# DOSSIERS ON *CHILO* SPECIES AS PESTS OF SUGARCANE

## Genus *Chilo* Zincken

Larvae of all *Chilo* species are stemborers that attack gramineous plants. The genus *Chilo* contains 41 species, mainly distributed in the Ethiopian and Oriental Regions. Because many *Chilo* species are notorious pests of gramineous plants such as corn, sugarcane, rice, sorghum, millet and other staple crops, their world distribution has largely been affected by accidental introductions into new geographical areas.

The genus *Chilo* was erected by Zincken in 1817, and Bleszynski (1970) provided a comprehensive review of the taxonomy of the genus. Bleszynski (1970) considered that the interpretation of the genus has for a long time been confused, because the taxonomy was based on wing venation. However, many taxonomic problems have been solved when taxonomists used the genitalia of both sexes in classification, and this is an excellent character in separating species and sometimes genera of Crambinae (see also Dyar & Heinrich 1927).

### Taxonomy

The genus *Chilo* belongs to superfamily Pyraloidea, family Crambidae, subfamily Crambinae. Earlier references put *Chilo* under Pyralidae and Crambinae as a subfamily, whereas now the Crambidae is considered a family. Maes (1998) demonstrated that characters of the tympanal organs make an easy distinction between Pyralidae and Crambidae:

Tympanum and conjonctivum lying along the same plane, not making a clear angle (Fig. 1) ..... ..... Pyralidae: Phycitinae and Galleriinae
Tympanum and conjonctivum making a clear angle, not lying along the same plane (Fig. 1) ..... ..... Crambidae: Crambinae and Schoenobiinae

The taxonomical history of the genus *Chilo*, based on Bleszynski (1970), is:

*Chilo* Zincken, 1817:23; Fernald, 1896: 77; Hampson, 1896: 954 [in part]; Kapur, 1950: 394; Okano, 1950: 122; Bleszynski, 1965: 98; Bleszynski, 1965: 102; Bleszynski, 1966: 478; Bleszynski, 1969: 12. Type species: [*Tinea*] *phragmitella* Hübner, [1805] [selected by Duponchel, 1836: 9].

*Diphryx* Grote, 1822:273. Type species: *Diphryx prolaella* Grote, 1882, by monotypy [syn. Hampson, 1896a: 954].

*Proceras* Bojer, 1856: (not paginated); Tams, 1942: 67, 410; Bleszynski, 1965: 122. Type species: *Proceras sacchariphagus* Bojer, 1856, by monotypy [syn. Bleszynski, 1966:477].

*Borer* Guenée in Maillard, 1862. Type species: *Borer saccharallus* Guenée, 1862, by monotypy [syn. Tams, 1942:67].

*Nephalia* Turner, 1911:113. Type species: *Nephalia crypsimetalla* Turner, 1911, by monotypy [syn. Bleszynski, 1966: 478].

*Hypiesta* Hampson, 1919: 538. Type species: *Hypiesta argyrogramma* Hampson, 1919, by monotypy [syn. Bleszynski, 1966: 478].

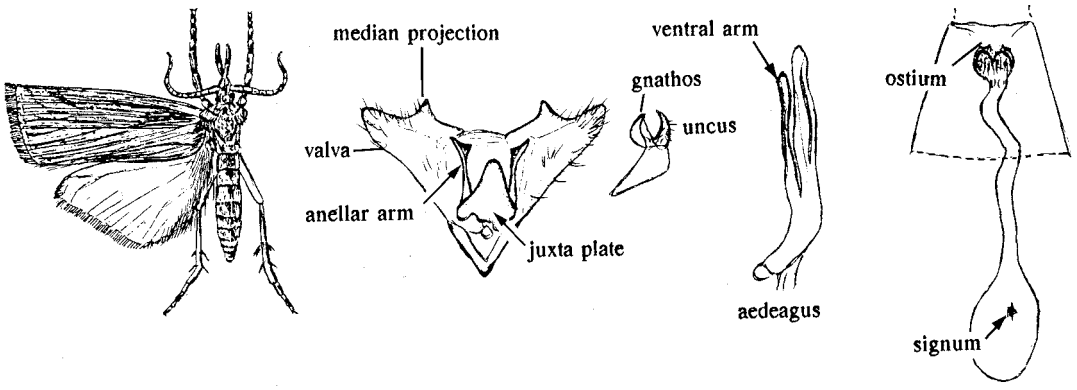
*Silveria* Dyar, 1925: 10. Type species: *Silveria hexhex* Dyar, 1925, by original designation [syn. Bleszynski, 1962*b*: 108].

*Diatraenopsis* Dyar & Heinrich, 1927: 39[in part].

*Silveria* Dyar: Dyar & Heinrich, 1927: 31.

*Chilotraea* Kapur, 1950: 402. Type species: *Chilo infuscatellus* Snellen, 1890, by original designation [syn. Bleszynski, 1962a: 1].

Bleszynski (1970) provides the following key for the identification of *Chilo* species. Many characters are those of the genitalia; they are shown in the following figure:




| | | |
|---|---|---|
| 1 | Fore wing with R1 free | 2 |
| - | Fore wing with R1 coincident with Sc | 36 |
| 2(1) | Face conical with distinct point | 3 |
| - | Face rounded without point | 23 |
| 3(2) | Face with distinct ventral ridge | 4 |
| - | Face with vestigial ridge or ventral ridge absent | 15 |
| 4(3) | Males | 5 |
| - | Females | 10 |
| 5(4) | Aedeagus with ventral arm | 6 |
| - | Aedeagus without ventral arm | 9 |
| 6(5) | Costa of valva with strong median projection | 15 |
| - | Costa of valva without distinct median projection | 7 |
| 7(6) | Arms of juxta-plate not swollen | 8 |
| - | Arms of juxta-plate distinctly swollen (Fig. 18) | *suppressalis* |
| 8(7) | Juxta-plate as in Fig. 19 | *hyrax* |
| - | Juxta-plate as in Fig. 23 | *christophi* |
| 9(5) | Arms of juxta-plate distinctly unequal in length (Fig. 13) | *phragmitellus* |
| - | Arms of juxta-plate almost equal in length (Fig. 14) | *luteellus* |
| 10(4) | Signum absent (except of area of scobinations) | 11 |
| - | Signum present | 12 |
| 11(10) | Ductus bursae with distinct swelling (Fig. 16) | *luteellus* |
| - | Ductus bursae without distinct swelling (Fig. 15) | *phragmitellus* |
| 12(10) | Signum elongate | 13 |
| - | Signum lamellate, rectangular or almost rectangular | 15 |
| 13(12) | Ductus bursae twisted at ostial pouch | 14 |
| - | Ductus bursae not twisted at ostial pouch | 15 |
| 14(13) | Ostial pouch large (Fig. 21) | *christophi* |
| - | Ostial pouch small, slightly demarcated | *suppressalis* |
| 15(3,6, - 12,13) | Fore wing with at least a few metallic scales | *erianthalis* |
| | Fore wing without metallic scales | 16 |
| 16(15) | Fore wing with small discal dot, or discal dot absent | 17 |
| - | Fore wing with very distinct, large discal dot. Male unknown | *tamsi* |
| 17(16) | Males | 18 |
| - | Females | 21 |
| 18(17) | Aedeagus with bulbose basal projection | 19 |
| - | Aedeagus without bulbose basal projection | *tumidicostalis* |
| 19(18) | Costa with strong median projection (Fig. 26) | *partellus* |
| - | Costa without strong median projection | 20 |
| 20(19) | Arms of juxta-plate very long, ventral arm of aedeagus very long (Fig. 24). Female unknown | *vergilius* |
| - | Arms of juxta-plate moderately long, ventral arm of aedeagus rather short (Fig. 108) | *demotellus* |
| 21(17) | Signum present (Fig. 28) | *partellus* |
| - | Signum absent | 22 |

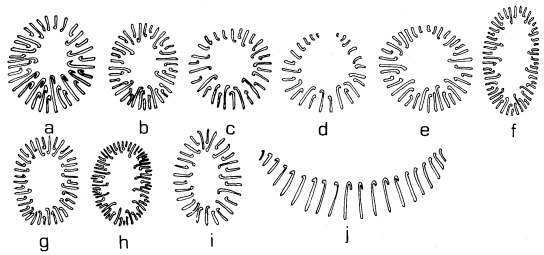
22(21) Indian species. Genitalia as in Fig. 36 ..... *tumidicostalis*
- North American species. Genitalia as in Fig. 110 ..... *demotellus*
23(2) Fore wing with at least a few metallic scales ..... 24
- Fore wing without metallic scales ..... 29
24(23) Males ..... 25
- Females ..... 27
25(24, Aedeagus with ventral arm ..... 26
- 40) Aedeagus without ventral arm (Fig. 37) ..... *ceylonicus*
26(25) Aedeagus with cornuti; juxta-plate with median long projection (Fig. 72). Ethiopian species ..... ..... *mesoplagalis*
- Aedeagus without cornuti; juxta-plate without median projection (Fig. 109). North American species ..... *plejadellus*
27(24) Signum much elongate (Fig. 111) ..... *plejadellus*
- Signum not elongate ..... 28
28(27) Oriental species. Costa of fore wing not edged with brown. Genitalia as in Fig. 41 ..... *ceylonicus*
- Ethiopian species. Costa of fore wing distinctly darkened with brown. Genitalia as in Fig. 78 ..... ..... *mesoplagalis*
29(23) Face slightly conical ..... *tumidicostalis*
- Face rounded ..... 30
30(29) Males ..... 31
- Females ..... 34
31(30) Cornuti in aedeagus absent (Fig. 25) ..... *pulverosellus*
- Cornuti in aedeagus present ..... 32
32(31) Aedeagus with bulbose basal projection (Fig. 55) ..... *agamemnon*
- Aedeagus without bulbose basal projection ..... 33
33(32) Arms of juxta-plate almost equal in length (Fig. 66) ..... *luniferalis*
- Arms of juxta-plate distinctly not equal in length, right arm much longer than valva (Fig. 67) ..... ..... *perfusalis*
34(30) Ductus bursae with projection near ostial pouch (Fig. 55) ..... *agamemnon*
- Ductus bursae without projection near ostial pouch ..... 35
35(34) Ductus bursae entirely lightly sclerotized (Fig. 22) ..... *pulverosellus*
- Ductus bursae partly heavily sclerotized (Figs 68-71) ..... *luniferalis* and *perfusalis*
36(1) Fore wing with metallic scales ..... 37
- Fore wing without metallic scales ..... 63
37(36) Neotropical species. Genitalia as in Figs 114-118 ..... *chiriquitensis*
- Old world species ..... 38
38(37) Oriental and Australian species ..... 39
- Ethiopian species ..... 51
39(38) Males ..... 40
- Females ..... 45
40(39) Juxta-plate symmetrical ..... 41
- Juxta-plate asymmetrical ..... 25
41(40) Aedeagus with ventral arm ..... 42
- Aedeagus without ventral arm ..... 44
42(41) Ventral arm of aedeagus notched ..... 43
- Ventral arm of aedeagus without notch (Fig. 31) ..... *pulveratus*
43(42, Pars basalis absent; notch of juxta-plate small (Fig. 38) ..... *auricilius*
- 70) Pars basalis present; notch of juxta-plate very deep (Fig. 46) ..... *polychrysus*
44(41) Arms of juxta-plate long; cornuti absent (Fig. 33) ..... *bandra*
- Arms of juxta-plate very short; cornuti present (Fig. 39) ..... *crypsimetallus*
45(39) Signum present ..... 46
- Signum absent ..... 48
46(45) One signum ..... 47
- Two signa (Fig. 34) ..... *pulveratus*
47(46) Signum very distinct, lamellate (Figs 40-42) ..... *ceylonicus*
- Signum weak ..... 48

48(45, - 47) Genitalia as in Fig. 35 ..... *bandra*
Genitalia as in Figs 43-45, 52 ..... 49
49(48) Genitalia as in Fig. 43. Signum present or absent ..... *auricilius*
- Genitalia as in Figs 44-45, 52. Signum absent ..... 50
50(49) Genitalia as in Figs 44-45 ..... *crypsimetallus*
- Genitalia as in Fig. 52 ..... *polychrysus*
51(38) Males ..... 52
- Females ..... 57
52(51) Cornuti very distinct, medium-sized (Figs 72, 74, 80-81) ..... 53
- Cornuti small (Figs 85-90, 94-96) ..... 55
53(52) Aedeagus with bulbose basal projection (Fig. 74) ..... *argyrogrammus*
- Aedeagus without bulbose basal projection ..... 54
54(53) Ventral arm of aedeagus very short (Fig. 72) ..... *costifusalis*
- Ventral arm of aedeagus very long (Figs 80-81) ..... *argyropastus*
55(52) Valva broad, slightly tapering (Figs 85-87) ..... *orichalcociliellus*
- Valva distinctly tapering caudad (Figs 88-90, 94-96) ..... 56
56(57) Arms of juxta-plate equal in length, or right arm at most three-quarters of length of left arm (Figs 88-90) ..... *aleniellus*
- Right arm of juxta-plate much shorter than left arm (Figs 94-96) ..... *thyrsis* and *quirimbellus*
57(51) One signum ..... 58
- Two signa (Figs 75-77) ..... *costifusalis*
58(57) Ductus bursae very short (Figs 82-83) ..... 59
- Ductus bursae very long (Figs 91-93, 97-99) ..... 60
59(58) Signum rounded (Fig. 82) ..... *argyropastus*
- Signum elongate, with slight median ridge (Fig. 83) ..... *argyrogrammus*
60(58) Seventh sternum with short spined plate and two almost triangular spined patches (Figs 91, 100) . ..... *orichalcociliellus*
- Triangle spined patches absent ..... 61
61(60) Ostial pouch with two distinct, heavily sclerotized rings (Figs 98, 107) ..... *quirimbellus*
- Ostial pouch with only one heavily sclerotized ring (Figs 92-93, 97, 99, 101-106) ..... 62
62(61) Ostial opening very small (Figs 92-93, 101-102) ..... *aleniellus*
- Ostial opening large (Figs 97, 99, 103-105) ..... *thyrsis* and *zoriandellus*
63(36) Ocellus reduced ..... *sacchariphagus*
- Ocellus well developed ..... 64
64(63) Males ..... 65
- Females ..... 73
65(64) Aedeagus with one big cornutus (Fig. 27) ..... *infuscatellus*
- Aedeagus without big cornutus ..... 66
66(65) Aedeagus with ventral arm ..... 67
- Aedeagus without ventral arm ..... 72
67(66) Ventral arm of aedeagus very short ..... 68
- Ventral arm of aedeagus long ..... 69
68(67) Arms of juxta-plate equal in length, very thin (Fig. 79) ..... *mercatorius*
- Arms of juxta-plate not equal in length (Fig. 56) ..... *diffusilineus*
69(67) Ventral arm of aedeagus broad with very deep notch ..... 70
- Ventral arm of aedeagus narrow, without notch ..... 71
70(69) Basal margin of main part of ventral arm of aedeagus almost perpendicular to stem of ventral arm (Figs 50-51). Fore wing without distinct, light, longitudinal lines ..... *terrenellus*
- Basal part of main part of ventral arm of aedeagus distinctly oblique (Figs 48-49). Fore wing with several light, longitudinal lines (Fig. 2) ..... *louisiadalis*
71(69) Ventral arm of aedeagus very long (Fig. 65) ..... *psammathis*
- Ventral arm of aedeagus rather short ..... 43
72(66) Pars basalis present; arm of juxta-plate short (Fig. 39) ..... *crypsimetallus*
- Pars basalis absent; arms of juxta-plate very long (Fig. 57) ..... *zacconius*
73(64) Signum present ..... 74
- Signum absent ..... 76

| | | |
|---|---|---|
| 74(73) | One signum | 75 |
| - | Two signa | *pulveratus* |
| 75(74) | Ostial pouch distinctly incised (Fig. 30) | *infuscatellus* |
| - | Ostial pouch not incised (Fig. 77) | *psammathis* |
| 76(73) | Ostial pouch with heavily sclerotized projection in ductus bursae (Figs 59-61) | *diffusilineus* |
| - | Ostial pouch without heavily sclerotized projection into ductus bursae | 77 |
| 77(76) | Ostial pouch with lightly sclerotized projection (Fig. 62) | *zacconius* |
| - | Ostial pouch without lightly sclerotized projection | 78 |
| 78(77) | Ostial pouch very distinctly demarcated (Fig. 63) | *incertus* |
| - | Ostial pouch not distinctly demarcated | 79 |
| 79(78) | Termen of fore wing distinctly oblique | *crypsimetallus* |
| - | Termen of fore wing slightly oblique | 80 |
| 80(79) | Fore wing with several light, longitudinal lines (Fig. 4) | *louisiadalis* |
| - | Fore wing without longitudinal light lines (Fig. 3) | *terrenellus* |

**Larvae**

Larvae can be distinguished from those of other genera infesting sugarcane by the arrangement of the crotchets:




**Arrangement of abdominal crochets: a-d, *Chilo* spp.; e, *Coniesta ignefusalis*; f, *Eldana saccharina*; g-h, *Maliarpha separatella*; i, *Scirpophaga* sp.; j, *Sesamia calamistis* (Meijerman & Ulenberg 1996, 1998).**

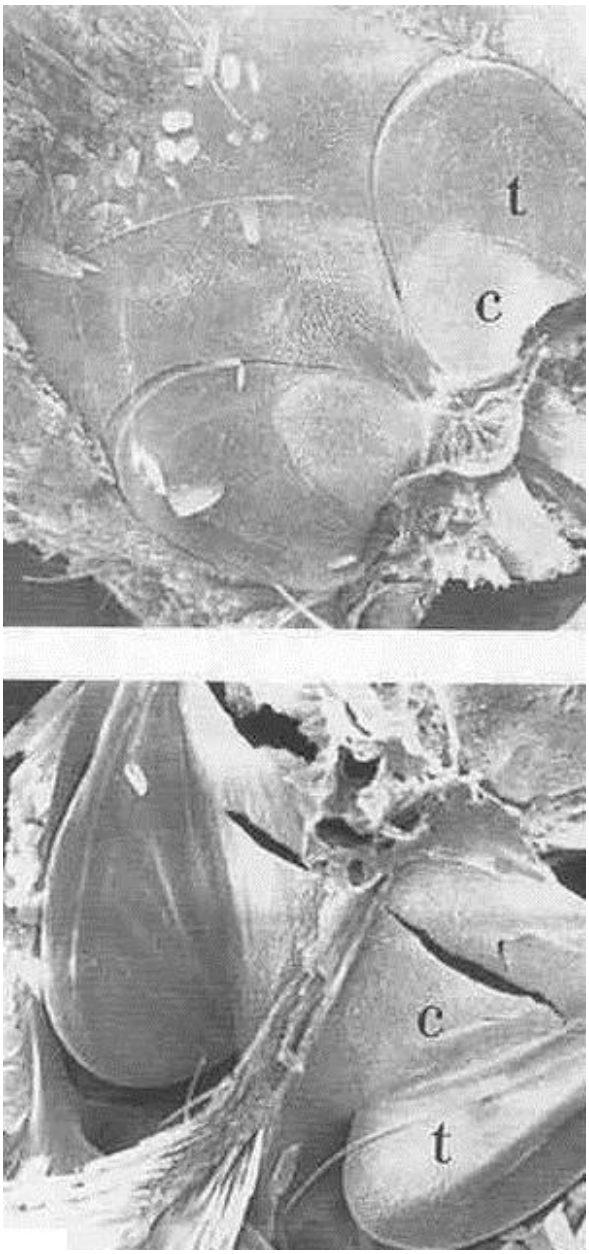
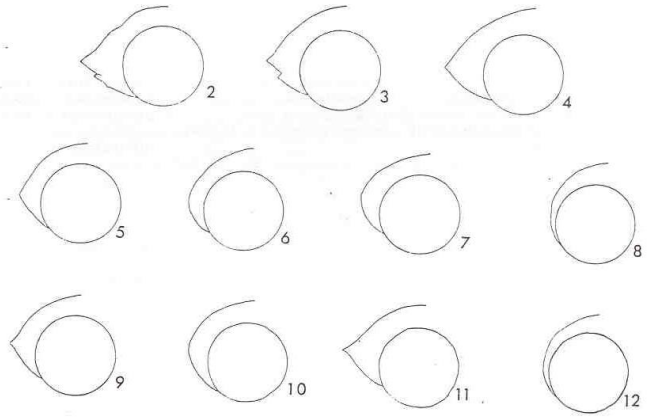
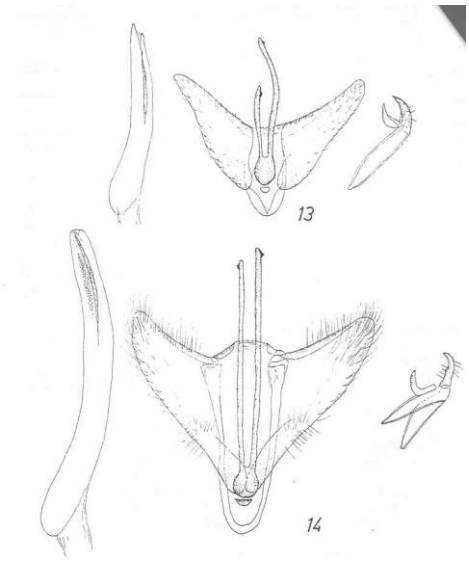


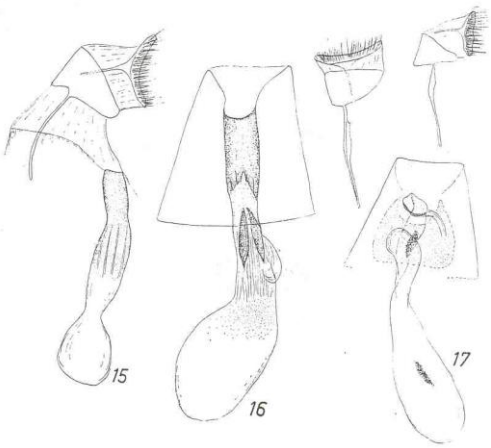

**Fig. 1.** Tympanal organs in Pyraloidae. (Upper) *Eldana saccharina* (Pyralidae: Galleriinae). (Lower) *Chilo* sp. (Crambidae: Crambinae). t = tympanum; c = conjonctivum (Maes 1998).



