These strict domestic quarantine measures have helped to prevent its spread, but the cane crop in the district itself continues to suffer severely from its annual depredations. With the new factory coming up at Manihari in the district, need for controlling the pest has become paramount. Possibilities of utilising the larval parasite *Apanteles flavipes* in keeping the pest under control need to be explored. Further the egg parasite—*Trichogramma minutum* Riley has shown promising results and this together with the larval parasite should offer considerable relief.

XIII. Summary

1. *Chilo tumidicostalis* has been recorded as a serious pest of sugarcane in Purnea and adjoining parts of Bhagalpur, Monghyr and Darbhanga Districts.

2. Regular surveys were undertaken to study the distribution and intensity of this pest in Bihar. The incidence of the pest was studied on three bases, *viz.*, stalk, joint and length bored and relationship with edaphic and environmental conditions worked out besides also the relative resistance of varieties. Thus the pest was found to be more pronounced in heavy than light soils and under water-logged and flooded conditions than areas not subject to them. Similarly ratoons were more affected than the plant crop.

3. Of the varieties examined B.O. 10 was found to be most resistant and Co 421 the least. Varieties Co 513, Co 356 and B.O. 11 were more near B.O. 10 while Co 313, Co 331, Co 453 and Co 299 that of Co 421. It

appeared that solid-cored varieties were generally less affected compared to others that developed considerable pith and cavity.

4. In view of the gregarious habit of the borer the extent of damage caused both to cane tonnage and quality was considerable. Thus the loss in tonnage varied from 8·2–12·6% and that in sugar per cent. juice from 10·73–48·55%. Co 313 was the least damaged from this latter point of view.

5. The nature and characteristics of damage have been described in detail.

6. The biology of the pest has been studied under laboratory conditions and the different morphological characters have been described. The phenomenon of polymorphism has been observed to be well pronounced in the larvæ during the different seasonal conditions. The characters differentiating the pupæ of this borer from that of the other sugarcane moth borers have been detailed.

7. The biology of its larval parasite, *Apanteles flavipes* Cam., has also been studied under laboratory conditions. The marked difference observed in the case of antennæ of the male and the female parasite have been described and illustrated.

XIV. ACKNOWLEDGEMENTS

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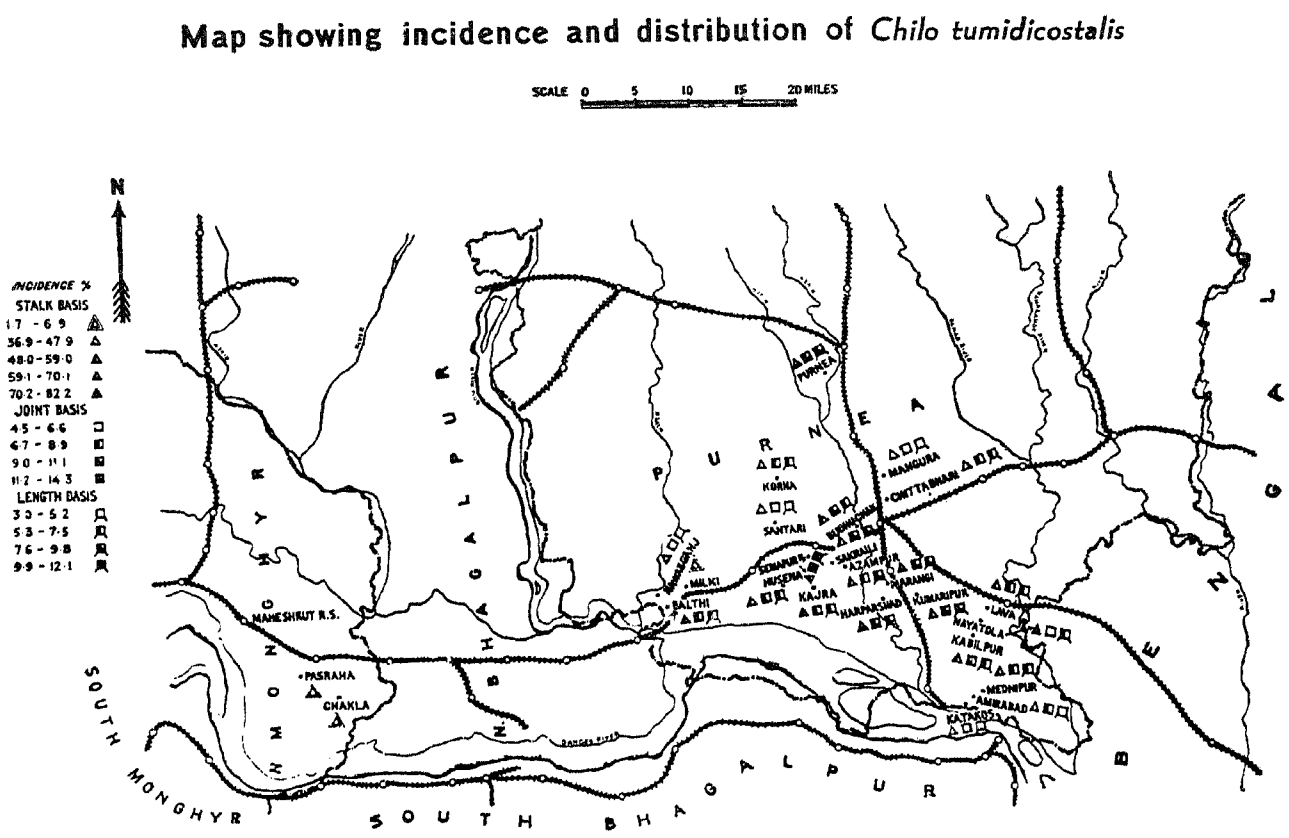