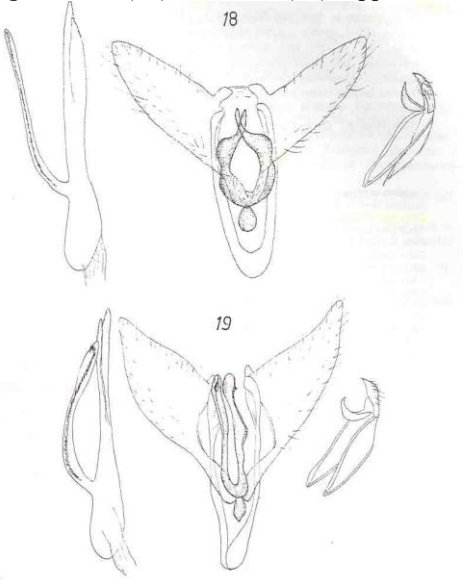

**Figs 2-12**. *Chilo* faces: (2) *phragmitellus;* (3) *suppressalis;* (4) *partellus;* (5) *tumidicostalis;* (6) *infuscatellus;* (7) *pulveratus;* (8) *agamemnon;* (9) *orichalcociliellus;* (10) *aleniellus;* (11) *plejadellus;* (12) *sacchariphagus*.



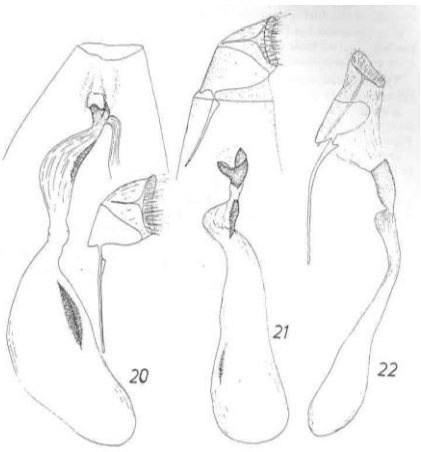

**Figs 13-14.** *Chilo* male genitalia: (13) *phragmitellus*; (14) *luteellus.*



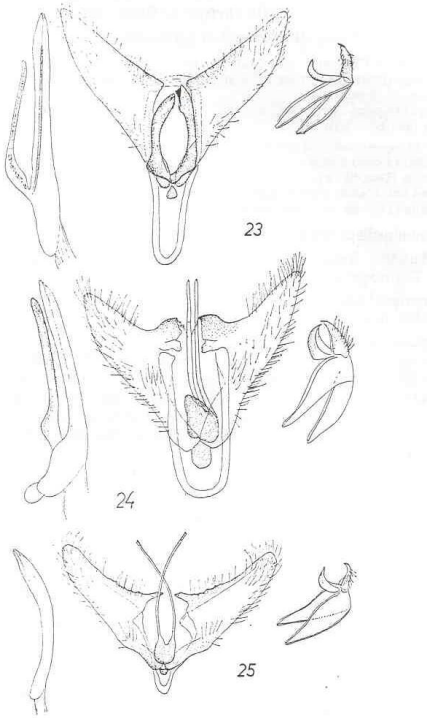

**Figs 15-17.** *Chilo* female genitalia: (15) *phragmitellus;* (16) *luteellus;* (17) *suppressalis*.



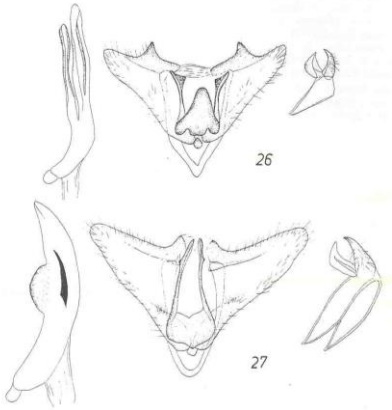

**Figs 18-19.** *Chilo* male genitalia: (18) *suppressalis*; (19) *hyrax*.



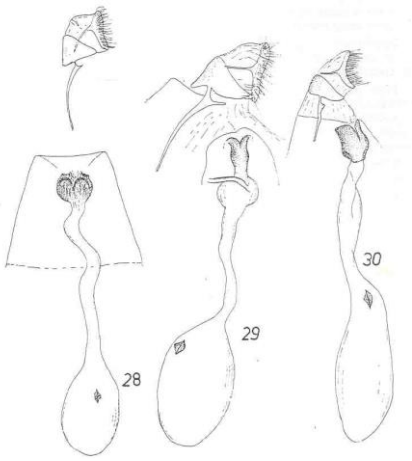

**Figs 20-22.** *Chilo* female genitalia: (20) *hyrax*; (21) *christophi*; (22) *pulverosellus*.



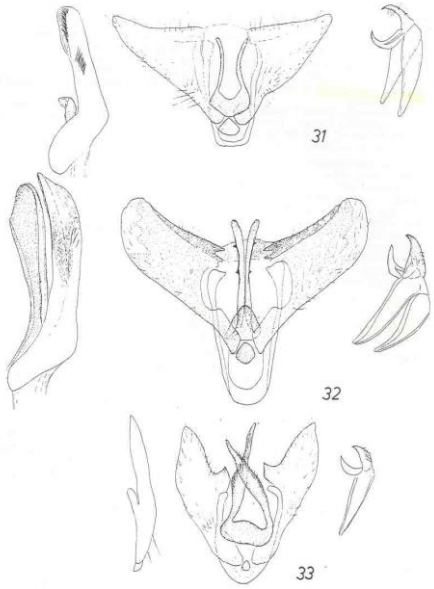

**Figs 23-25.** *Chilo* male genitalia: (23) *christophi*; (24) *vergilius*; (25) *pulverosellus.*



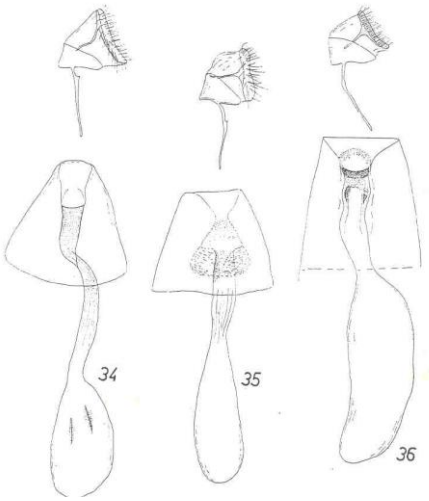

**Figs 26-27.** *Chilo* male genitalia: (26) *partellus*; (27) *infuscatellus*.



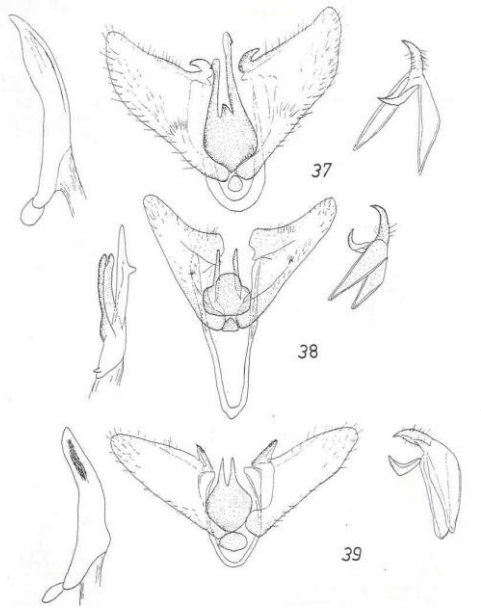

**Figs 28-30.** *Chilo* female genitalia: (28) *partellus*; (29) *tamsi*; (30) *infuscatellus.*



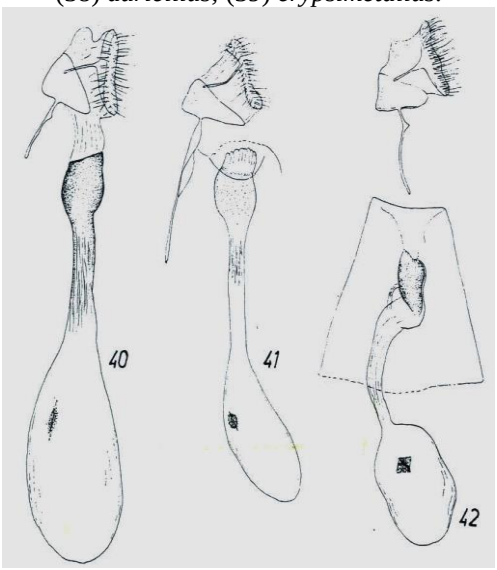

**Figs 31-33.** *Chilo* male genitalia: (31) *pulveratus*; (32) *tumidicostalis*; (33) *bandra.*



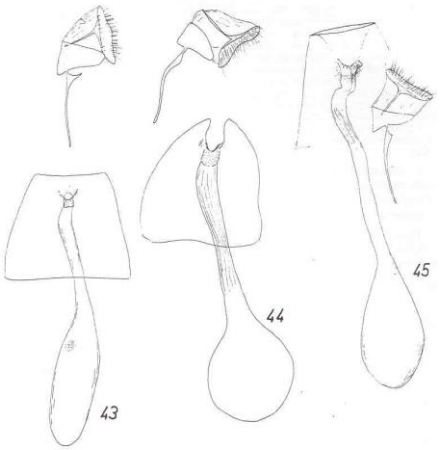

**Figs 34-36.** *Chilo* female genitalia: (34) *pulveratus*; (35) *bandra*; (36) *tumidicostalis.*



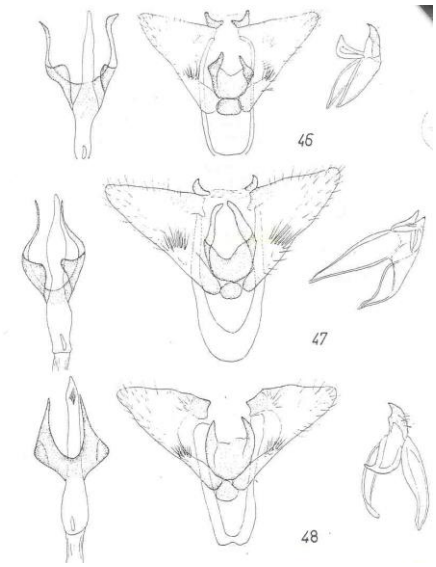

**Figs 37-39.** *Chilo* male genitalia: (37) *ceylonicus*; (38) *auricilius*; (39) *crypsimetallus*.



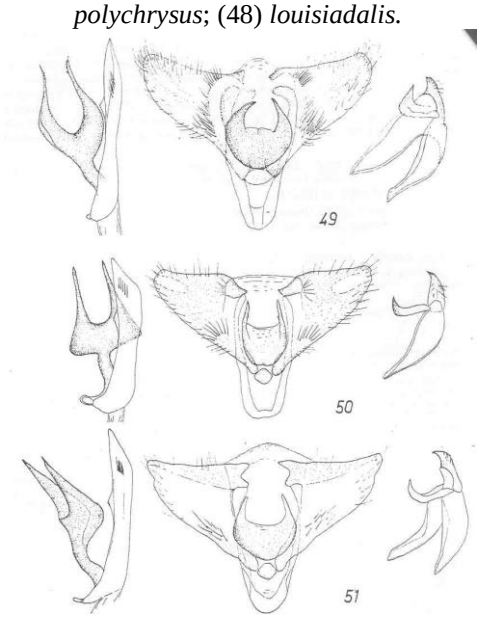

**Figs 40-42.** *Chilo ceylonicus* female genitalia.



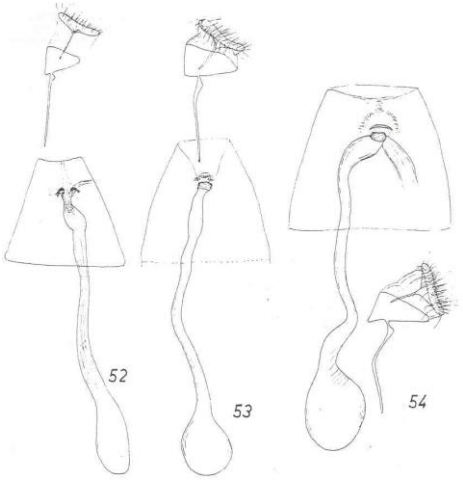

**Figs 43-45.** *Chilo* female genitalia: (43) *auricilius*; (44) *crypsimetallus*; (45) ? *crypsimetallus.*



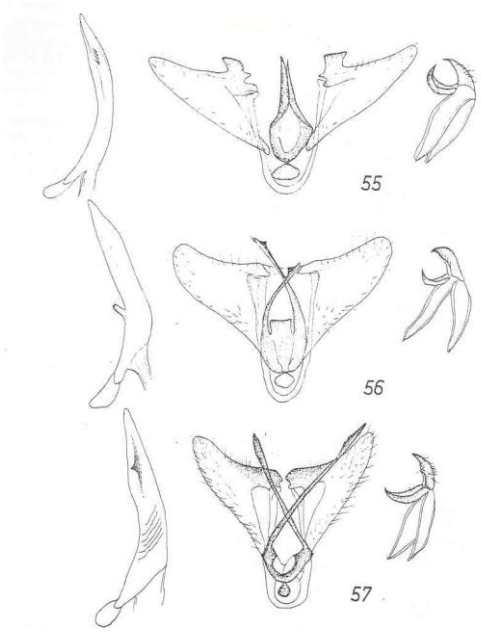

**Figs 46-48.** *Chilo* male genitalia: (46-47) *polychrysus*; (48) *louisiadalis.*



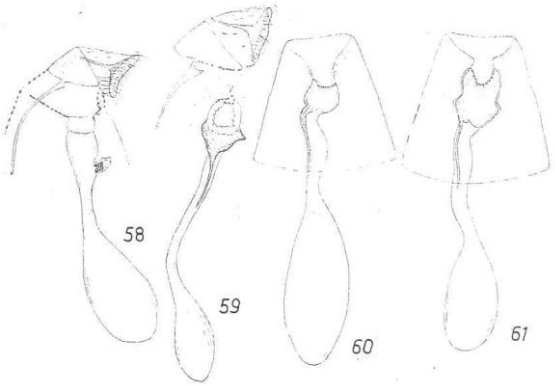

**Figs 49-51**. *Chilo* male genitalia: (49) *louisiadalis*; (50-51) *terrenellus.*



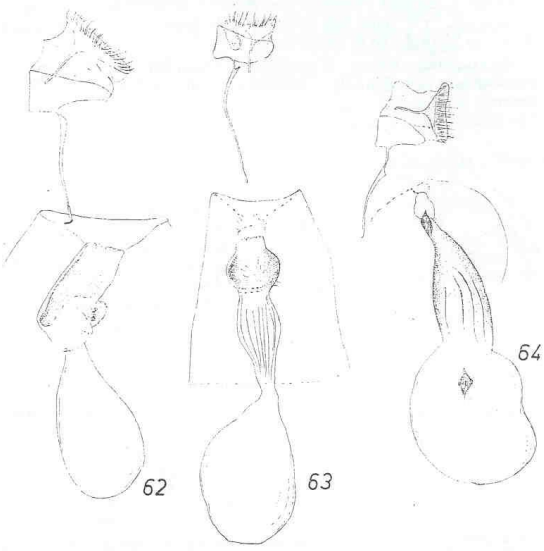

**Figs 52-54.** *Chilo* female genitalia: (52) *polychrysus*; (53) *louisiadalis*; (54) *terrenellus.*



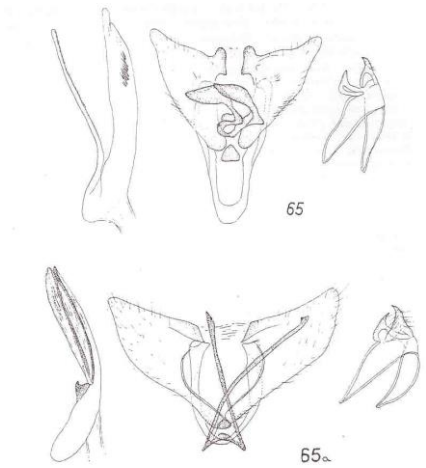

**Figs 55-57.** *Chilo* male genitalia: (55) *agamemnon*; (56) *diffusilineus*; (57) *zacconius.*



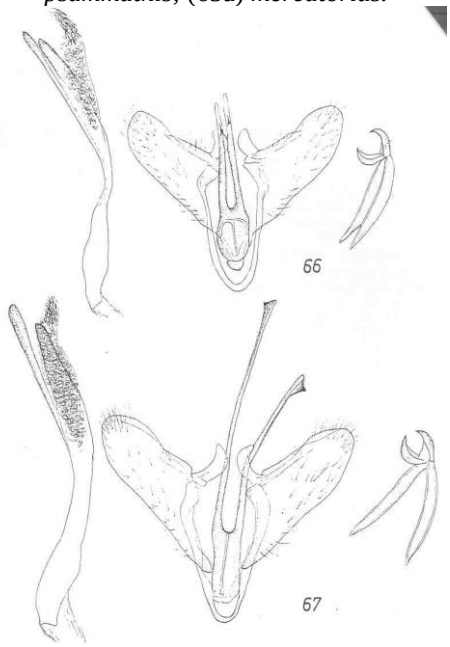

**Figs 58-61.** *Chilo* female genitalia: (58) *agamemnon*; (59-61) *diffusilineus.*



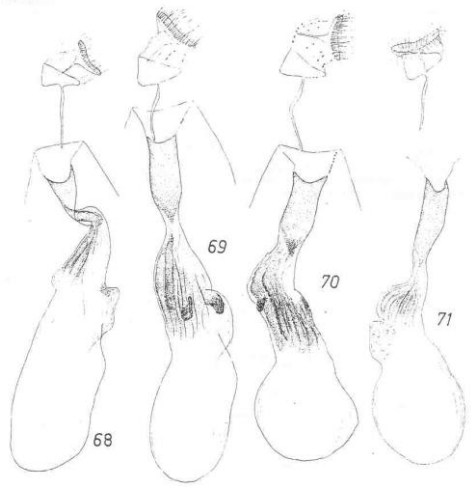

**Figs 62-64.** *Chilo* female genitalia: (62) *zacconius*; (63) *incertus*; (64) *psammathis.*



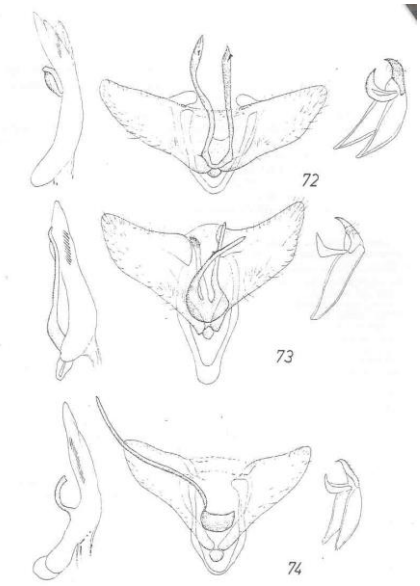

**Figs 65-65a.** *Chilo* male genitalia: (65) *psammathis*; (65a) *mercatorius.*



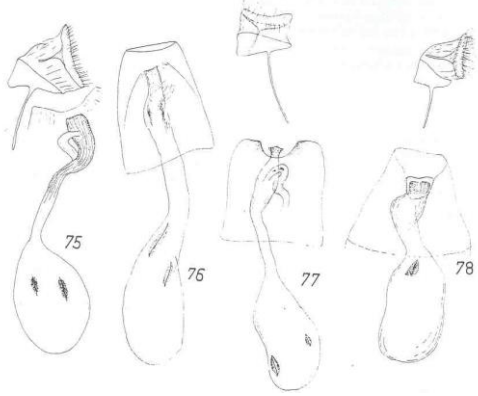

**Figs 66-67.** *Chilo* male genitalia: (66) *luniferalis*; (67) *perfusalis*.



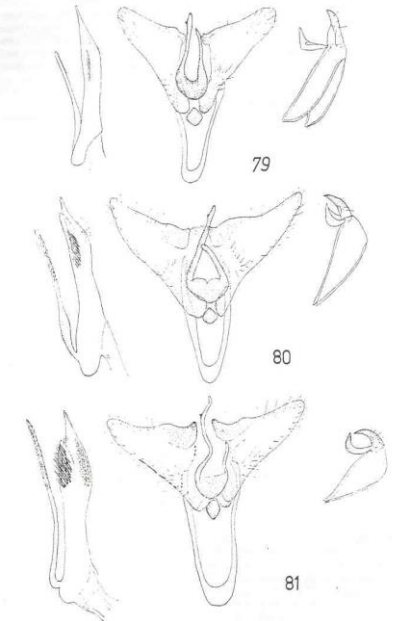

**Figs 68-71.** *Chilo* female genitalia: (68) *luniferalis*; (69-71) *perfusalis.*



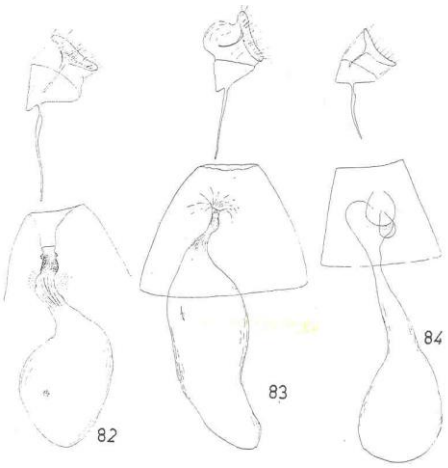

**Figs 72-74.** *Chilo* male genitalia: (72) *costifusalis*; (73) *mesoplagalis;* (74) *argyrogrammus*.



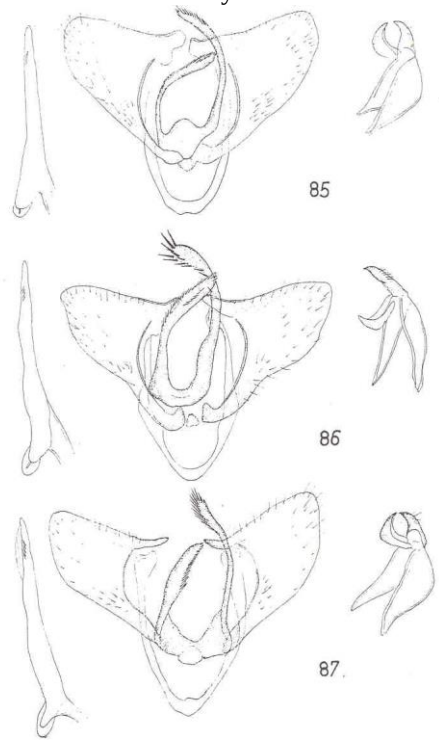

**Figs 75-78.** *Chilo* female genitalia: (75-77) *costifusalis*; (78) *mesoplagalis.*



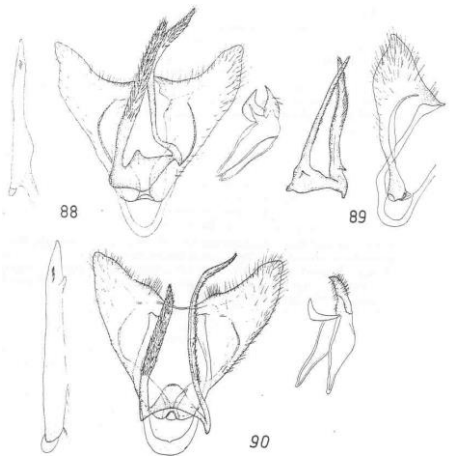

**Figs 79-81.** *Chilo argyropastus* male genitalia.



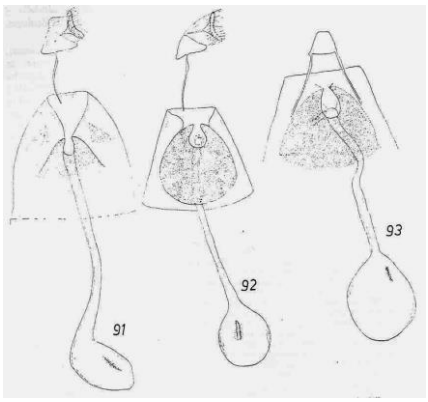

**Figs 82-84.** *Chilo* female genitalia: (82) *argyropastus*; (83) *argyrogrammus*; (84) sp., Kenya.



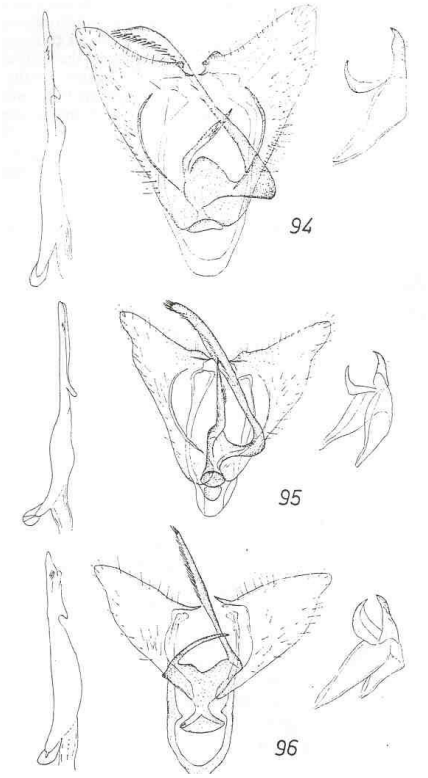

**Figs 85-87.** *Chilo orichalcociliellus* male genitalia.



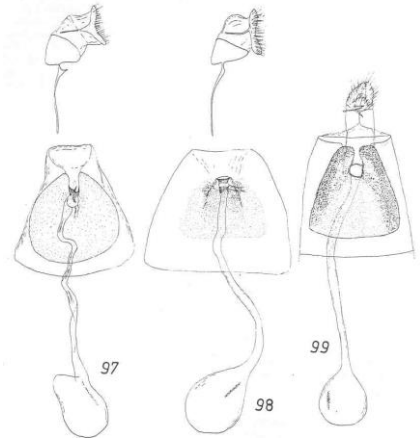

**Figs 88-90.** *Chilo aleniellus* male genitalia.



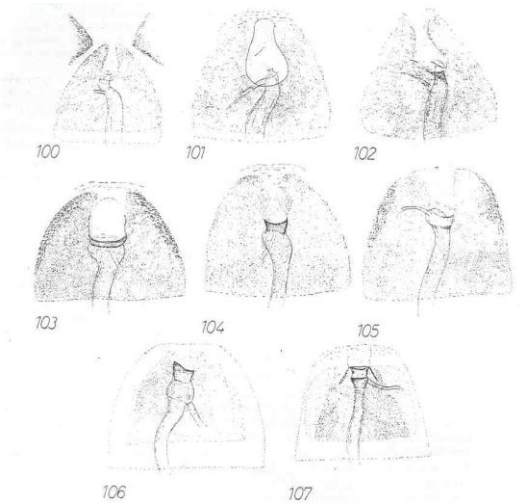

**Figs 91-93.** *Chilo* female genitalia: (91) *orichalcociliellus*; (92-93) *aleniellus.*



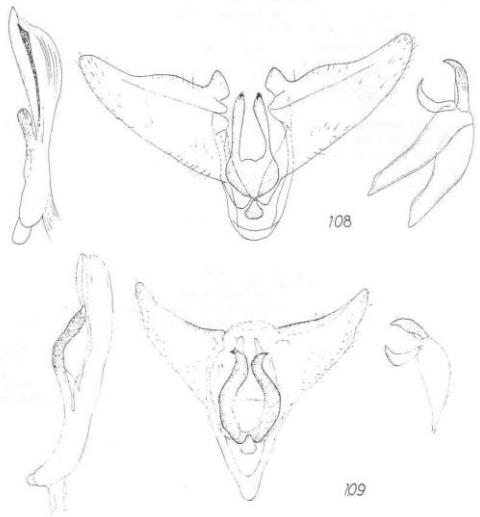

**Figs 94-96.** *Chilo* male genitalia: (94) *thyrsis*; (95) *thyrsis* ssp.; (96) *quirimbellus.*



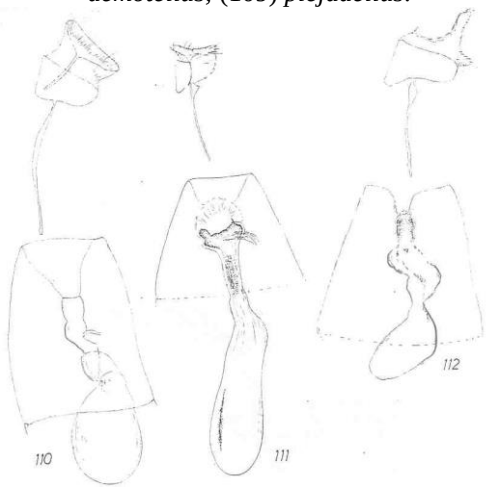

**Figs 97-99.** *Chilo* female genitalia: (97) *zoriandellus*; (98) *quirimbellus*; (99) *thyrsis.*



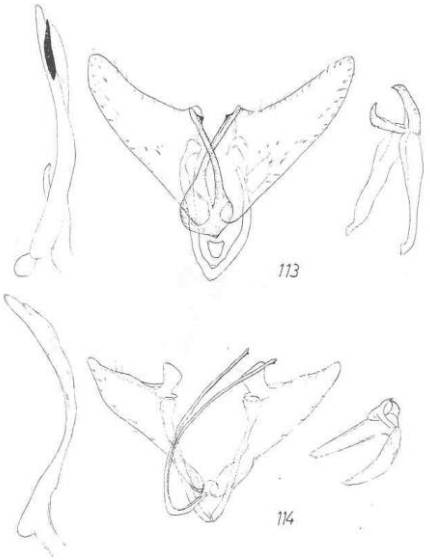

**Figs 100-107.** *Chilo*, seventh segments and caudal parts of female genitalia: (100) *orichalcociliellus*; (101) *aleniellus*; (102) *aleniellus* ? ssp.; (103) *thyrsis*; (104) *thyrsis* ? ssp.; (105) *thyrsis* ? ssp.; (106) *zoriandellus*; (107) *quirimbellus*.



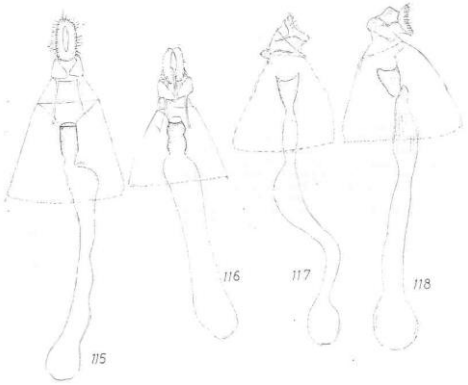

**Figs 108-109**. *Chilo* male genitalia: (108) *demotellus*; (109) *plejadellus*.



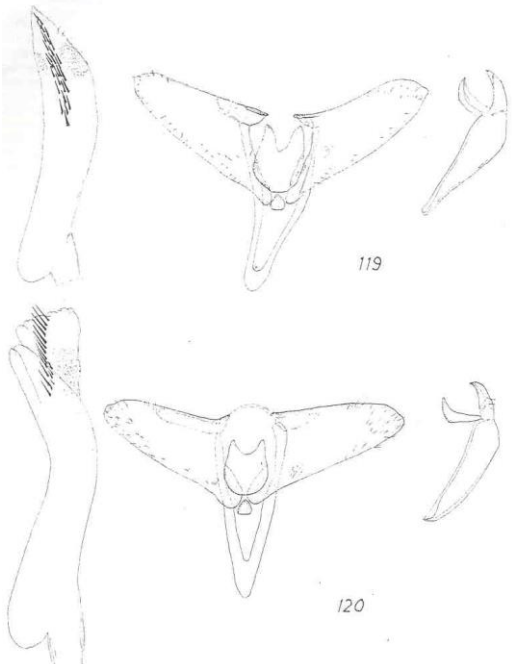

**Figs 110-112.** *Chilo* female genitalia: (110) *demotellus*; (111) *plejadellus*; (112) *erianthalis.*



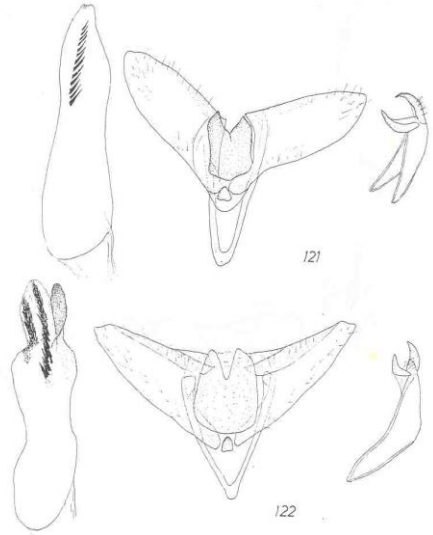

**Figs 113-114.** *Chilo* male genitalia: (113) *erianthalis*; (114) *chiriquitensis.*



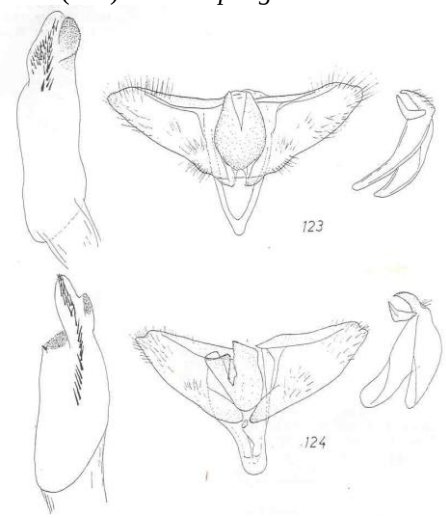

**Figs 115-118.** *Chilo chiriquitensis* female genitalia.



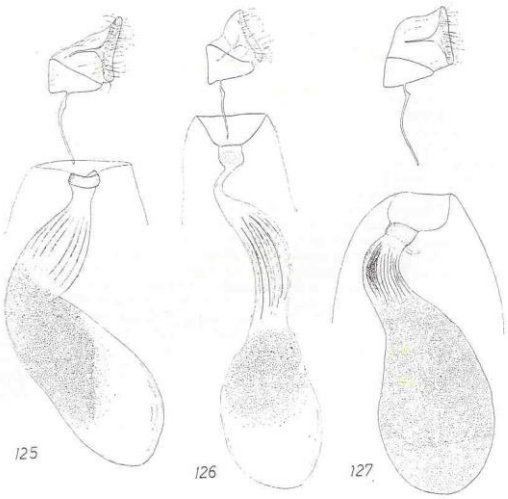

**Figs 119-120.** *Chilo sacchariphagus sacchariphagus* male genitalia.



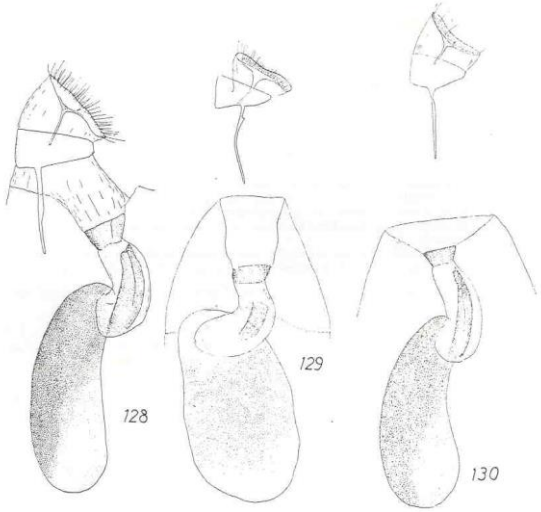

**Figs 121-122.** *Chilo sacchariphagus* male genitalia: (121) *sacchariphagus sacchariphagus*; (122) *sacchariphagus indicus*.




**Figs 123-124.** *Chilo sacchariphagus* male genitalia: (123) *sacchariphagus indicus*; (124) *sacchariphagus stramineellus*.




**Figs 125-127.** *Chilo sacchariphagus* female genitalia: (125) *sacchariphagus sacchariphagus*; (126) *sacchariphagus sacchariphagus;* (127) *sacchariphagus indicus.*




**Figs 128-130.** *Chilo sacchariphagus stramineellus* female genitalia.

***Chilo agamemnon* Bleszynski**

*Chilo agamemnon* Bleszynski 1970: 145.
*Chilo simplex* (Butler); auct. in part. [misidentified].

*Chilo agamemnon* Bleszynski was for a long time recorded from the Near East as *Chilo simplex* Butler (synonym of *suppressalis*), which does not occur in the Near East.

**Types**
Holotype male, Gemmaiza, Egypt, in Naturhistorisches Museum, Vienna.

**Common names**
Purple lined borer, lesser sugar cane borer.

**Distribution**
Egypt, Israel, Sudan, Uganda (Bleszynski 1970).

**Host plants**
Maize, rice, sugarcane, sorghum. *Echinochloa crus-galli*, *Agropyron repens* (*Elymus repens*), *Vossia cuspidata*.

**Symptoms**
Infestation results in lines of holes on young leaves when they open up. Later, stemboring activity results in the formation of tunnels close to the internodes.

**Economic impact**
*Chilo agamemnon* is mainly a pest of maize (corn), but also attacks rice and sugarcane. Studies from Egypt report on damage levels ranging from 5.80 to 17.22% of bored internodes, with plant cane usually being less susceptible to infestation than ratoon crops (Besheit *et al.* 1998). In addition, Allam *et al.* (2006) recorded decreased sugar contents and increased dextran and pH levels in sugarcane attacked by this species. While in maize, *C. agamemnon* is responsible for damage rates of 25-29% (Semeada 1998). In Israel, a rapid decline of *C. agamemnon* populations since 1973 was thought to be a result of the increase in the area used for growing sweet maize, which is not the insect's preferred host (Melmad 1990).

**Morphology**
***Adults***
*Chilo agamemnon* is externally similar to *diffusilineus* and *zacconius*, which are also characterized by an oblique shaded area running from the apex of the fore wing. *Chilo zacconius* is a West African species, while the ranges of *agamemnon* and *diffusilineus* overlap in Sudan. The two species can easily be separated from *agamemnon* by the genitalia.

Bleszynski (1970) gives the following description of this species. Ocellus well developed. Face broadly rounded, slightly protruding forward beyond eye; corneous point and ventral ridge both absent. Labial palpus 3 (male) to 4 (female) times as long as diameter of eye. Fore wing: length 8.0-14.5 mm; $R_1$ free; ground-colour dull yellow to brown ochreous; subterminal line rather distinct in male, reduced in female, brown, weakly dentate, excurved, without subdorsal tooth; median line present in male, ill-defined or absent in female; discal dot present, but diffused or absent in some specimens; well developed brown-shaded area extending obliquely from apex to discal dot; terminal dot present. Hind wing glossy cream greyish to silky white.

***Male genitalia*** (Fig. 55). Pars basalis distinct, pointed, minutely toothed; arms of juxta-plate equally long, gradually tapering to points, without subbasal teeth; aedeagus distinctly curved, bulbose basal projection present; ventral arm absent; row of minute cornuti present.

***Female genitalia*** (Fig. 58). Ostial pouch well demarcated from ductus bursae, bowl-shaped, rather lightly sclerotized, with wrinkled margins; with lateral projection with a heavily sclerotized patch; signum absent.

**Detection methods**
In young plants, inspect growing point and young leaves. Check for stemboring activity around and near the internodes.

**Biology and Ecology**
*Chilo agamemnon* females oviposit on maize plants 90-230 cm high, with the largest numbers of egg masses on plants about 175 cm high (Ismail 1989). Larvae feed on leaves, then bore inside the stems close to the internodes. Continuous high soil moisture in dryland agriculture as a result of irrigation favours the production of several generations of *C. agamemnon*. However, flooding of infested sugarcane fields after harvest reduces damage in the following season (Rivnay 1967; Ezzat & Atries 1969).

**Natural Enemies**
***Trichogramma evanescens* (Westw.) (Hymenoptera: Trichogrammatidae):** Egg parasitoid, recorded to attack *C. agamemnon* among other corn and sorghum borers in Egypt (Ragab *et al*. 1999). During 1987-96, *T. evanescens* was released once each year early in the season at 20,000/feddan [1 feddan=0.42 ha] in sugarcane fields. Treatment reduced infection by 50-79% and resulted in higher yields (Abbas 1997). Much lower release rates have been reported to also reduce damage in sugarcane fields in Egypt (Khewa *et al*. 2006).

**Pathogens**
***Bacillus thuringiensis* (subsp. kurstaki HD-1):** Bacterial biocide, available as (Dipel-2X) is used in Egypt against *C. agamemnon* and other maize and cane borers (Hafez *et al*. 1998).

**Management**
***Chemical Control***
Methomyl and monocrotophos are the recommended insecticides in Egypt. Furadan (carbofuran) 10% at 10 kg/feddan, 7 days after sowing, and at 6.0 kg/feddan 50 days after transplanting and Lindane 5% granules (at 17.5 kg/feddan) give good control results (Abdallah *et al.* 1991). While in maize, application of Polytrin (a foliar insecticide containing Profenofos and Cypermethrin) significantly decreased mean borer number/plant (Mesbah *et al*. 2002a).