FIG. 1. North-East Bihar (1940).

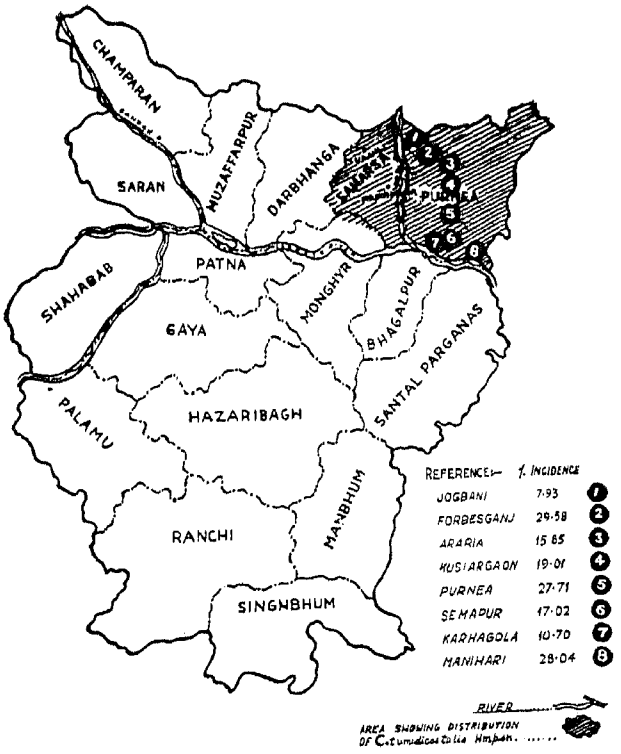
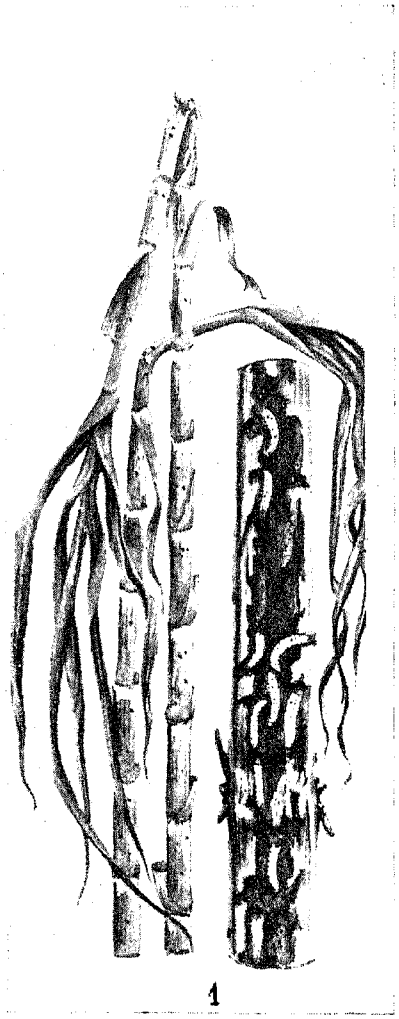


FIG. 2. Bihar (1953-54).