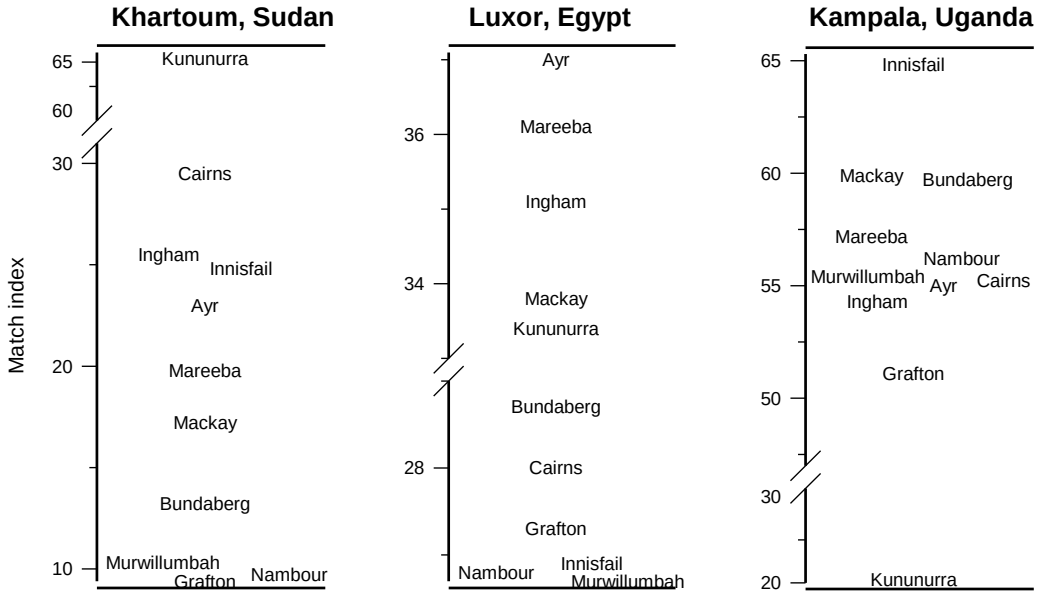
***Cultural Controls***
Land levelling by lasers in sugarcane fields in Egypt, resulting in slopes of 3 cm per 100 m, reduced the amount of water required for irrigation by 28.8%, and in turn reduced percentage of infested internodes and circular tunnels from 10.47 and 22.83% to 3.18 and 7.83%. It is suggested that reducing the quantity of water required for irrigation affects pest activity by reducing relative humidity (Karaman *et al.* 1998). It was also shown that increased Nitrogen fertilizer rates favoured borer infestation while an increase in Phosphorus rates resulted in lower infestation levels (Ali *et al.* 2001). In maize crops, spraying with foliar nutrients (Potasin F, ascorbic acid, Polymex and copper sulfate) reduced infestation by the tree major moth borer species (*Sesamia cretica*, *Ostrinia nubilalis* and *Chilo agamemnon*) (Mesbah *et al.* 2002b).

***Plant Resistance***
In Egypt, sugarcane varieties with high sugar yields and on the same time tolerant to borer damage are G 84/47, 85/285, 85/166, 85/37 and GT 54/9, in which damage levels less than 10% bored internodes were recorded in both plant cane and 1st ratoon (Besheit *et al.* 1998). While studies on chemical resistance of rice cultivars to *C. agamemnon* in Egypt showed that greater total protein contents increased infestation in most cultivars, while presence of silica, alanine, glycine, histidine+arginine, aspartic acid+serine and valine decreased infestation (Soliman *et al.* 1997).

**Means of Movement**
The most likely means of entry of this species into Australia would be by the introduction of infested planting material. The chance of the introduction of moths or eggs on aircraft, in luggage, or on people is much smaller, though still significant.

**Phytosanitary Risk**

***Entry potential:*** Medium - isolated from Australia, but readily transmitted on infected planting material.
***Colonisation potential:*** High in all sugarcane-growing areas.
***Spread potential:*** High, unless strict controls imposed over movement of infested material.
***Establishment potential:*** Depends on biotype introduced (see Match Indexes for climates at selected locations and principal Australian areas below).



***Chilo auricilius* Dudgeon**

*Chilo auricilia* Dudgeon 1905: 405.
*Diatraea auricilia* (Dudgeon): Fletcher 1928: 58; Gupta 1940: 799.
*Chilotraea auricilia* (Dudgeon): Kapur 1950: 408.
*Chilo popescugorji* Bleszynski 1963: 179.
*Chilo auricilia* Dudgeon: Bleszynski & Collins 1962: 239.
*Chilo auricilius* Dudgeon; Bleszynski 1965: 113; 1969: 16.

**Types**
*auricilia*: Holotype male, [India] Burogah, N. Bihar, in Natural History Museum, London.
*popescugorji*: Holotype female, Formosa, in Muzeul G. Antipa, Bucharest.

**Common names**
Stalk borer, gold-fringed rice borer, gold-fringed stem borer, dark headed stem borer, sugar cane stalk borer.

**Distribution**
Bangladesh, Burma, China, East Malaysia, Hong Kong, India, Indonesia (Java, Kalimantan, Moluccas, Sulawesi, Sumatra), Nepal, Papua New Guinea, Philippines, Sri Lanka, Taiwan, Thailand, Vietnam (Bleszynski 1970; Chundurwar 1989; David & Easwaramoorthy 1990; Harris 1990).

**Host Plants**
Sugarcane, rice, maize and sorghum (Bleszynski 1970; Huang *et al.* 1985; Chundurwar 1989; Harris 1990).

**Symptoms**
Eggs are laid in clusters on the lower surface of the leaves. Young larvae feed within the top leaf sheaths and later bore inside cane stalks causing dead hearts. Infestation also results in holes on or near the buds. This affects germination and tillering and infested setts should not be used for planting in the field (Sardana 2000b).

**Economic impact**
*Chilo auricilius* is a major pest of sugarcane in South East Asia and it is considered to be one of the most damaging cane pests in northern India (Neupane 1990). The expansion of planting soft, but high sugar, varieties, as well as excess usage of nitrogen fertilizers, caused this species to become a key pest in Bihar, India (Kumar *et al.* 1987). *Chilo auricilius* is also a major pest of sugarcane in western Uttar Pradesh in India since its appearance in 1954 (Atwal 1962; Rai *et al.* 1999). The pest is recorded as infesting plant cane and ratoon crops and these may serve as a source of infestation of the following plant crop. Shenhmar *et al*. (1998b) recorded sugar recovery percentage of 9.85% in uninfested compared to 9.78, 9.35, 9.30, 6.26, 3.94 and 2.39% in canes showing 5, 10, 15, 40, 50 or 80% infestation levels, respectively. Based on the value of commercial cane sugar yield in Haryana, India, in 1990-92, the economic injury level was determined at 17.83 larvae per 6 m cane row (Sardana 1996).

This pest species also feeds on rice and considered to be one of its key pests in Bangladesh (Husain & Begum 1985). In Nanning, Guangxi, China, *C. auricilius* was reported to cause up to 8.6% damage in rice (Meng *et al.* 1997). *Chilo auricilius* is also reported to be a major pest of rice in some parts of India and Bangladesh (Neupane 1990), it is however regarded as a minor pest of rice in some parts of Papua New Guinea (Li 1990). *Chilo auricilius* was known to mainly feed on sugar cane in Indonesia until Hattori & Siwi (1986) reported it to feed on rice for the first time in Java and South Kalimantan.

**Morphology**
***Adults***
*Chilo auricilius* is morphologically very similar to *C. polychrysus* and only distinguishable by the genitalia. In a survey of *Chilo* species on rice in the Philippines, *C. auricilius* accounted for 73% of the total number of specimens collected while *C. polychrysus* was not recorded. The morphological similarity

of the larvae and adults of these two species had led to earlier erroneous records of *C. polychrysus* in the Philippines, similar confusion may therefore exist in other countries where the distributions of the two species overlap (Barrion *et al.* 1990).

Bleszynski (1970) gives the following description to this species:
Ocellus small but distinct. Face produced forward, smooth, or with small point; ventral ridge absent. Labial palpus 3 (male) to 4 (female) times as long as diameter of eye. Fore wing: length 8.0-13.0 mm, maximum width 3.0-4.0 mm; $R_1$ confluent with *Sc*; ground-colour yellow, in some instances brownish; variably irrorated with brown scales; discal dot present; subterminal line close to termen, represented by row of metallic scales; median line concolorous with subterminal line; few small silvery specks in middle of wing; terminal dots large; fringe shiny golden. Hind wing light brownish. Coloration and pattern of fore wing is variable: in some specimens for wing almost unicolorous yellow; one examined specimen has very strongly developed silvery specks covering most of the wing surface; sometimes the silvery specks are irregularly dispersed, while in other specimens they form two parallel transverse lines.
***Male genitalia*** **(**Fig. 38): Pars basalis absent; saccus large; juxta-plate with two symmetrical arms ending well before basal-costal angle of valva; aedeagus with distinct, sub-apical conical projection; ventral arm long, with notched apex; bulbose basal projection small; cornutus absent.
***Female genitalia*** (Fig. 43): Ostial pouch slightly demarcated from ductus bursae, moderately or heavily sclerotized; small; signum absent, but several examined specimens with a patch of scobinations or rather distinct irregularly shaped signum.

**Biology and Ecology**
Female moths lay their eggs in clusters on the lower surface of sugarcane leaves, then first and second instars feed within the top leaf sheaths. Later larval instars bore inside cane stalks causing dead hearts. Equal densities of eggs were recorded from dry cane leaves, green leaves and trash on the ground and in groups of 2-6. Incubation period ranges between 5.8 to 8.8 days, and one female lays 100-150 eggs. The hatchability of eggs varies from 39 to 90%. Larval duration varies greatly and ranges between 21-85 days, while pupal period is about 5.8-14 days. The life cycle can be completed within 36.4-111.1 days depending on climatic conditions, with 5-8 larval instars. Adult longevity is about 2.4-3.9 days.

In Nayagarh, Orissa, India, the pest is active from late June to November when the maximum temperature is 32.5°C to 36.1°C and relative humidity is between 71.3 and 79.5%. High temperature, high relative humidity and rainfall favour multiplication, with high relative humidity being very conducive to borer survival. Four distinct generations were recorded from mid June to late January (Dubey *et al*. 1988; Jena & Patnaik 1997b; Shenhmar & Singh 1997; Sardana 1998b). While in Haryana, Sardana & Das (2001) recorded that infestation by *C. auricilius* was negatively correlated with minimum temperature and sunshine and positively correlated with maximum temperature, relative humidity and rainfall. In Gujarat, *C. auricilius* occurs sympatrically with *C. sacchariphagus* from June to December in cane fields (Pandya *et al.* 1996). Sukhija et al (1994) recorded an increase in infestation due to applying nitrogen fertilizer to cane plants. Similar results are recorded by Singh & Singh (1983) who found that infestation increased with rising N rates from 0 to 150 kg N/ha. Infestation also increased with diminishing interrow spacing from 90 to 45 cm.

In Yibing Prefecture, China, the biology and ecology of *C. auricilius* were studied mainly on rice, but also on maize and other crops. The pest had 3-4 generations a year with the larvae overwintering in the rice stubble and rice straw. The first generation occurred in late June and early July, the second in late July to mid August, and the third in September. Adults emerge mainly at night, with a ratio of females to males of 1.00:0.83. Copulation occurred soon after adult emergence and peaked between 03.00 and 07.00 h. The average preoviposition period was 1.5-2.1 days and females produced between 97 and 219 eggs, depositing them on the leaves of the lower parts of the rice plants. Oviposition peaked between 21.00 and 01.00 h. Larvae of the first generation attacked early maize, and larvae of the second and third generations attacked rice. 80% of the larvae pupated in injured rice stems, and a few pupated on the inner side of the leaf sheath (Huang *et al.* 1985).

**Natural Enemies**

***Parasitoids***

***Allorhogas pyralophagus* (Hymenoptera: Braconidae)**: Larval parasitoid native to Mexico. Reported to have been introduced into India for the control of the stemborer complex but did not seem to have established (Varma *et al.* 1987; Varma & Nigam 1989 Shenhmar *et al.* 1990; Easwaramoorthy *et al.* 1992).

***Apanteles baoris* Wilkinson (Hymenoptera: Braconidae)**: Recorded as attacking *C. auricilius* larvae in India (Butani 1972).

***Apanteles ruficrus* Hal. (Hymenoptera: Braconidae)**: This parasitoid was first recorded during a routine survey in sugarcane fields of Uttar Pradesh, India. The parasitoid caused 2.8% parasitism of *C. auricilius* host larvae. The parasitoid was found, together with *C. flavipes*, parasitizing larvae during October. The number of adult parasitoids emerging from a single larva ranged from 10 to 78 (Nigam 1984).

***Campyloneurus mutator* Fabricius (Hymenoptera: Braconidae)**: Larval parasitoid, recorded from India (Butani 1972).

***Centeterus alternecoloratus* Cushman (Hymenoptera: Ichneumonidae)**: Pupal parasitoid. Recorded attacking *C. auricilius* in rice fields (Butani 1972).

***Cotesia flavipes* Cameron (Hymenoptera: Braconidae)**: A gregarious larval endoparasitoid, recorded to attack *C. auricilius* larvae in sugarcane fields in India (Butani 1972; Nigam 1984; Nair 1988). An Indonesian strain of the parasitoid is maintained in India using *C. auricilius* as a host. The parasitoid was reared on the larvae for 11 successive generations without affecting its potential. Parasitoid males and females live for 8.7 ± 3.3 and 5.4 ± 2.3 days, respectively. Total developmental period of immatures is 23.7 ± 0.4 days, with third- to fifth-instar larvae being more preferred for oviposition and development. Three-day-old cocoons could be stored at 10°C for 15 days with 71.6% emergence (Tanwar & Varma 1996). In Uttar Pradesh, field releases of 1600 mated *C. flavipes* females/ha reduced *C. auricilius* infestation by 44.2% (Tanwar & Varma 2002). Mohyuddin (1991) mentions that a local strain of *C. flavipes* was encapsulated in *C. auricilius* in Sumatra, Indonesia. Following the introduction of a strain from Thailand, a high rate of parasitism of both *C. auricilius* and *C. sacchariphagus* was achieved.

***Diatraeophaga striatalis* (*Lydella striatalis*) Towns. (Diptera: Tachinidae)**: Larval parasitoid. Well established in central Java on *C. auricilius*. Mass releases of the parasitoid in cane fields effectively control the borer (Samoedi 1989).

***Eupelmus* sp. (Hymenoptera: Eupelmidae)**: Possibly a larval parasitoid, recorded from India attacking *C. auricilius* in rice fields (Butani 1972).

***Stenobracon deesae* Cameron (Hymenoptera: Braconidae)**: Larval parasitoid. Reported from Bihar, Bombay, Madras, Mysore, Punjab and Uttar Pradesh, parasitizing a wide range of stemborers including *C. auricilius* (Butani 1958).

***Sturmiopsis inferens* Townsend (Diptera: Tachinidae)**: Larval parasitoid indigenous to India. Recorded attacking *C. auricilius* in India (Butani 1972; David *et al.* 1989; Jaipal & Chaudhary 1994) and Indonesia (Mohyuddin 1987). In Uttar Pradesh, India, mass releases of this parasitoid were conducted in 1996-97, where 15 gravid females were released fortnightly. Parasitism increased from 0% to 25.0% in the period from June to August and reached a maximum of 43.48% during September-November (Rai *et al*. 1999). Under laboratory conditions, the average larval and pupal periods on *C. auricilius* larvae at 27 ± 1°C were 10.2 and 10.5 days, respectively. At higher temperatures of 30 and 32°C, average larval and pupal periods decreased to 9.65 and 8.78, and 9.45 and 9.16 days, respectively. Higher temperatures reduced adult fertility and survival rates (Jaipal & Chaudhary 1994). Parasitoid larvae hibernate inside their hosts. Chandra & Avasthy (1988) found *C. auricilius* to be the best of five hosts for laboratory rearing of *S. inferens*. A two- to three-day-old male is successfully capable of fertilizing three females. Nine to twelve days after mating, gravid females lay 1-3 larvae on the frass at the borer's hole, irrespective of whether the hole harboured a healthy, parasitized or no host larva. Parasitoid activity in the field slows in winter. Activity commenced in February-March at an average maximum and minimum temperature of 30.5 and 13.4°C, respectively; and relative humidity of 50%. During a survey in Haryana, India, for natural enemies of *C. auricilius*, a puparium of the tachinid *Sturmiopsis inferens* yielded 15 adults of the eulophid *Nesolynx thymus*. Therefore it is important to make sure accidental release of the hyperparasitoid is avoided when *S. inferens* is introduced in new areas (Varma 1989).

***Tetrastichus israeli* Mani & Kurian (*Aprostocetus israeli* Mani) (Hymenoptera: Eulophidae)**: Pupal parasitoid, recorded attacking *C. auricilius* in rice fields in India (Butani 1972).

***Trichogramma chilonis* (Hymenoptera: Trichogrammatidae)**: Extensive releases of this parasitoid are conducted in India. In July 1989, inundative releases in cane fields at 50,000 individuals/ha reduced the infestation of *C. auricilius* from 61% in control areas to 12.6% in treated areas by December (Varma *et al.* 1991). In 1995, *T. chilonis* was mass released in nine locations in the Punjab, India, for the control of *C. auricilius*. 50,000 parasitized eggs/ha were released during July to October at 10 day intervals. Releases decreased the mean incidence of *C. auricilius* from 14.88% to 7.14% and reduced damage by 52.02%. The parasitoid was recovered from five of the six locations where it was released (Brar *et al.* 1996). Similarly, (Shenhmar *et al.* 2003) showed that eleven to twelve releases of *T. chilonis* at 50,000/ha from July to October in Punjab reduced *C. auricilius* incidence by 55-60%. Other releases were also carried out in Nayagarh, Orissa, India, and resulted in good control of both *C. auricilius* and *C. infuscatellus* (Mishra *et al.* 1997). This parasitoid is also reported to attack *C. auricilius* eggs in Pakistan and Indonesia (Mohyuddin 1987), Taiwan (Cheng *et al.* 1987) and China (Liu *et al.* 1996). Shenhmar *et al.* (1998a; 2001) developed a technique of using gelatin capsules containing eggs of *Corcyra cephalonica* parasitized by *T. chilonis* for the release of adult. This method proved to provide better control of *C. auricilius* than the use of parasitized host eggs glued on paper strips.

***Trichogramma japonicum* Ashm. (Hymenoptera: Trichogrammatidae)**: Recorded to attack eggs of *C. auricilius* in Taiwan (Box 1953). This parasitoid was released in the Punjab, India, along with applications of carbofuran (Mann & Doomra 1996).

***Trichogramma nanum* Zhnt. (Hymenoptera: Trichogrammatidae)**: Recorded on *C. auricilius* eggs in Malaysia (Box 1953).

***Tropobracon* (*Shirakia*) *schoenobii* (Viereck) (Hymenoptera: Braconidae)**: Recorded as attacking *C. auricilius* larvae in paddy rice in India (Butani 1972).

***Vipio* (*Stenobracon, Bracon, Glyptomorpha*) *deesae* (Cameron) (Hymenoptera: Braconidae)**: This species is common all over India on a range of sugarcane stemborers including *C. auricilius* (Butani 1972).

***Vipio* sp. (Hymenoptera: Braconidae)**: Larval parasitoid on *C. auricilius* in India (Butani 1972).

***Predators***

***Forficula* sp. (Dermaptera: Forficulidae):** Recorded as preying on *C. auricilius* larvae in cane fields of Uttar Pradesh, India (Butani 1972).

***Pathogens***

Delfin (2.0 kg/ha), Dipel 8L (2.0 l/ha) and Cen Tari (1.5 kg/ha) are all formulations of *Bacillus thuringiensis* Berliner. All gave high mortality rates of *C. auricilius* after 72 h of treatment in the laboratory (Shenhmar & Varma 1997). Suspensions of *Beauveria bassiana* obtained from a medium consisting of rice husk resulted in 81.5% larval mortality in the laboratory (Siwach & Jaipal 2004).

**Management**

***Chemical control***

In Gujarat, India, three application of phorate 10 G at 1 kg a.i./ha reduced infestation of a stemborer complex, including *C. auricilius* and *C. sacchariphagus*. Carbofuran 3-G at 1.5 kg a.i./ha resulted in 40.66% reduction of infestation by *C. auricilius* and gave the highest productivity in Orissa, India (152.07 t/ha) (Jena *et al.* 1994b). Two sprays with cypermethrin at 0.1 kg a.i./ha gave best results against *C. auricilius* on sugarcane in the Punjab. Sprays in July gives better results than those in September (Singla & Duhra 1992). While in Lucknow, Uttar Pradesh, two foliar sprays of monocrotophos at 0.75 kg/ha in August and September resulted in low infestation by both *C. auricilius* and *Scirpophaga excerptalis* (Tanwar *et al.* 2003). In Bangladesh, application of granules of cartap (Padan) at 3 kg a.i./ha in July and August gave satisfactory control of the borer (Miah *et al.* 1983).

Extracts of neem (*Azadirachta indica*) and peppermint (*Mentha piperita*) had a negative impact on egg and larval survival of *C. auricilius* (Mumtaz *et al.* 2006).

***Cultural controls***

Certain farming practices followed in India are recorded to reduce *C. auricilius* incidence in cane. These include trash burning, removing plant residues and removing 'water shoots' in ratoon crops, earthing up in May and June, and applying fertilizers during the pre monsoon season. In Orissa, India, infestations were reduced to (8.23%) where these practiced are followed compared to other plots (19.3%) (Jena *et al.* 1998).

***Pheromones***

Four pheromone components were detected in ovipositor washings and volatiles from *Chilo auricilius* female moths using combined gas chromatography and electroantennography. The components were identified as: (i) (Z)-7 dodecenyl acetate (Z7-12:Ac) (looplure); (ii) (Z)-8-tridecenyl acetate (Z8-13:Ac); (iii) (Z)-9-tetradecenyl acetate (Z9-14:Ac); and (iv) (Z)-10-pentadecenyl acetate (Z10-15:Ac). Field tests in northern India showed that a combination of (ii), (iii) and (iv) in their naturally occurring ratio (8:4:1) provided a highly attractive synthetic source for trap use. Looplure (i) was found to reduce catches of males of *C. auricilius*, both when dispensed with the other three components and when released from dispensers surrounding a trap baited with the other three components (Nesbit *et al.* 1986; Beevor 1990).

***Plant Resistance***

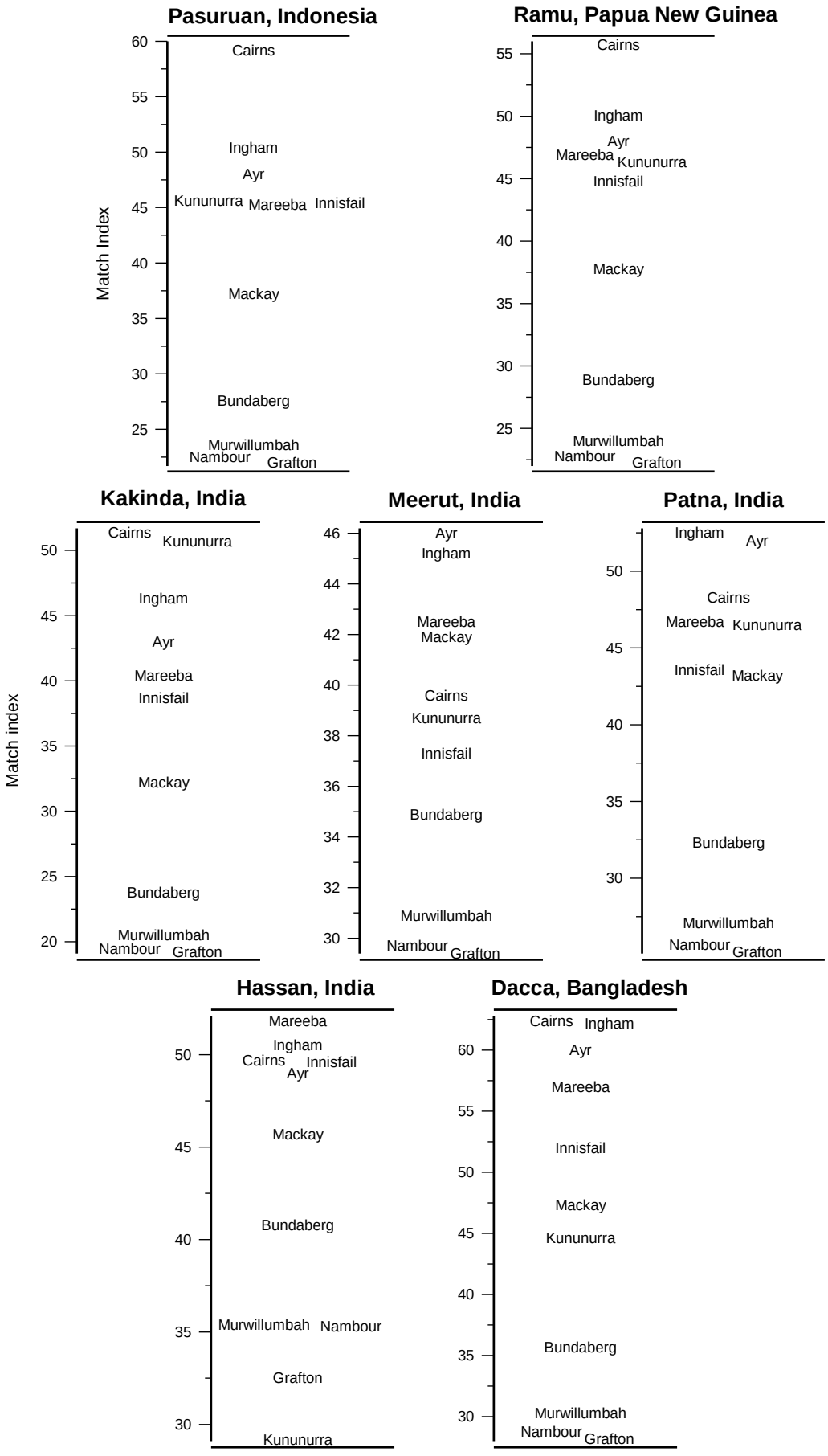
In a recent study in India to evaluate 145 sugarcane genotypes for resistance to *C. auricilius*, no genotypes ware completely resistant to the pest, however, early maturing genotypes were more susceptible to infestation than mid-late ones (Sharma *et al.* 2007a). It was also shown that, neutral detergent fibre (NDF), cellulose, lignin, phenol and tannin contents in leaf sheath and stalk are negatively correlated with susceptibility to *C. auricilius* infestation, while higher total sugar contents increased plant susceptibility to infestation (Sharma *et al.* 2007b). While in sugarcane mill zones of Haryana, India, Pal & Singh (2001) rated cultivars Co.S.8436 and Co.7717 to be highly susceptible and Co.S.767 to be moderately susceptible.

**Means of Movement**

The most likely means of entry of this species into Australia would be by the introduction of infested planting material. The chance of the introduction of moths or eggs on aircraft, in luggage, or on people is much smaller, though still significant.

**Phytosanitary Risk**

***Entry potential:*** High – close to Australia and readily transmitted on infected planting material.
***Colonisation potential:*** High in all sugarcane-growing areas.
***Spread potential:*** High, unless strict controls imposed over movement of infested material.
***Establishment potential:*** Depends on biotype introduced (see Match Indexes for climates at selected locations and principal Australian areas below).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Innisfail
Mackay
Bundaberg
Murwillumbah
Nambour
Grafton
Ramu, Papua New Guinea
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Cairns
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Mareeba
Kununurra
Innisfail
Mackay
Bundaberg
Murwillumbah
Nambour
Grafton
Kakinda, India
Match index
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Cairns
Kununurra
Ingham
Ayr
Mareeba
Innisfail
Mackay
Bundaberg
Murwillumbah
Nambour
Grafton
Meerut, India
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32
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Ayr
Ingham
Mareeba
Mackay
Cairns
Kununurra
Innisfail
Bundaberg
Murwillumbah
Nambour
Grafton
Patna, India
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Cairns
Mareeba
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Nambour
Grafton
Hassan, India
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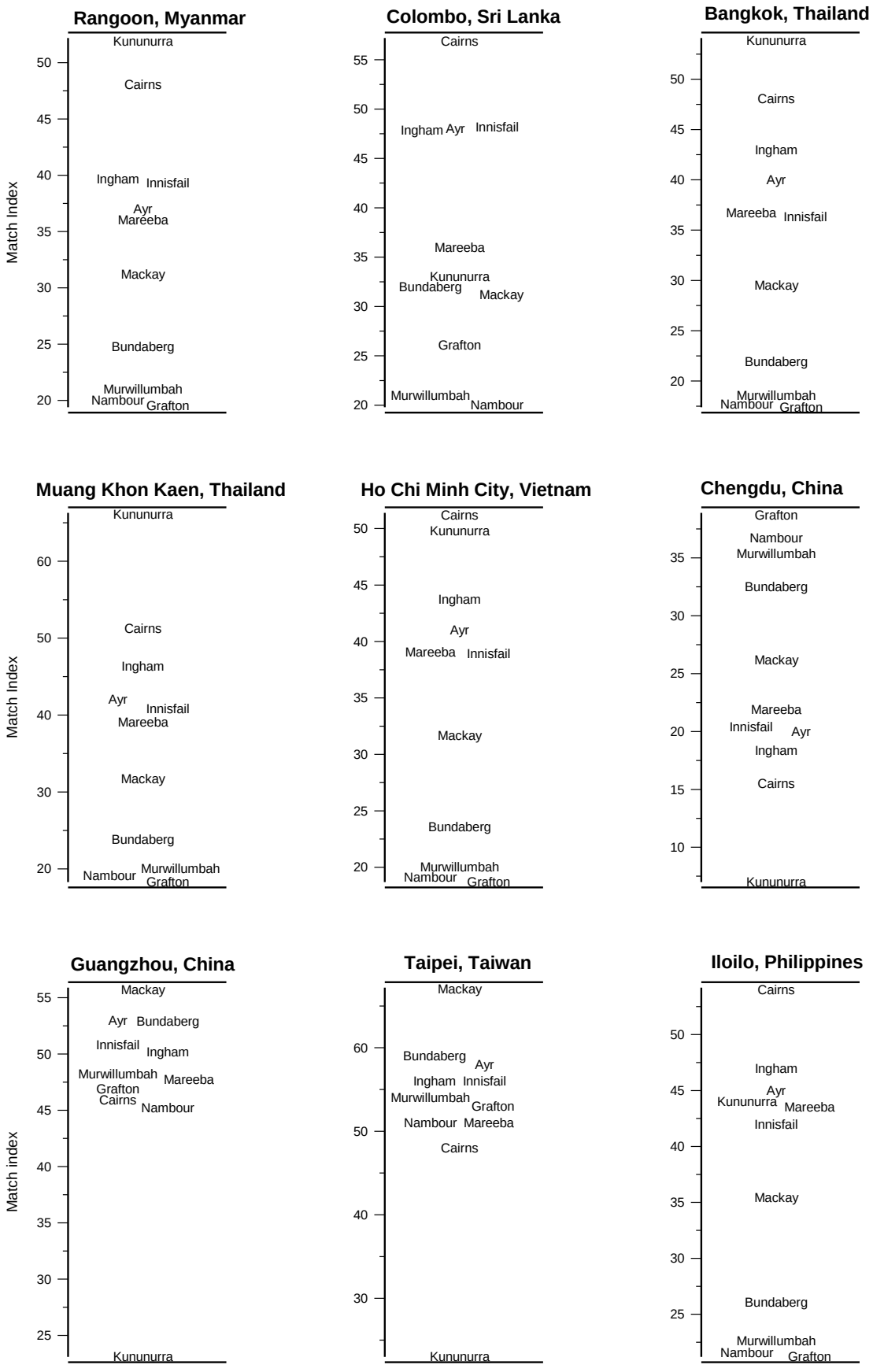
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Innisfail
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Mackay
Bundaberg
Murwillumbah
Nambour
Grafton
Colombo, Sri Lanka
Cairns
Ingham
Ayr
Innisfail
Mareeba
Kununurra
Bundaberg
Mackay
Grafton
Murwillumbah
Nambour
Bangkok, Thailand
Kununurra
Cairns
Ingham
Ayr
Mareeba
Innisfail
Mackay
Bundaberg
Murwillumbah
Nambour
Grafton
Muang Khon Kaen, Thailand
Match Index
Kununurra
Cairns
Ingham
Ayr
Innisfail
Mareeba
Mackay
Bundaberg
Nambour
Murwillumbah
Grafton
Ho Chi Minh City, Vietnam
Cairns
Kununurra
Ingham
Ayr
Mareeba
Innisfail
Mackay
Bundaberg
Murwillumbah
Nambour
Grafton
Chengdu, China
Grafton
Nambour
Murwillumbah
Bundaberg
Mackay
Mareeba
Innisfail
Ayr
Ingham
Cairns
Kununurra
Guangzhou, China
Match index
Mackay
Ayr
Bundaberg
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Ingham
Murwillumbah
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Grafton
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Nambour
Kununurra
Taipei, Taiwan
Mackay
Bundaberg
Ayr
Ingham
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Murwillumbah
Grafton
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Mareeba
Cairns
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Iloilo, Philippines
Cairns
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Kununurra
Mareeba
Innisfail
Mackay
Bundaberg
Murwillumbah
Nambour
Grafton

***Chilo diffusilineus* (de Joannis)**

*Diatraea diffusilinea* de Joannis 1922: 124.
*Chilo phaeosema* Martin 1958: 189.
*Chilo diffusilineus* (de Joannis): Bleszynski 1969: 113.

**Types**
*diffusilinea:* Holotype male, Makulane, Mozambique, in Muséum d' Histoire Naturelle, Geneva.
*phaeosema*: Holotype male, Makaholi, Zimbabwe, in Natural History Museum, London.

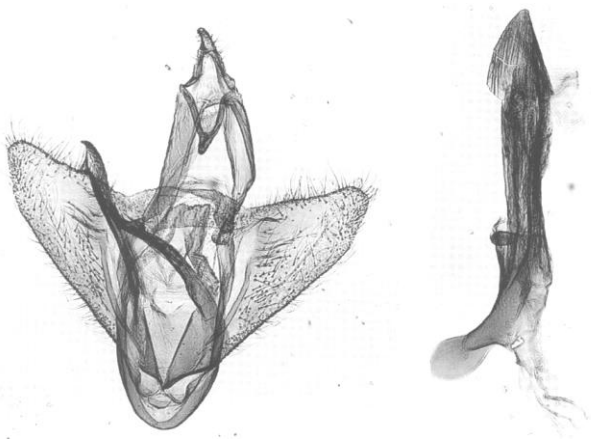
**Distribution**
Ethiopia, Guinea, Malawi, Mozambique, Nigeria, Senegal, Sierra Leone, Sudan, Tanzania, Uganda, Zimbabwe (Bleszynski 1970; Maes 1998).

**Host plants**
Rice, maize, sorghum, *Panicum* sp., *Paspalum scrobiculatum*, *Pennisetum typhoides*, *Oryza longistaminata* (Bonzi 1982).

**Symptoms**
Similar to *C. zacconius*.

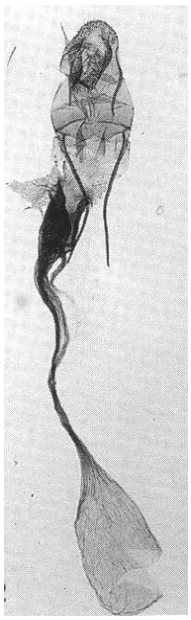
**Economic impact**
Though this species is widely distributed in tropical Africa, there is little published information on its pest status. *Chilo diffusilineus* does not seem to be a significant pest of rice in Africa (Maes 1998).

**Morphology**
***Adults***
*Chilo diffusilineus* is very similar externally to *agamemnon* and *zacconius*. Bleszynski (1970) gives the following description to this species: Similar to *agamemnon*. Fore wing: length 8.0-13.0 mm. $R_1$ free; ground-colour varying from orange-yellow to brown-yellow.
***Male genitalia*** (Fig. 56). Pars basalis absent; juxta-plate with two long arms of equal length, but in some specimens the right arm shorter than the left arm; each arm provided with a distinct, subapical tooth and subapical short hairs; distinctly with basal part curved; bulbose basal projection varying in size, ventral arm very short; cornuti absent.



*Chilo diffusilineus* male genitalia (After Polaszek 1998).

***Female genitalia*** (Fig. 59 - 61). Ostial pouch very well demarcated from ductus bursae; heavily sclerotized, produced as a long, heavily sclerotized rod into ductus bursae; in some specimens, a distinct, lateral, thorn-like projection; signum absent.



*Chilo diffusilineus* female genitalia (After Polaszek 1998).

***Larvae***
Non-diapause larvae cream-coloured with large cream-coloured or, especially on the thorax segments, light brown pinacula. Head capsule brown. Prothoracic shield and suranal plate slightly darker than the cuticle. Dorsal surface of the body with five reddish brown longitudinal stripes. Crochets on abdominal prolegs biordinal, in a complete circle. Can be very small towards the lateral side (Meijerman & Ulenberg 1998).

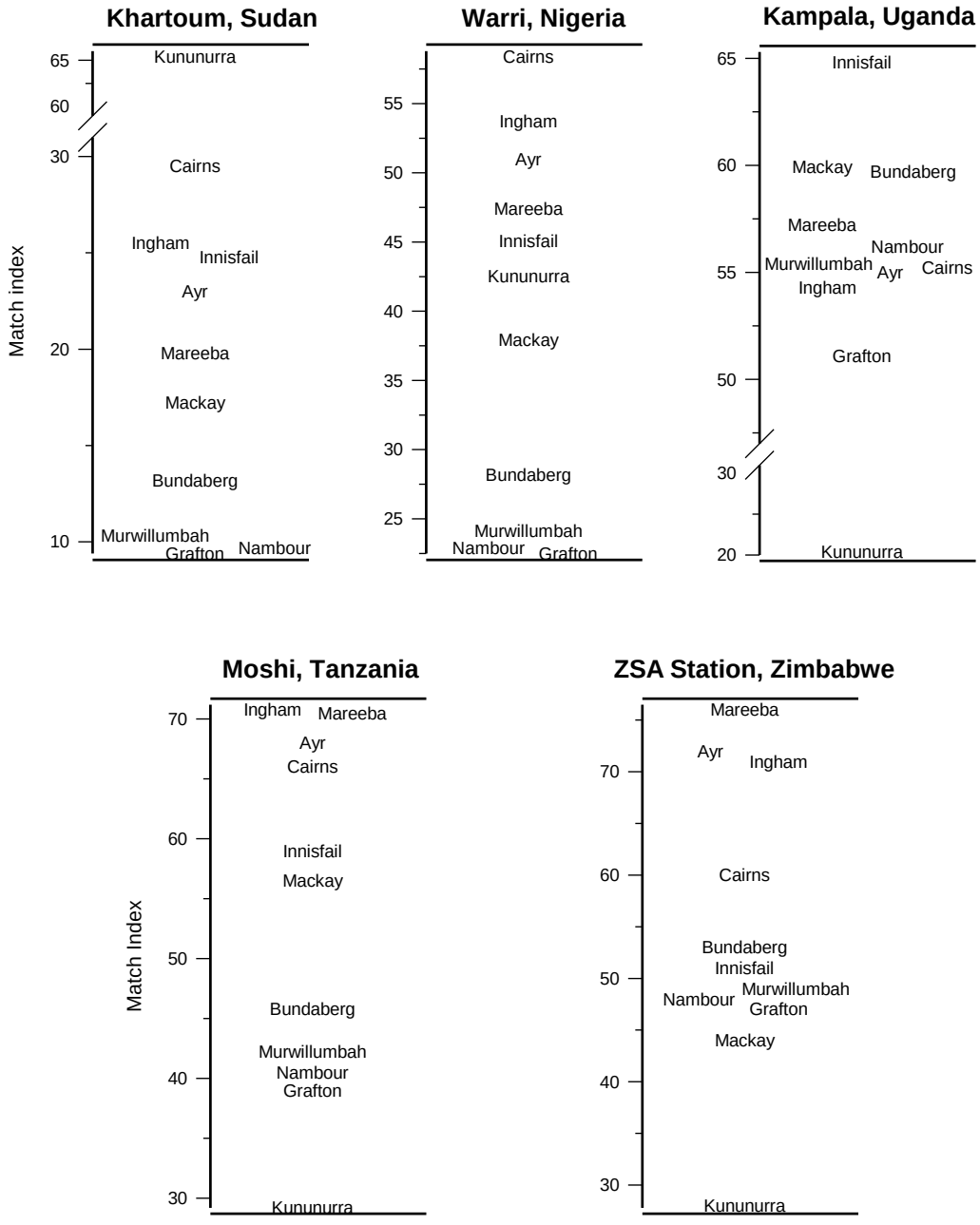
**Detection methods**
*Chilo diffusilineus* is similar in appearance and its damage symptoms to *C. zacconius* (Heinrichs 1998). Bordat & Pichot (1978) report that *C. diffusilineus* prefers lowland rice fields, while *C. zacconius* prefers upland rice.

**Biology and Ecology**
Similar to that of *Chilo zacconius*.

**Management**
No data available.

**Means of Movement**
The most likely means of entry of this species into Australia would be by the introduction of infested planting material. The chance of the introduction of moths or eggs on aircraft, in luggage, or on people is much smaller, though still significant.

**Phytosanitary Risk**
***Entry potential:*** Medium - isolated from Australia, but readily transmitted on infected planting material.
***Colonisation potential:*** High in all sugarcane-growing areas.
***Spread potential:*** High, unless strict controls imposed over movement of infested material.
***Establishment potential:*** Depends on biotype introduced (see Match Indexes for climates at selected locations and principal Australian areas below).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Match index
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Murwillumbah
Grafton
Nambour
Warri, Nigeria
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Murwillumbah
Nambour
Grafton
Kampala, Uganda
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Innisfail
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Murwillumbah
Ayr
Cairns
Ingham
Grafton
Kununurra
Moshi, Tanzania
Match Index
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Ingham
Mareeba
Ayr
Cairns
Innisfail
Mackay
Bundaberg
Murwillumbah
Nambour
Grafton
Kununurra
ZSA Station, Zimbabwe
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Mareeba
Ayr
Ingham
Cairns
Bundaberg
Innisfail
Nambour
Murwillumbah
Grafton
Mackay
Kununurra

***Chilo infuscatellus* Snellen**

*Chilo infuscatellus* Snellen 1890: 94; Shibuya 1928b: 54; Bleszynski, 1962b: 111; 1965: 116; 1969: 15.
*Argyria sticticraspis* Hampson 1919: 449; Gupta 1940: 788; Isaac & Rao 1941: 799; Isaac & Venkatraman 1941: 806 [syn. Kapur 1950].
*Argyria coniorata* Hampson 1919: 449 [syn. Fletcher 1928].
*Diatraea calamina* Hampson 1919: 544 [syn. Kapur 1950].
*Diatraea auricilia* (Dudgeon): Fletcher & Ghosh 1920: 387.
*Diatraea shariinensis* Eguchi 1933: 3 [syn. Kapur 1950].
*Chilo tadzhikiellus* Gerasimov 1949: 704.
*Proceras infuscatellus* (Snellen): Kalshoven 1950: 413.
*Chilotraea infuscatellus* (Snellen): Kapur 1950: 404.

**Types**
*infuscatellus:* Lectotype male, Java, in Museum van Natuurlijke Historie, Leiden.
*sticticraspis*: Holotype female, Coimbatore, India, in Natural History Museum, London.
*coniorta:* Lectotype male, Pusa, India, in Natural History Museum, London.
*calamina*: Lectotype female, Kinuya, Burma, in Natural History Museum, London.
*shariinensis:* Lectotype female, Shariin, Korea, in Natural History Museum, London.
*tadzhikiellus:* Lectotype male, Tadzhikistan, in Zoological Institute, St Petersburg.