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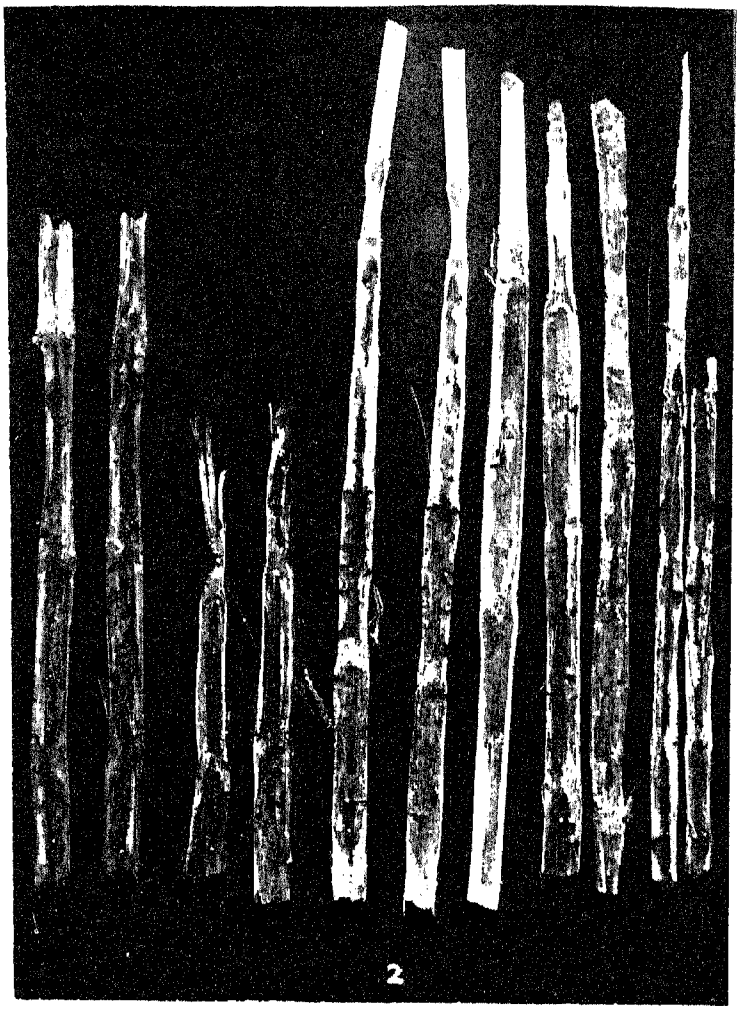

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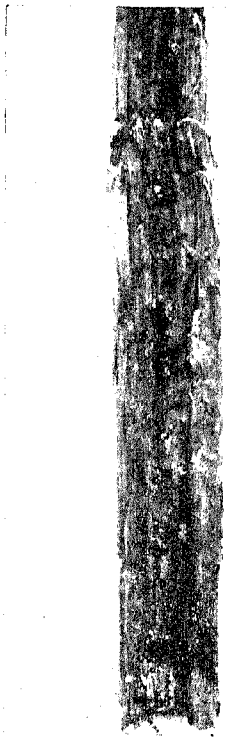

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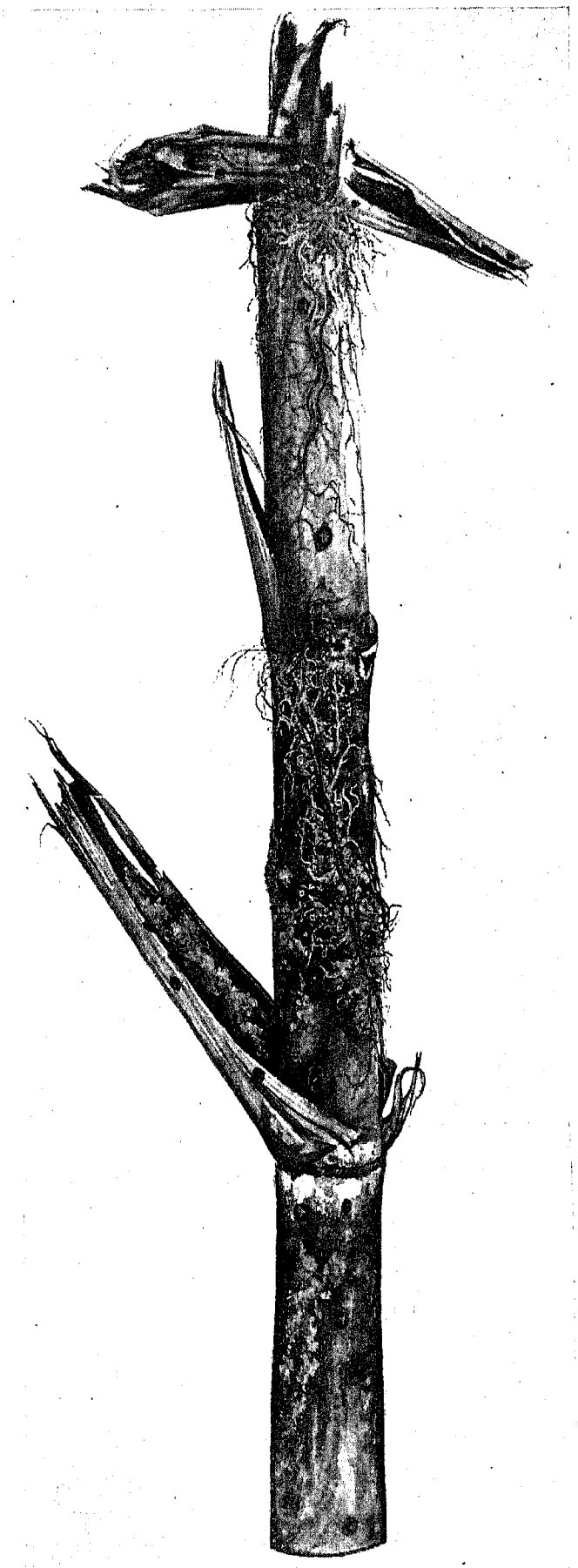