**Common names**
Shoot borer, early shoot borer, sugarcane stemborer, sugarcane shoot borer, yellow top borer, striped stemborer.

**Distribution**
Afghanistan, Bangladesh, Burma, China, India, Indonesia, Korea, Malaysia, Nepal, Pakistan, Papua New Guinea, Philippines, Sri Lanka, Tadzhikistan, Taiwan, Thailand, Timor, Vietnam (Carl 1962; Bleszynski 1970; CAB 1972; Chundurwar 1989; David & Easwaramoorthy 1990; Harris 1990; Neupane 1990).

**Host plants**
*Chilo infuscatellus* is a key pest of sugarcane, but also attacks maize, millet, sorghum, rice, barley, oat, juar (*Andropogon sorghum*), rarhi and batri (*Saccharum spontaneum*), ikri (*Saccharum fuscum*), *Rottboellia compressa*, *Cynodon dactylon*, *Echinochloa colonum*, *Cyperus rotundus*, *Panicum* spp. and Jove grass (*Rottboelia compressa*) (Bleszynski 1970).

**Symptoms**
*Chilo infuscatellus* damages the crop during the shoot stage as young larvae first feed on the outer leaves of sugarcane plants. The larvae then tunnel into the stem as third instars (Easwaramoorthy & Nandagopal 1986; Harris 1990; Kuniata 1998).

**Economic impact**
*Chilo infuscatellus* causes considerable losses during the early periods of sugarcane growth in India, mainly during the summer months (Nagalakshmi *et al.* 1999). Due to heavy infestations with this pest, the Bihar State Planning Board of India declared North Bihar to be an endemic area for *C. infuscatellus* (Kumar *et al.* 1987). However, Sardana & Sahi (2000) stated that a decline in the incidence of *C. infuscatellus* is evident in the north western zone of Haryana, India. They showed that, during 1989-96, the pest incidence was above 20%, then declined sharply to about 3.0-4.0% in the following 4 years. In addition, eight sugar mill zones of Haryana, India, were surveyed on the basis of the presence of dead hearts as an indication of *C. infuscatellus* infestation in June 1993. Results showed that the highest percentage of damaged tillers were in the mill area of Rohtak (7.7%), followed by Karnal (5.9%), Shahbad (5.0%), Kaithal (4.9%) and Sonipat (4.5%). Damage in other zones was 3% or less, and overall incidence of the pest in the state was less than 4.5% (Saini *et al.* 2000). Similar observations were made by Singh *et al.* (1998), who tested some 40 sugarcane varieties for shoot borer incidence at the Research Farm of the Sugarcane Research Institute, Shahjahanpur, India, as well as in the field, during 1995-98. They recorded

low infestation incidences of the shoot borer, ranging from 2-5.3%. These results suggest that the pest has changed status to be a minor pest of less economic importance in sugarcane fields in India.

In Taiwan, Cheng (1999) recorded damage rates of 0.78±0.29% internodes in autumn cane and 1.55±0.46% in spring cane due to *Chilo infuscatellus*.

This species is considered to be a minor pest of sugar cane at Ramu and on Vulcan Island (PNG) where it attacks young plants and ratoon cane shoots (Li 1990).

**Morphology**

***Adults***

Bleszynski (1970) gives the following description of *C. infuscatellus*: Ocellus well developed. Labial palpus 3 (male) to 3.5 (female) times as long as diameter of eye. Face rounded, slightly protruding forward beyond eye; Fore wing: length 10.0-13.0 mm; $R_1$ confluent with *Sc*; ground-colour and maculation very variable, dull, from light sand-yellow to chocolate-brown; discal dot present or variably reduced; transverse lines present or absent; terminal dots present; metallic scales absent. Hind wing dirty white (male) to silky white (female).

***Male genitalia*** (Fig. 27): Pars basalis slight: juxta-plate symmetrical, arms reaching the basal-costal angle of valva; each arm provided with a toothed strengthening; aedeagus with strong ventral swelling; a single, tapering, curved, large cornutus present.

***Female genitalia*** (Fig. 30): Ostial pouch well demarcated from ductus bursae, heavily sclerotized, deeply incised anteriorly; signum lamellate with median ridge.

**Detection methods**

In young plants, inspect growing point and young leaves. Check for stemboring activity around and near the internodes.

**Biology and Ecology**

*Chilo infuscatellus* infests cane plants mainly at the shoot stage (and up to the 17$^{th}$ week of planting) (Pandya & Patel (2007a). The pest typically has five generations a year, entering a diapause during winter in northern India, while in southern India the pest is present through out the year, resulting in six generations a year (Harris 1990). Adults mate within 24 hours of emergence, usually between 20:00 and 24:00. Gravid females oviposit on the underside of the leaf surface, and usually the largest number of eggs is laid on the first day of oviposition. In Northern India, fecundity of adult female moths varies from 201.2 to 252.0 eggs/female and incubation period of eggs ranges from 5-9 days. Early instars feed on the outer leaves and third instars tunnel into the stems. Total larval period ranges between 26.2 to 145.4 days, and pupal stage is about 7.7-19.2 days (Saikia *et al.* 1996). The life cycle lasts 4-6 weeks and high temperature and humidity favour multiplication. In Southern India, studies by Kumar *et al.* (2004) in Tirupati, Andhra Pradesh, reveal a higher egg laying capacity of adult females (320 – 350 eggs/female), a shorter incubation period of 4.36 – 4.44 days, a shorter larval period of 16.68 – 17.10 days and a shorter pupation period (6.94 – 7.16 days) compared to the previous study. The same authors recorded longevity of male and female moths to vary from 3.60 to 3.82 and 4.32 to 4.46 days, respectively, with a male: female sex ratio of 1:1.92 and a total period from egg to adult of 31.96 – 32.63 days.

In the Nizamabad district of Andhra Pradesh, India, the main build up of the population takes place in April and reaches a peak in May. The pest's activity starts declining afterwards in August and succeeding months, with the existence of a small population until harvest which facilitates carry over from one crop to another (Singh & Varma 1995). In Haryana, India, *C. infuscatellus* infestation starts in mid April in ratoon crops and in early May in planted crops, and reaches a peak at the end of June, when average maximum temperatures is around 31.4-41.4°C, minimum temperatures 17.7-28.5°C and relative humidity 27-62%. Infestation becomes negligible by the end of July to mid-August, and pest incidence is not correlated with rainfall (Mahla & Chaudhary 1992). Field experiments were conducted in Tamil Nadu, India to study the effect of time of planting on early shoot borer infestation and cane yield. The authors recorded that January-planted sugarcane had the highest cane yield (89.22 t/ha) and the lowest shoot borer incidence (10.02%). The authors found that *C. infuscatellus* mainly affected the sugarcane shoot stage from March to May, but the losses caused by the pest were partly compensated by the higher sugar recovery

obtained for this period of planting compared to planting during the rainy season. The authors therefore recommended avoiding the planting of sugarcane from March to May (Thirumurugan *et al.* 2001).

Jena *et al.* (1997) showed that infestation levels were positively and significantly correlated with maximum, minimum and mean temperature, while rainfall had no effect on the infestation level. In addition, Parsana *et al.* (1994) found that the highest rate of dead hearts occurring due to *C. infuscatellus* was recorded where minimum level of irrigation (0.4 CPE) were used, while as levels of irrigation increased with the drip system, *C. infuscatellus* damage decreased. This agrees with (Singla & Duhra 1990) who showed that, in Punjab, higher planting density increased the incidence of *C. infuscatellus* when the crop was irrigated at, and after, an interval of 8-10 days. Similarly, Kumar *et al.* (2007) in Andhra Pradesh recorded lower incidence of the pest (23.79 and 18.23%) when wider cane planting spacings of 120 and 150 cm were followed, and a higher pest incidence (41.50 and 34.89%) when narrow spacings 60 and 90 were followed.

At Faisalabad, Pakistan, populations of *C. infuscatellus* reaches a peak in late May, with maximum temperature (34-37°C), minimum temperature (20-27°C) and RH (52-70%) being conducive to the building up of the pest population (Rana 1997), while in Uttar Pradesh, India, the incidence of *C. infuscatellus* was highest in the spring planted crop and negligible in the late spring planted crop (Singh *et al.* 1997). In Gujarat, the pest was observed from January to June and November to December (Pandya *et al.* 1996), similarly in South Gujarat, both *C. infuscatellus* and *Scirpophaga excerptalis* occur sympatrically in cane fields during January-April (Pandya *et al.* 1995). Additionally, Tanwar & Bajpai (1993) showed that *C. infuscatellus* incidence was positively correlated with maximum temperature in Sardarnagar, Gorakhpur, Uttar Pradesh, India. Sardana & Kumar (1992) recorded higher borer infestation in saline soil compared to non-saline conditions.

In Karnal, India, Sardana (1998a) estimated the economic injury level for *C. infuscatellus* in early sugarcane, using Sevidol (carbaryl + lindane) as an insecticide, to be 16.8%. A similar EIL was determined by Mishra *et al.* (1998) in Orissa, India, to be 15.46%. The pest follows a negative binomial distribution pattern and exhibits an aggregated pattern of distribution, probably due to environmental heterogeneity in the area of study. Sardana (1997) showed that the five quadrants of the field (north, south, east, west and central) did not differ in borer population. Based on values of the intrinsic rate of natural increase, the optimum constant laboratory temperature for *C. infuscatellus* was determined at 30-35. The favourable range under both constant and fluctuating conditions was 27.5-35.0 ±1°C. The mean generation time varied from 30 to 40 days within this range. The intrinsic rate of natural increase fell to a minimum above 40 and below 25°C (Mahla & Chaudhary 1990).

Prolongation of the crushing period leading to delayed harvesting, availability of early ratoon sprouts for oviposition and late tillers left unharvested were the most important factors favouring the carry over of the pest from one season to another. Fifth generation populations were active from the first week of November to the second week of March (Saikia & Roy 1998).

In Zhanjiang, Guangdong, China, heavy infestations of *C. infuscatellus*, *Tetramoera schistaceana* and *C. sacchariphagus* were recorded in sugarcane in recent years, with an average infestation rate of 25-29%, and reaching a maximum of 98%. The three species occur coincidentally in space and time, mainly on the 3-15 internodes of sugarcane plants (LiangZhen *et al.* 2000).

In a study of cane resistance to *Chilo infuscatellus*, it was found that the variety that had the greatest sucrose content (22%) was also the most susceptible and sustained the highest percentage of tunnelling (22.62%) (Karnatak *et al.* 1999).

Natural control of *C. infuscatellus* by means of parasitoids was studied at the Taiwan Sugar Research Institute Experiment Station during the period from 1984-94. Of 1975 larvae collected, 15, 9, and 8 larvae were parasitized by *Meloboris sinicus*, *Cotesia flavipes* and *Microbracon chinensis* (*Amyosoma chinense*), respectively. Only one pupa was parasitized by *Xanthopimpla stemmator* of the 202 pupae obtained. During the young cane stage (from the first half of March to the last half of May), 1.9-10.6% of larvae were parasitized, while few parasitoid were found from June to August. However, percentage parasitism

seems to be higher in the growing stage (early September to early November), ranging from 8.3 to 15.4% parasitism, and numbers of larvae and pupae was recorded to decline gradually until harvest (Cheng *et al.* 1999).

**Natural Enemies**

***Parasitoids***

***Allorhogas pyralophagus* (Hymenoptera: Braconidae**) Larval parasitoid native to Mexico. Reported to have been introduced into India for the control of the stemborer complex but did not seem to have established (Varma *et al.* 1987; Shenhmar *et al.* 1990; Easwaramoorthy *et al.* 1992).

***Apanteles phytometrae* Wilkinson (Hymenoptera: Braconidae):** Larval parasitoid, recorded in India (Butani 1972).

***Aprostocetus* sp. (Hymenoptera: Eulophidae):** Pupal parasitoid recorded from India (Butani 1972).

***Brachycoryphus nersei* Cameron (Hymenoptera: Ichneumonidae)**: Pupal parasitoid. Recorded attacking *C. infuscatellus* in Orissa, India (Butani 1972).

***Bracon chinensis* Szepligetti (Hymenoptera: Braconidae):** Larval parasitoid. Attacks *C. infuscatellus* in India (Box 1953; Butani 1972), Taiwan (Box 1953) and the Philippines (Box 1953).

***Chelonus munakatae* (Hymenoptera: Braconidae):** Egg-larval parasitoid. Releases of this parasitoid were made in China during 1975-1983 for the control of *C. infuscatellus* (Li 1985).

***Campyloneurus mutator* Fabricius (*Pycnobracon mutator*) (Hymenoptera: Braconidae):** Larval parasitoid, Recorded attacking a range of *Chilo* species in India (Butani 1972).

***Centeterus alternecoloratus* Cushman (Hymenoptera: Ichneumonidae)**: Parasitoid on a range of *Chilo* species in maize in India. Reared successfully in the laboratory on *C. infuscatellus* (Butani 1972).

***Cotesia flavipes* (Cameron) (Hymenoptera: Braconidae):** A gregarious larval endoparasitoid. This species is recorded attacking medium and large size *C. infuscatellus* larvae in Taiwan (Cheng *et al.* 1987), India (Butani, 1958; Butani 1972; Maninder & Varma 1982; Srikanth *et al.* 1999), Pakistan (Mohyuddin, 1991) and Philippines (Box 1953). Two strains of this parasitoid were examined in 1993 and 1994 for the control of *C. infuscatellus*, *C. auricilius* and *Acigona steniellus* (*Bissetia steniella*) on sugarcane in the Punjab, India. A total of 800 adult parasitoids/ ha were released from April to October at 10-day intervals. Where the indigenous strain was released, average incidence of *C. infuscatellus* was 7.1%, while it was 15.3% where the Indonesian strain was released, compared to 16.5% where no releases had been made. Therefore the indigenous strain proved more effective than the Introduced one (Shenhmar & Brar 1996). In Pakistan, *C. flavipes* became established on the maize pest *Chilo partellus* following its introduction from Japan in 1962, but seldom attacked *C. infuscatellus*. Therefore, the existence of strains of *C. flavipes* was proposed, with different strains preference for different hosts and host plants. Shami & Mohyuddin (1992) reared *C. flavipes* on *C. infuscatellus* fed on sugarcane in the laboratory for 5 successive generations, and recorded a change in preference from maize to sugarcane. The preference changed back from sugarcane to maize in 5 generations again when the sugarcane-adapted strain was reared on *C. partellus* fed on maize.

***Drapetis* sp. (Diptera: Empididae):** Recorded from *C. infuscatellus* larvae from Orissa, India (Butani 1972).

***Exorista quadrimaculata* Baranov (Diptera: Tachinidae):** Larval parasitoid, Recorded attacking *C. infuscatellus* in Mysore, India (Butani 1972).

***Goniozus indicus* Ashmead (Hymenoptera: Bethylidae)**: A gregarious larval endoparasitoid. This species has a very wide range of stemborer species, Recorded attacking *C. infuscatellus* in sugar cane fields in India (Box 1953; Butani 1972).

***Goniozus* sp. (Hymenoptera: Bethylidae)**: Larval parasitoid. Recorded from the Philippines (Box 1953) and Taiwan (Cheng 1986; Cheng *et al.* 1987).

***Gotra marginata* Brulle (*Listrognathus marginatus* WLK.) (Hymenoptera: Ichneumonidae):** Reported to be an active larval parasitoid on *C. infuscatellus* during March to October in Bihar, India (Butani 1972).

***Horogenes lineata* Ishida (Hymenoptera: Ichneumonidae):** Larval (?) parasitoid, recorded from Taiwan (Box 1953).

***Isotima* sp. (Hymenoptera: Ichneumonidae):** Larval parasitoid, recorded on *C. infuscatellus* in Pakistan (Carl 1962), the Philippines (Alba 1989) and India (Tuhan & Pawar 1983).

***Macrocentrus jacobsoni* Szépl. (Hymenoptera: Braconidae):** Larval parasitoid. Recorded attacking *C. infuscatellus* larvae in sugarcane fields in Taiwan (Box 1953).

***Melcha ornatipennis* Cameron (Hymenoptera: Ichneumonidae):** Pupal parasitoid, common in the whole of Northern India. It is active from July to October and requires about 17-18 days to complete its life cycle (Butani 1958).

***Meloboris sinicus* (Holmgren) (Hymenoptera: Ichneumonidae):** Larval parasitoid. Recorded to give 4.7% parasitism of *C. infuscatellus* in sugarcane fields in Taiwan (Cheng *et al.* 1999).

***Mepachymerus* (*Stellocerus*) *tenellus* (Diptera: Chloropidae) Becker**: Recorded attacking larvae of *C. infuscatellus* in sugar cane fields of Orissa, India (Butani 1972).

***Microbracon chinensis* Taiwan (Hymenoptera: Braconidae)**: Larval parasitoid. Recorded in Taiwan (Cheng *et al.* 1987).

***Stenobracon deesae* Cameron (Hymenoptera: Braconidae)**: Larval parasitoid: Found in China, India, Pakistan, and was introduced into Africa and Indian Ocean Islands. Attacks *C. infuscatellus* larvae in sugar cane fields in India (Box 1953; Butani 1958) and Pakistan (Carl 1962).

***Stenobracon nicevillei* Bingham (Hymenoptera: Braconidae):** Larval parasitoid, attacks a range of *Chilo* species in India, Nepal, Sri Lanka, also introduced into Madagascar and Reunion but apparently without success. Attacks *C. infuscatellus* larvae in sugarcane fields in India (Butani 1958).

***Stenobracon trifasciatus* Szépl. (Hymenoptera: Braconidae):** Larval parasitoid**.** Recorded attacking *C. infuscatellus* larvae in sugarcane fields in Taiwan and Indonesia (Box 1953).

***Sturmiopsis inferens* Townsend (Diptera: Tachinidae):** In Tamil Nadu, India, a single adult female parasitoid of this species is recorded to larviposit an average of 285 larvae with an average of 1.21 larvae per host. More than 70% of the larvae are laid at the bore hole made by the host larvae in sugarcane seedlings. Larviposition began on the sixth day after emergence of the female and mating reached its peak after 7-11 days. Number of larvae laid at a bore hole varies from 1 to 9. *S. inferens* prefers third-, fourth- and fifth-instar pyralid larvae and shoots with only wet frass. Larviposition could also occur in shoots with second-instar larvae and freshly formed pupae (David *et al.* 1988; David *et al.* 1989; Easwaramoorthy *et al.* 1999).

***Sturmiopsis* (*Winthemia*) *semiberbis* Bezzi (Diptera: Tachinidae):** Larval parasitoid, Recorded attacking *C. infuscatellus* and other *Chilo* and *Sesamia* species in Mysore, India (Butani 1958).

***Telenomus beneficiens* (Zehntner) (Hymenoptera: Scelionidae):** Recorded attacking *C. infuscatellus* eggs in India (Butani 1972) and Taiwan (Box 1953).

***Telenomus dignoides* Nixon (Hymenoptera: Scelionidae):** Egg parasitoid, found allover India on a number of *Chilo* species including *C. infuscatellus* (Butani 1972).

***Tetrastichus ayyari* Rohwer (Hymenoptera: Eulophidae)**: Pupal parasitoid recorded from Tamil Nadu and Mysore, India (Butani 1972).

***Tetrastichus israeli* Mani (Hymenoptera: Eulophidae):** Pupal parasitoid, India (Butani 1972).

***Tetrastichus schoenobii* Ferriere (Hymenoptera: Eulophidae):** Egg parasitoid recorded in India (Butani 1972).

***Tetrastichus* sp. (Hymenoptera: Eulophidae)**: Recorded from Bombay, Mysore and Tamil Nadu, India (Butani 1972).

***Trichogramma australicum* Girault:** India (Butani 1972).

***Trichogramma evanescens minutum* Riley:** India (Butani 1958).

***Trichogramma chilonis* (*T. confusum*):** Releases of this parasitoid in cane fields in Pakistan reduced borer infestation (Mohyuddin 1991; Ashraf *et al.* 1995; Ashraf & Fatima 1996). In Faisalabad, Pakistan, the release of 60000 eggs parasitized by *T. chilonis* per acre resulted in 83% reduction in *C. infuscatellus* infestation (Shahid *et al.* 2007). Other studies also in Faisalabad showed that the release of *T. chilonis* at 20000 eggs/acre reduced *C. infuscatellus* infestation down to 6.75% and 6.40% in 2002 and 2003 respectively (Rana *et al.* 2007). Lower infestation rates (5.00% & 4.33%) were recorded in plots where trash mulching was also implemented in addition to parasitoid release. This parasitoid species is also recorded from Nepal (Neupane 1990), Taiwan (Cheng *et al.* 1987), China (Liu *et al.* 1996), and Philippines (Javier & Gonzalez 2000). In Karnataka, India, the release of 250,000 *T. chilonis*/ha over five dates commencing 30 days after transplanting gave similar control results to the treatment of Sevidol as a whorl application at 30 days after transplanting (Patil *et al.* 1996b). While nine releases of a temperature tolerant strain (PDBC) and a Punjab strain (Ludhiana) at 50000 parasitoids/ha were as effective as application of cartap hydrochloride (Padan 4G) at 25 kg/ha in reducing the incidence of *C. infuscatellus* by 52.7 and 50.5% over untreated control, respectively (Singh *et al.* 2007).

***Trichogramma chilotraeae*:** In Thailand, this species was mass reared on *Corcyra cephalonica* and released over an area of 100 rai (6.25 rai = 1 ha) at a rate of 50 000/rai on a weekly basis for 8 weeks in

1983-84. After 8 weeks the percentage of deadheart was reduced from 12 to 4% compared to 10% damage in untreated fields (Meenakanit *et al.* 1988).
***Trichogramma japonicum* Ashmead:** India (Butani 1972), Indonesia (Girault 1914; Box 1953), Taiwan (Box 1953) and Pakistan (Hashmi & Rahim 1985).
***Trichogramma minutum* Riley:** India (Box 1953).
***Trichogramma nagarkattii*:** China (Guo 1988).
***Trichogrammatoidea nana* Zehntner:** India (Butani 1958; Butani 1972).
***Trichogramma nanum* Zhnt.:** India and Indonesia (Box 1953).
***Trichogramma nubilale*:** In China, rates of 7500 parasitoids/ha of this parasitoid released in sugarcane plantations reduced incidence of dead heart due to *C. infuscatellus* to 4.0% compared to 7.2% in untreated fields. Rates of parasitism ranges between 58.6% and 70.0% during April-August (Guo 1988).
***Trichogramma* sp.:** Philippines (Alba 1991).
***Tropobracon schoenobii* (Viereck) (Hymenoptera: Braconidae)**: Larval parasitoid. Attacks *C. infuscatellus* and other stemborers in sugarcane and paddy rice fields in India (Butani 1972).
***Xanthopimpla punctata* Fabricus (Hymenoptera: Ichneumonidae):** Pupal parasitoid, India (Butani 1972).
***Xanthopimpla stemmator* Thunberg (Hymenoptera: Ichneumonidae):** Pupal parasitoid, recorded from Taiwan (Sonan 1929; Cheng *et al.* 1987) and India (Butani 1972).
***Vipio deesae* (Cameron) (Hymenoptera: Braconidae):** Larval parasitoid. Common all over India on *Chilo* and *Sesamia* species in sugarcane (Butani 1972).

**Mermithid nematodes - *Hexamermis cathetospiculae*:** Malaysia (Poinar & Chang 1985) and ***Amphimermis* sp.:** Pakistan (Carl 1962).

***Predators***
***Micraspis univittata* (Hope) (Coleoptera: Coccinellidae):** Prey range studies in Bihar, India, revealed that both larval and adult stages of this species can feed on eggs and young larvae of *C. infuscatellus* (Easwaramoorthy *et al.* 2001a).
***Hippasa greenalliae* (Blackwell) (Aranea: Lycosidae):** Predatory spider recorded from India (Easwaramoorthy *et al.* 1996).
***Oxyopes shweta* (Aranea: Oxysposidae):** Predatory spider recorded from India (Easwaramoorthy *et al.* 1996).

***Pathogens***
***Beauveria* nr. *bassiana*** Second- and third-instar larvae of *C. infuscatellus* were highly susceptible (51.47 to 65.2%) to this fungus even at a low dosage ($10^5$ or $10^6$ spores/mL). mortality reached 68.53-75.93% at $10^7$ spores/mL. Larval mortality decreased with age increase or decrease in spore concentration. The fungus took less time to cause mortality in 2nd instar larvae (Sivasankaran *et al.* 1990).
***Nosema infuscatellus***: China (Wen & Sun 1989).
**Granulosis virus (GV):** India (Easwaramoorthy & David 1979; Easwaramoorthy & Jayaraj 1987).
***Bacillus thuringiensis***: Tamil Nadu, India (Kesavan *et al.* 2003).

Nematode species *Heterorhabditis indica* (LN2), *H. bacteriophora* (German isolate) and *Steinernema glaseri* (Australian isolate) caused 100% mortality of the pest in laboratory studies (Sankaranarayanan *et al.* 2003).

**Management**
***Chemical Control***
In India, the standard chemical control against *C. infuscatellus* is the use of Sevidol 4:4 Sevin (carbaryl) + gamma BHC (lindane) granules. Other control methods include soil incorporation of Padan (cartap) and fipronil as a prophylactic application. Sprays of Lindane, fipronil and Padan were also effective (Nagalakshmi *et al.* 1999). Residues of lindane (0.5-2.0 kg/ha) in soil of sugarcane were still found after 180 days, with a half life of 45-55 days (Singh & Singh 1997). In the Indian Punjab, Cartap hydrochloride and Endosulfan applied after germination gave good control of the pest (Duhra 1999). In Orissa, India, one to six applications of 0.4 kg monocrotophos a.i./ha between 30 and 105 days after emergence resulted in a low percentage of dead hearts (6.2%) and high cane yields (110.7 t/ha) (Mishra *et al.* 1998). Other

effective treatments are carbofuran at 1.5 kg a.i./kg, phorate 10 G, aldrin 30 EC and aldrin 5% dust (Jena *et al.* 1994a). Application of cypermethrin (0.02%) or decamethrin (deltamethrin) (0.0056%) applied at 30-75 days after planting results in satisfactory results (David & Ramachandran 1990). Application of carbofuran 3G at the rate of 1.0 kg a.i./ha 15 and 45 days after germination is recommended in Nayagarh, Orissa, India (Jena & Patnaik 1997a). In Pusa, India, soil application of lindane granules at 0.5, 1.0, 1.5 and 2.0 kg a.i./ha reduced *Chilo infuscatellus* infestation by 79.24% (Singh & Singh 1998). In Cuddalore, chlorpyrifos 10% as granules at 1.0 and 1.5 kg/ha gave 39.5 and 50.9% reduction in borer infestation and increased cane yield (Rajendran 1999b). While in trials in Vuyyuru, Andhra Pradesh, Jhansi & Rao (2004) recorded the lowest incidence of the shoot borer (4.80%) when trash mulching was implemented in addition to spraying with endosulfan at 0.07% at 4, 6 and 9 weeks after planting.

Furadan 3G (carbofuran) at 12 kg/ac, Padan 4G (cartap) at 9 kg/ac, Basudin 10G (diazinon) at 9 kg/ac and Thimet 5G (phorate) at 10 kg/ac all gave good control of *C. infuscatellus* in study plots in Tandojam, Pakistan, with Furadan achieving the highest mortality levels (Talpur *et al.* 2002).

Sett treatment with Imidacloprid, and sett and soil treatment with Amrutguard (neem-based insecticide) offered a degree of protection against termite species (*Odontotermes obesus* and *Microtermes obesi*) as well as early shoot borer in Haryana, India (Jaipal & Singh 2003).

In Bangladesh, application of granules of cartap (Padan) at 3 kg a.i./ha in both July and August gave satisfactory control of the stemborer complex, including *C. infuscatellus* (Miah *et al.* 1983).

In China, a mixture of trichlorfon and dimehypo applied to the whirl of cane plants gave 72.1-83% control (Guo *et al.* 2000).

***Plant extracts***

In Melalathur, India, various plant extracts were tested against *C. infuscatellus* and the spraying of neem (*Azadirachta indica*) seed kernel extract (NSKE) at 5% on day 30 and 59 after planting was effective, giving an 18.2% reduction in shoot borer incidence. Sugar yield in the NSKE 5% treatment gave similar results to Prosophis 5% extract and monocrotophos at 0.04% (Thirumurugan *et al.* 2000). Solayappan *et al.* (2000) recorded that NEMENTO, which is a combination of neem seed kernel extract and leaves of *Mentha spicata* and tobacco, was most effective at 5% in promoting germination and reducing infestation. More recent studies in Melalathur, Tamil Nadu, recorded that sugarcane plots treated with neem cake at 250 kg/ha had less cumulative *C. infuscatellus* incidence compared to untreated plots (Thirumurugan & Koodalingam 2005). While a field experiment in Tamil Nadu showed that, during the first 2 months after planting, the application of neem cake (basal application at 500 kg/ha) + neem seed kernel extract (5% spray) reduced shoot borer infestation to 27.7 and 29.4%, compared to 41.3% when Endosulfan was used (Rajendran 2001).

Application of acetone extracts of *Vitex negundo* leaves collected from Kanchipuram, Tamil Nadu, India, resulted in mortality levels of *C. infuscatellus* of up to 64.29% in the filed (Solayppan *et al.* 2002).

***Time of Planting***

In Orissa, India, Jena & Patnaik (1996) showed that planting of sugarcane from January to April resulted in 13.04-24.84% dead hearts 105 days after planting due to *C. infuscatellus* infestation, while planting during June-October reduced pest infestation to 1.54-5.45%. Infestation increased again when planting took place during November-December (5.08-10.56%). However, in the clay loam soil of the Sugarcane Research Station, Tamil Nadu, India, January-planted sugarcane had the highest yield (89.22 t/ha) and the lowest shoot borer incidence (10.02%). Similarly, in the Chittoor district of Andhra Pradesh, Kumar *et al.* (2007) recorded that the January-planted crop suffered lower cumulative incidence (34.73%) of *C. infuscatellus* than the February and March-planted crops.

Although *C. infuscatellus* borer mainly affected the shoot stage from March to May, the higher sugar recovery obtained due to January planting outweighed the pest damage. Therefore, it was suggested that planting from March to May (the rainy season) should be avoided as a management tool (Thirumurugan *et al.* 2001). Similarly, (Jhansi & Rao 1996) showed that delaying the planting date leads to reductions in

percentage of juice sucrose and cane yield. In Uttar Pradesh, Pandey *et al.* (1994) recommended planting at the end of April to minimize *C. infuscatellus* infestation.

***Intercropping***

Contradictory results were recorded regarding the use of intercropping in management of *C. infuscatellus*. In Karnal, India, Sardana (2000a) tried intercropping cane with green gram, cowpea, pigeon pea, sunflower, maize, sorghum, okra, mint, black gram and sun hemp (*Crotalaria juncea*). Results showed that borer incidence was higher in the sugarcane monoculture (13.7%), compared to intercropped cane (7.5-13.0%) in 1997-1998 crop, but borer incidence was significantly lower only with the maize and green gram intercrops. In the following crop (1999-2000), the green gram, black gram and sun hemp treatments recorded significantly lower incidences of the borer (1.4-1.8%), compared to the monoculture (10.8%). It was concluded based on this and other observations that only green gram was found to significantly reduce the incidence of *C. infuscatellus*. Additionally, in Uttar Pradesh, India, intercropping with the spice crops, coriander, onions, garlic, methi (fenugreek), saunf (*Foeniculum vulgare*), mangrail (*Nigella sativa*) and ajawain (*Trachyspermum copticum*) reduced the incidence of *C. infuscatellus* on sugarcane from 8.87% to 1.60-2.86% according to the spice intercrop (Varun *et al.* 1994). Other records from Tamil Nadu, India, showed that intercropping of black gram (*Vigna mungo*), green gram (*V. radiata*) or soybean reduced *C. infuscatellus* damage, with green gram being the most effective, reducing infestation by a maximum of 51%, followed by black gram (31%) and soybean (18%) (Rajendran *et al.* 1998). However, Srikanth *et al.* (2000) showed that intercropping cane with black gram, cowpea, green gram and soybean did not reduce infestation by *C. infuscatellus*. Shoot borer incidence was significantly higher in 25 day and 65-day-old sugarcane-soybean intercrop plots than in sugarcane monocrop plots of corresponding age. However, the differences were not significant in a 30-day-old crop, while numbers of natural enemies did not differ between intercropping and monocropping. Recent studies in Nadia, West Bengal, India, showed that borer damage was significantly lower in plots where coriander was used as an intercrop with sugarcane (Giri 2005), while in Bagalkot, Karanataka, Rachappa & Naik (2004) recorded the highest activity of the egg parasitoid *Trichogramma chilonis* in plots where sugarcane was intercropped with coriander.

***Pheromone Trapping***

In China, the use of the electroantennogram recording technique indicated that the major attractive component in the abdominal tips extracts from *C. infuscatellus* females was (Z)-11-hexadecen-1-ol (Wu *et al.* 1984). In Taiwan, sticky traps baited with 13 mg of (Z)-11-hexadecenol and placed at the height of 0.2 m attracted a daily average of 1.6 males per trap, while baited sticky and water-pan traps, placed at 0.2 m height resulted in a daily average of 0.65 and 0.36 males per trap, respectively (Chen *et al.* 1993).

***Varieties and Plant Resistance***

There are numerous studies on variety tolerance and breeding for resistance to a range of moth borers in India and Pakistan (see for example Gul *et al.* 2002; Kumar *et al.* 2002; Bhoopathi R & Karnatak AK. 2003; Taleb & Rahman 2004; Abdullah *et al.* 2006; Chaudhary & Jaipal 2008). In a study in Tamil Nadu, Subramanian *et al.* (2004) found that the plant's leaf angle is negatively correlated with pest incidence. Other studies revealed that a thick sclerenchymatous layer of the leaf sheath, shorter vascular bundle distance, higher compressive strength of the stalks and higher tillering ability were the factors responsible for resistance to the pest. It was also found that greater silica, potassium, magnesium, phenol and ascorbic acid contents, smaller quantities of amino nitrogen and chlorophyll, and fewer aminoacids and organic acids increased resistance to *C. infuscatellus* in cane (Kennedy & Nachiappan 1992).

***Biological Control***

Not all biological control attempts against *C. infuscatellus* were successful; in 1981- 1982, two larval parasitoids were introduced to PNG from India by the Commonwealth Institute of Biological Control. These were *Bracon chinensis* (Szépl) and an Indian strain of *C. flavipes*, which appears to be physiologically and behaviourally different from the indigenous strain in PNG. A number of 10,000 parasitoids of *B. chinensis* and 22,000 of *C. flavipes* have been released in the Ramu Valley but neither of them seem to have became established (Li 1990).

A granulovirus (GV) that infects shoot borer larvae was found to be widely spread throughout Tamil Nadu in India. The virus causes 1.4-30% larval mortality in sugar fields of Coimbatore. In the laboratory,

treating *C. infuscatellus* eggs with the virus at doses of $10^5$ to $10^9$ inclusion bodies (IB) per mL, painted on with a brush, caused 26.3-81.2% mortality of hatchlings. Young larvae were also highly susceptible when fed on virus-contaminated diet (Easwaramoorthy & Santhalakshmi 2000). The application of $10^9$ or $10^8$ IBS of the virus reduced infestation by *C. infuscatellus* and increased cane yield in Madhya Pradesh (Choudhary & Singh 1998). Two sprays of granulosis virus at 10 IB/mL 30 and 45 days after planting gave equal control level to conventional pesticide treatment using Sevidol (carbaryl + lindane) 4:4G applied 30 days after planting (Patil *et al.* 1996a).

Laboratory studies on the nuclear polyhedrosis virus (GmNPV) of the wax moth (*Galleria mellonella*) at doses ranging from 2 x $10^7$ to 2 x $10^8$ POB/ml induced up to 94.4% mortality in *C. infuscatellus* (Parthasasathy & Rabindra 2002).

Treatment with *Beauveria* nr. *bassiana*, an entomopathogenic fungus, resulted in high mortality at and 25°C, which is the optimum temperature for maximum susceptibility of third instars larvae of *C. infuscatellus* to infection (Sivasankaran *et al.* 1990; Sivasankaran 1998).

In Tamil Nadu, India, 35 day old sugarcane plants were sprayed with *Bacillus thuringiensis* MG1 and MG2, *Bacillus sphaericus* GR, *Pseudomonas fluorescens*, *Beauveria bassiana* and granulosis virus (GV). The highest early shoot borer larvae reduction was observed in plots treated with MG2 (19.53%) and GV (19.68%) 1 day after spraying (DAS). At 15 DAS, the lowest early shoot borer incidence were recorded in GV (7.03%) and MG2 (7.34%) treated plots. Plots treated with *Beauveria bassiana* had the highest early shoot borer infestation at both one and 15 DAS (60.21 and 21.05%, respectively) (Mala & Solayappan 2001). In addition, *Bacillus thuringiensis* formulations (Delfin, Biobit, Dipel) were shown to result in good control of early shoot borer in sugarcane fields of Tamil Nadu, India (Kesavan *et al.* 2003).

***Integrated Pest Management Approach***

An Integrated Pest Management approach was described by (Jaipal 2000), where by the timing of irrigation (10-day intervals), application of recommended dose of urea and earthing up during formative phase, helped the crop escape shoot borer attack and improved crop vigour. Timely mechanical removal of top borer infested shoots or its egg masses and adults helped reduce the incidence by over 50 % in all the cultivars. Inundative releases of the egg parasitoid, *Trichogramma chilonis*, during July-October, helped reduce infestation of the stalk borer complex (*C. infuscatellus*, *Scirpophaga excerptalis* and *C. auricilius*) in sugarcane fields of subtropical India (Haryana). Similarly, in Orissa, India, a treatment schedule adopting trash mulching, frequent irrigation, earthing up and application of monocrotophos and the use of *T. chilonis* resulted in the lowest percentage infestation by the borer (Sharma *et al.* 1997). Also, harvesting during February, before the start of moth emergence, could reduce the population build-up in the succeeding crops in sugar cane fields in India (Saikia & Roy 1998). Cane trash mulch applied to a thickness of 10 cm on the ridges 3 days after planting cane on red loam soil in the Dharmapuri district of Tamil Nadu conserves soil moisture, suppresses weed growth and the incidence of *C. infuscatellus.* Treatment with trash mulch with additional $K_2O$ (60 kg/ha) is recommended for increased cane and sugar yields (Kathiresan *et al.* 1991).

Field trials in Cauvery delta region, Tamil Nadu, showed that intercropping sugarcane with daincha (*Sesbania aculeata*) in combination with treatment of pressmud (mill mud) at 12.5 t/ha + application of granulosis virus (GV) at $10^7$ POB/ml + neem seed kernel extracts at 5% (NSKE 5%) resulted in 68.23% reduction in pest incidence (Subramanian & Kannappan 2003).

A “maximum protection” treatment protocol in Navsari, Gujarat, used 0.1% dimethoate as sett treatment; 1 kg carbofuran/ha at 30 days after planting (DAP) and 1 kg phorate/ha at 60 DAP; 0.075% endosulfan at 120 DAP; 1 kg carbofuran/ha at 150 DAP; release of *Trichogramma chilonis* 7 times at 40000 parasites per hectare at 15 days interval beginning from 135 DAP and detrashing of lower leaves at 6, 7 and 8 months after planting. This method resulted in satisfactory management of *C. infuscatellus*, the top borer (*Scirpophaga excerptalis*), the root borer (*Polyocha depressella*), the internode borer (*Chilo sacchariphagus indicus*) and the stalk borer (*Chilo auricilius*) (Pandya & Patel 2007b). While in Tamil Nadu, an IPM approach was followed and included trash mulching on ridges with sugarcane dry ash 3-5 days after planting, the use of 20% more sett rate over the conventional sett rate of 75000/ha for late season

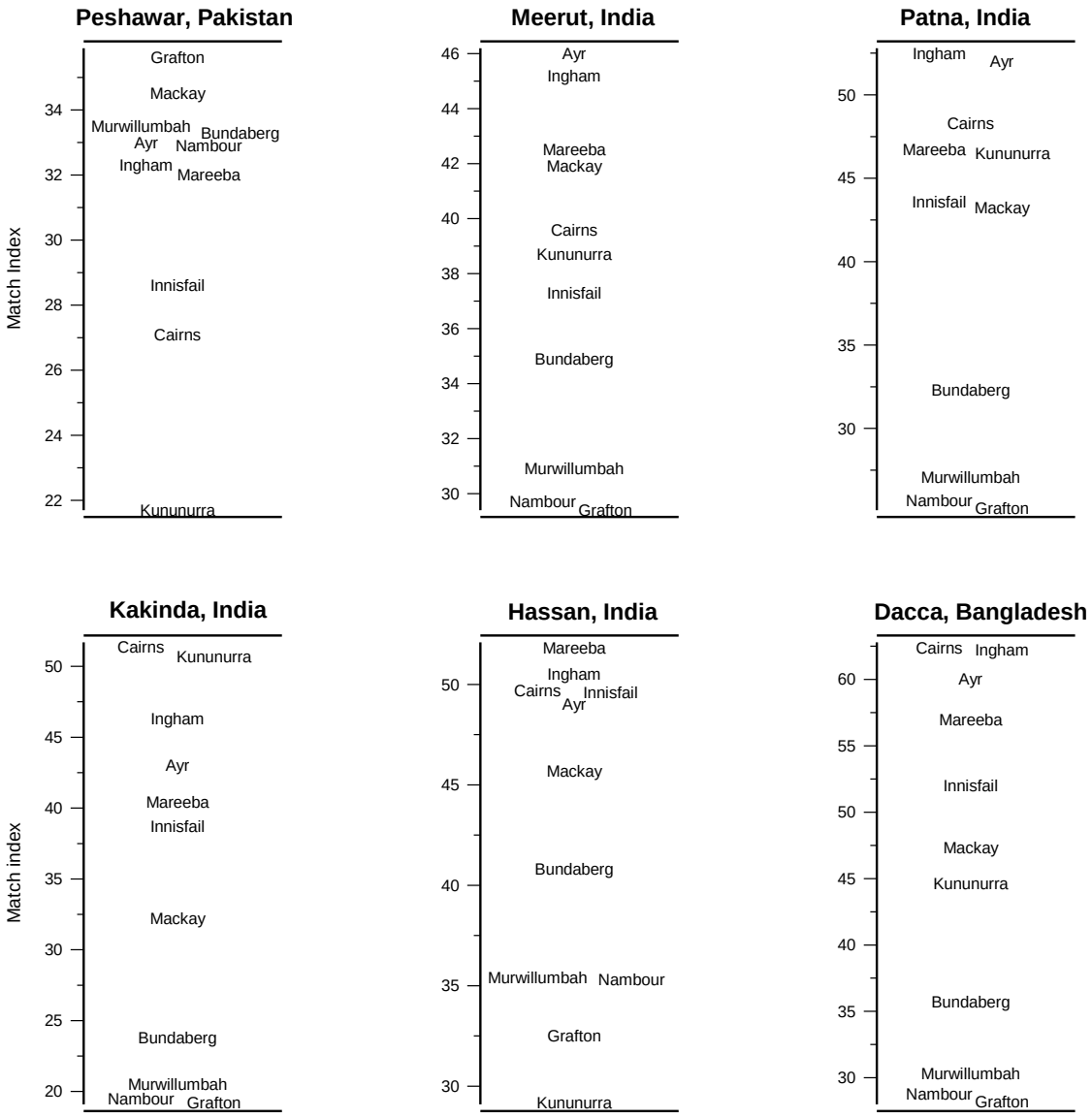
planting, irrigation once a week from the third to the tenth week, partial earthing up after the second weeding and fertilizer application, detrashing the cane during the fifth and seventh month of cultivation, release of egg parasitoid *Trichogramma chilonis* at 2.5 CC/ha 6 times at fortnightly intervals after 5 months of planting and harvesting at the 12 month without delay. This program resulted in an increase in millable cane and crop yield by 36.45% and reduced *Chilo infuscatellus* infestation (Rajendran 2006). This approach however differs in one aspect highlighted by (Singla & Duhra 1990) and Kumar *et al.* (2007) who showed that higher planting density increases *C. infuscatellus* infestation.