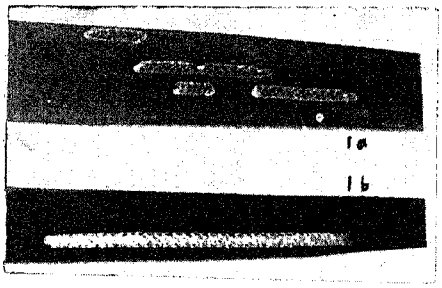
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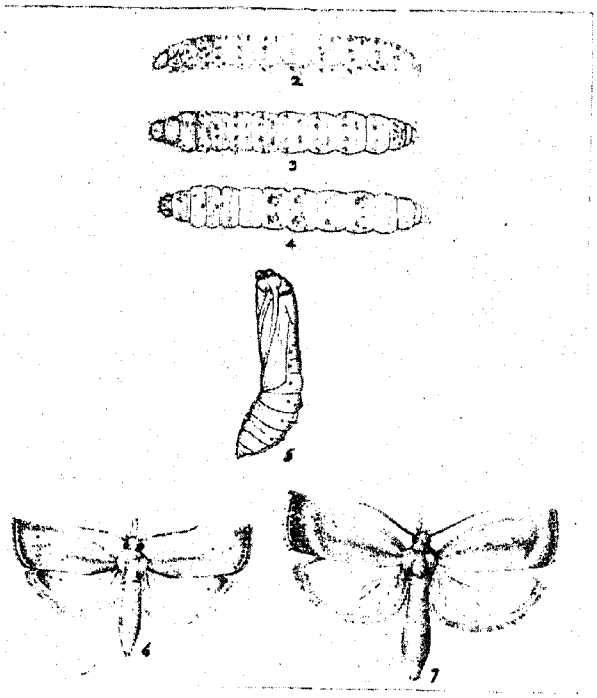
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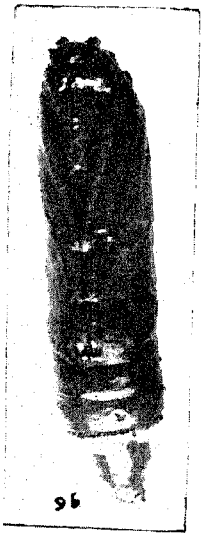
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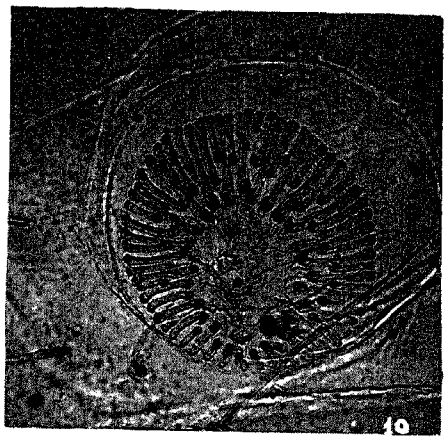
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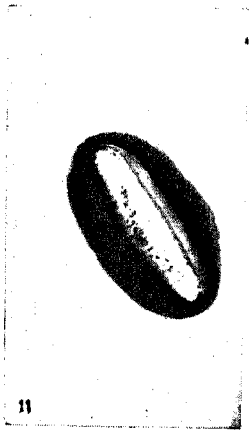
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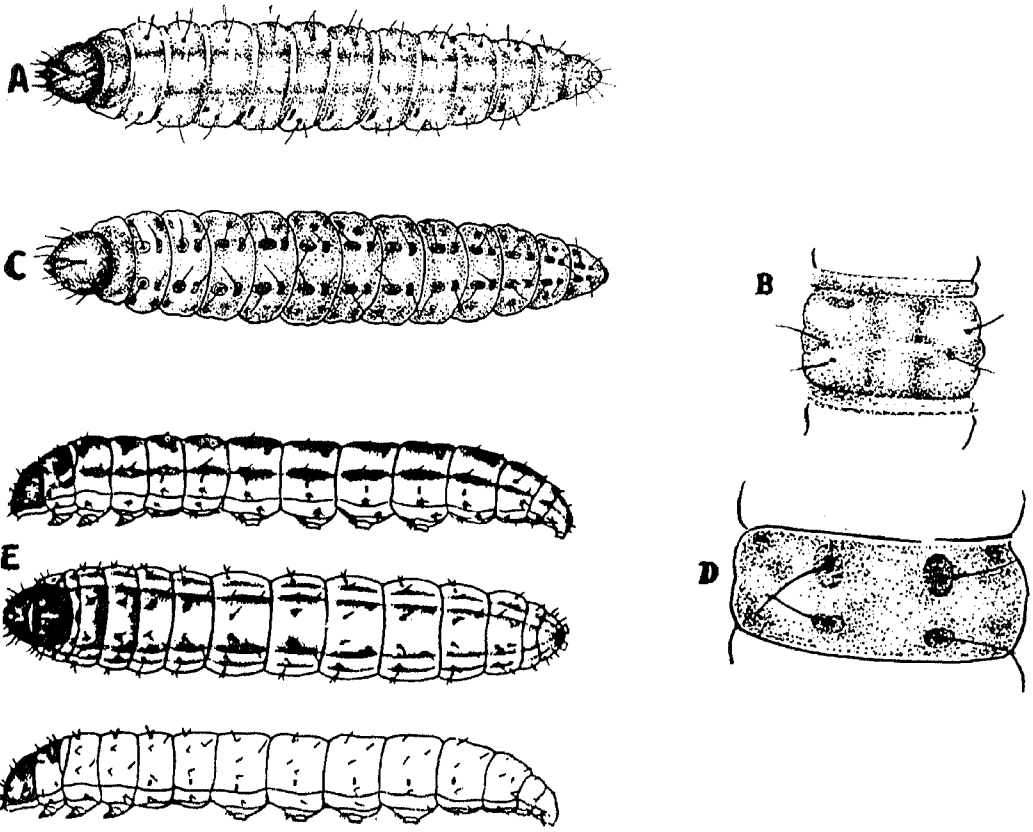
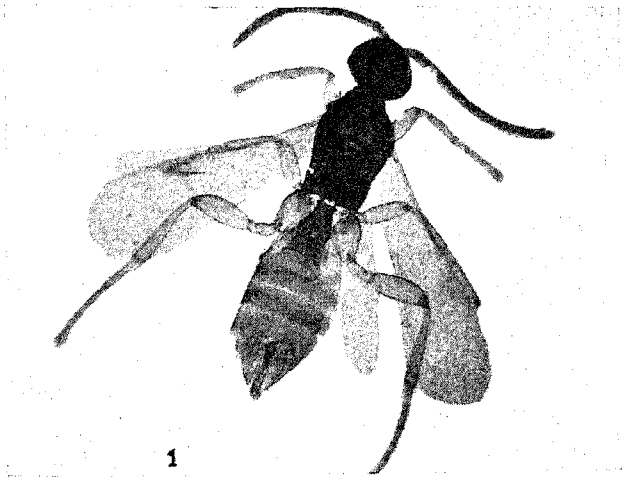
Chilo Tumidicostalis
(Polymorphism in Larvæ)





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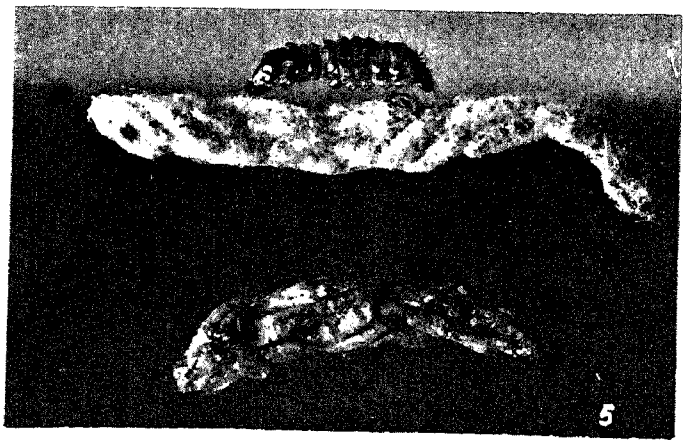

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6

Explanation of Plates

Plate IV

Maps showing Incidence and Distribution of the Pest

Fig. 1. North-East Bihar (1940). Fig. 2. Bihar (1953–54).

Plate V

Damage Caused by Chilo tumidicostalis

Fig. 1. Cane completely hollowed by the borer has broken down by wind. It also shows the number of holes made by the borers. A piece is cut open longitudinally, showing the number of larvae feeding inside.

Fig. 2. Various damaged canes split open longitudinally showing the ravages of the pest.

Figs. 3 and 4. Enlarged portions of the damaged cane, split open longitudinally, showing the typical symptoms of insect damage including the frass.

Plate V A

Cane stalk severely damaged by the borer showing numerous holes and also copious frass sticking to the stem as also deposited in between the stalk and leaf sheath.

Plate VI

Different Stages of Chilo tumidicostalis

Figs. 1 *a* and *b*. Egg masses.
Figs. 2, 3 and 4. Larvae.
Fig. 5. Pupa (lateral view).
Fig. 6. Adult moth, male.
Fig. 7. Adult moth, female.
Fig. 8. Chaetotoxy of larva.
Fig. 9 *a*. Female pupa (ventral view).
Fig. 9 *b*. Male pupa (ventral view).
Fig. 10. Crochets on the proleg of larva.
Fig. 11. Spiracle of larva.

Plate VI A

A = Larva showing Stripes.
B = Abdominal Segment showing Stripes.
C = Larva showing Warts.
D = Abdominal Segment showing Warts.
E = Larva showing Stripes and Warts Both.
F = Larva without Stripes or Warts.

Plate VII

Apanteles flavipes *Cam*., *A Larval Parasite of* C. tumidicostalis

Fig. 1. Adult female.
Fig. 2. Antenna of female.
Fig. 3. Adult male.
Fig. 4. Antenna of male.
Figs. 5 and 6. Cocoons of the parasite.

Plate VII A

Damaged cane piece split open longitudinally showing the white mass of cocoons of *Apanteles flavipes* lying in the larval tunnel near the host.