**Means of Movement**

The most likely means of entry of this species into Australia would be by the introduction of infested planting material. The chance of the introduction of moths or eggs on aircraft, in luggage, or on people is much smaller, though still significant.

**Phytosanitary Risk**

***Entry potential:*** High – close to Australia and readily transmitted on infected planting material.
***Colonisation potential:*** High in all sugarcane-growing areas.
***Spread potential:*** High, unless strict controls imposed over movement of infested material.
***Establishment potential:*** Depends on biotype introduced (see Match Indexes for climates at selected locations and principal Australian areas below).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Match Index
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30
28
26
24
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Grafton
Mackay
Murwillumbah
Bundaberg
Ayr
Nambour
Ingham
Mareeba
Innisfail
Cairns
Kununurra
Meerut, India
46
44
42
40
38
36
34
32
30
Ayr
Ingham
Mareeba
Mackay
Cairns
Kununurra
Innisfail
Bundaberg
Murwillumbah
Nambour
Grafton
Patna, India
50
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35
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Ingham
Ayr
Cairns
Mareeba
Kununurra
Innisfail
Mackay
Bundaberg
Murwillumbah
Nambour
Grafton
Kakinda, India
Match index
50
45
40
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25
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Cairns
Kununurra
Ingham
Ayr
Mareeba
Innisfail
Mackay
Bundaberg
Murwillumbah
Nambour
Grafton
Hassan, India
50
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Mareeba
Ingham
Cairns
Innisfail
Ayr
Mackay
Bundaberg
Murwillumbah
Nambour
Grafton
Kununurra
Dacca, Bangladesh
60
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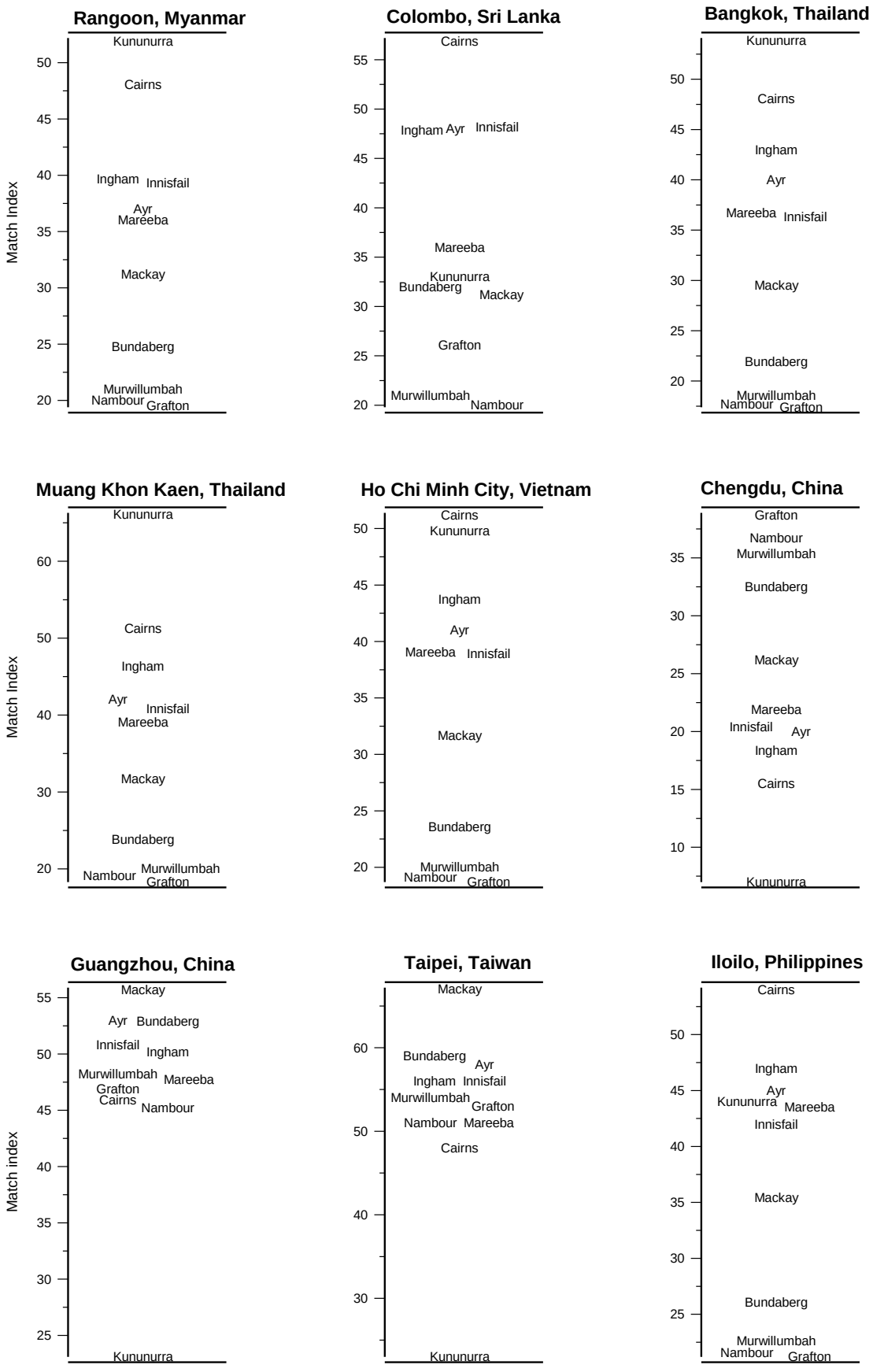
Mackay
Kununurra
Bundaberg
Murwillumbah
Nambour
Grafton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Match Index
Kununurra
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Ingham
Innisfail
Ayr
Mareeba
Mackay
Bundaberg
Murwillumbah
Nambour
Grafton
Colombo, Sri Lanka
Cairns
Ingham
Ayr
Innisfail
Mareeba
Kununurra
Bundaberg
Mackay
Grafton
Murwillumbah
Nambour
Bangkok, Thailand
Kununurra
Cairns
Ingham
Ayr
Mareeba
Innisfail
Mackay
Bundaberg
Murwillumbah
Nambour
Grafton
Muang Khon Kaen, Thailand
Match Index
Kununurra
Cairns
Ingham
Ayr
Innisfail
Mareeba
Mackay
Bundaberg
Nambour
Murwillumbah
Grafton
Ho Chi Minh City, Vietnam
Cairns
Kununurra
Ingham
Ayr
Mareeba
Innisfail
Mackay
Bundaberg
Murwillumbah
Nambour
Grafton
Chengdu, China
Grafton
Nambour
Murwillumbah
Bundaberg
Mackay
Mareeba
Innisfail
Ayr
Ingham
Cairns
Kununurra
Guangzhou, China
Match index
Mackay
Ayr
Bundaberg
Innisfail
Ingham
Murwillumbah
Mareeba
Grafton
Cairns
Nambour
Kununurra
Taipei, Taiwan
Mackay
Bundaberg
Ayr
Ingham
Innisfail
Murwillumbah
Grafton
Nambour
Mareeba
Cairns
Kununurra
Iloilo, Philippines
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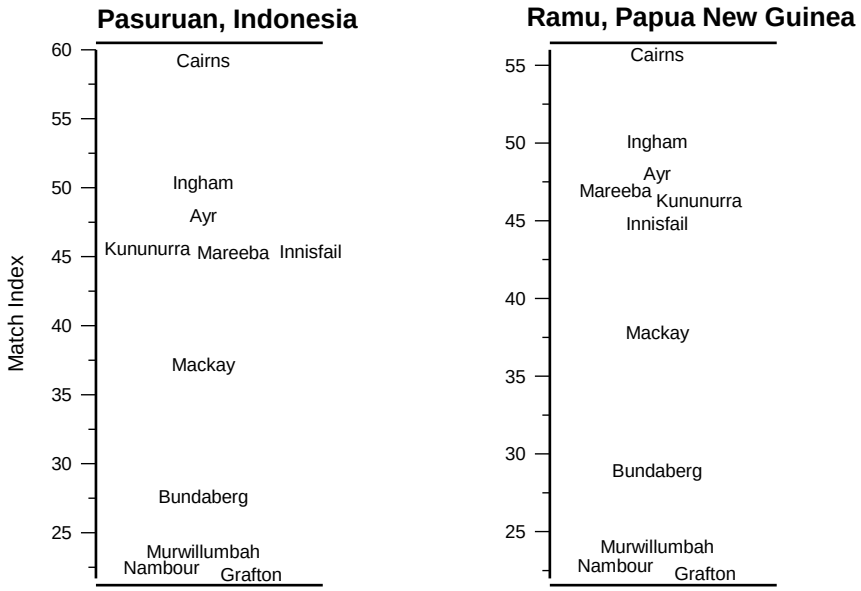
Grafton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Kununurra
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Innisfail
Mackay
Bundaberg
Murwillumbah
Nambour
Grafton
Ramu, Papua New Guinea
55
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Cairns
Ingham
Ayr
Mareeba
Kununurra
Innisfail
Mackay
Bundaberg
Murwillumbah
Nambour
Grafton

***Chilo orichalcociliellus* (Strand)**

*Diatraea orichalcociliella* Strand 1911: 91.
*Diatraea argyrolepia* Hampson 1919: 54 [syn. Bleszynski 1970].
*Chilo argyrolepia* (Hampson): Bleszynski 1962: 112.
*Chilo orichalcociliella* (Hampson): Bleszynski 1962: 112.

**Types**
*orichalcociliella*: Holotype male, Tanzania, in Zoological Museum, Berlin.
*argyrolepia*: Lectotype female, Mt Mlanje, Malawi, in Natural History Museum, London.

**Common names**
This species is called the coastal stalk borer in Kenya

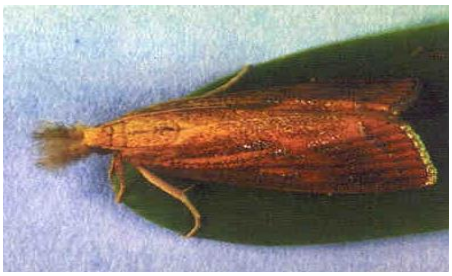
**Distribution**
Congo, Eritrea, Kenya, Madagascar, Malawi, Nigeria, South Africa, Tanzania (Bleszynski 1970; Mathez 1972; Hill 1983; Polaszek 1998; Haile & Hofsvang 2001).

**Host plants**
Maize, sorghum, finger millet, Pearl millet, sugarcane, Napier grass (*Pennisetum purpureum*), Guinea grass.

**Symptoms**
Similar to *C. partellus*.

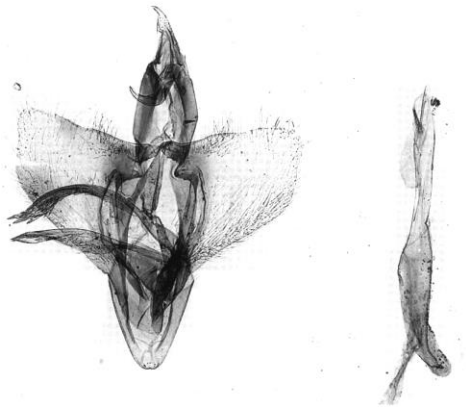
**Economic impact**
The importance of *C. orichalcociliellus* has been declining in eastern Africa since the 1970s due to the invasion of the exotic *C. partellus* (Overholt *et al.* 1997) into the continent. Evidence over a 30-year period indicates that *C. orichalcociliellus* is being gradually displaced by *C. partellus*. Ofomata *et al.* (2000), working in Kenya, found that *C. partellus* had a higher fecundity than *C. orichalcociliellus* at 25 and 28°C, though not at 31°*C.* In addition, *C. partellus* larvae develop faster than *C. orichalcociliellus* in maize and sorghum and consume more maize than *C. orichalcociliellus;* it also terminates diapause faster than *C. orichalcociliellus* (Ofomata *et al.* 1999). On the other hand, *C. orichalcociliellus* was able to survive better than *C. partellus* in napier and guinea grasses. The shorter developmental period of *C. partellus* seems to give it a competitive advantage over the slower developing *C. orichalcociliellus*. However, the ability of *C. orichalcociliellus* to complete development in two native grasses where *C. partellus* does not survive well may provide a refuge that allows *C. orichalcociliellus* to escape extirpation in certain parts of East Africa. While more recent results by NanQing *et al.* (2006) reveal that the regional synchrony of this species has increased in comparison to both the native and the exotic borers *Sesamia calamistis* and *Chilo partellus* after the introduction of the larval parasitoid *Cotesia flavipes* (Hymenoptera: Braconidae). No recent data is available on the impact of this pest on sugarcane.

**Morphology**
***Adults***
Bleszynski (1970) gives the following description of *C. orichalcociliellus*: Ocellus moderately or fully developed. Face produced forward, conical, in many specimens with distinct corneous point, sometimes broadly rounded without corneous point, or with weak point; ventral ridge always present. Labial palpus 3 (male) to 4 (female) times as long as diameter of eye. Fore wing: length 8.5-15.5 mm, maximum width 3.6-6.5 mm; $R_1$ confluent with *Sc*; ground-colour straw-yellow to ochreous yellow dusted with brown scales; sub-terminal line formed by row of metallically shiny, golden specks; median line distinct, con-colorous with subterminal line; discal dot absent; terminal dots present; fingers metallically shiny, golden, unicolorous. Hind wing cream-yellow, in some instances darkened with grey.



*Chilo orichalcociliellus* adult (After Polaszek 1998).

***Male genitalia*** (Figs 85-87): Valva short and broad, with broadly rounded apex; saccus normal; juxta-plate with two long arms densely clothed with short bristles; the arms are evenly long, or the right arm is longer than the left arm; aedeagus thin with bulbose basal projection; ventral arm absent; subapical patch of small cornuti.



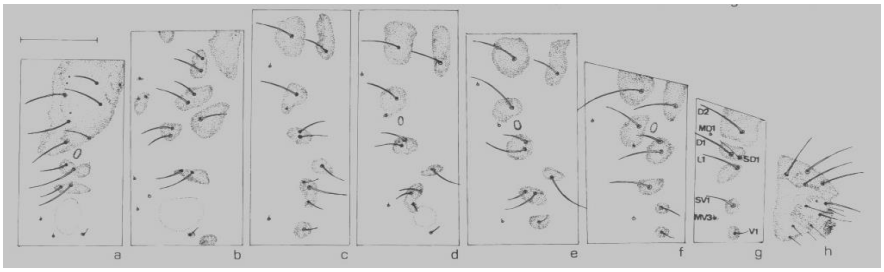
*Chilo orichalcociliellus* male genitalia (After Polaszek 1998).

***Female genitalia*** (Figs. 91, 100): Seventh sternum with large, almost triangular, heavily sclerotized plate, densely clothed with minute spikes and with two rather triangular patches also clothed with spikes, situated at either side of ostial pouch; caudal part of plate with deep; window-shaped notch with membrane; genital opening small; ductus seminalis narrow; ostial pouch lightly sclerotized; one distinct, elongate, scobinate signum; corpus bursae reaching almost base of abdomen.

*Chilo orichalcociliellus* female genitalia (After Polaszek 1998).

Bleszynski (1970) states that *C. orichalcociliellus* is externally indistinguishable in colour and pattern from *C. aleniellus*, *C. thyrsis*, *C. quirimbellus* and *C. zoriandellus*, but could be separated using the female genitalia.

***Larvae***
Non-diapausing larvae cream coloured with a spotted appearance caused by large brown pinacula, four longitudinal stripes along their body. Diapause larvae either completely pale or striped. Head capsule, prothoracic shield and suranal plate brown. Oval-shaped black spiracles, internal tracheal system visible. Dorsal surface of the body with four reddish brown or purple longitudinal stripes. Meso- and metathorax with a small asetose tubercle anterior to the large dorsal asetose tubercle. Crochets on abdominal prolegs at least partly triordinal, in a complete circle, sometimes smaller towards the lateral side than towards the meson (Meijerman & Ulenberg 1998).



*Chilo orichalcociliellus* setal map (After Polaszek 1998).

**Detection methods**
Refer to *C. partellus*.

**Biology and Ecology**
The biology of this species is very similar to that of *C. partellus*, but *C. orichalcociliellus* seems to be more tolerant to higher temperatures (see Economic Importance).

**Biological Control**
***Parasitoids***
Two gregarious larval endoparasitoids, *Cotesia flavipes* and *Cotesia sesamiae* are recorded on *C. orichalcociliellus* in Africa (Overholt 1998).

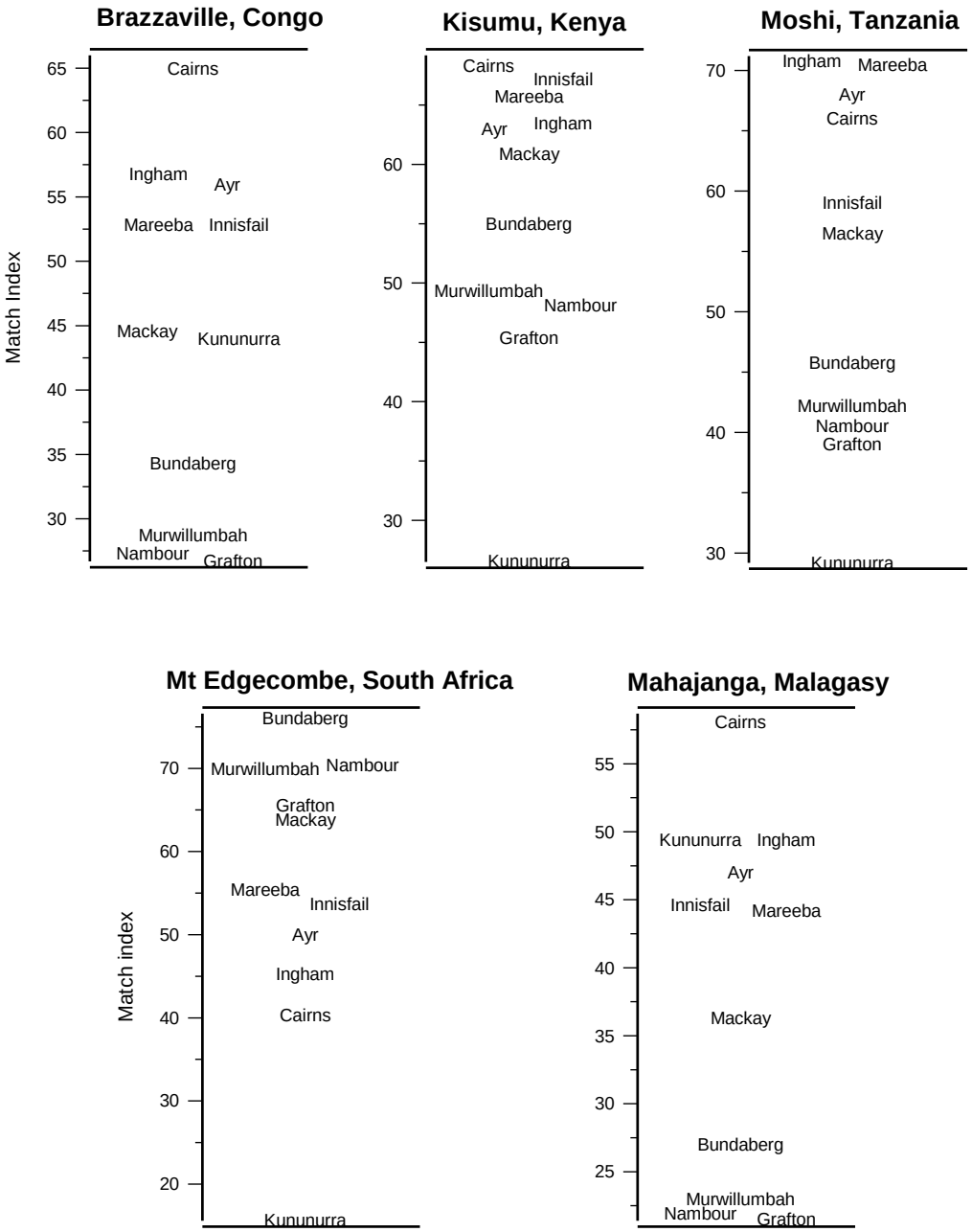
**Management**
***Chemical Control***
Dipterex [trichorfon], is one of the insecticides generally recommended in Kenya. Pyrethrum marc was found to be as effective as Dipterex (Warui *et al.* 1986).

**Intercropping**
Intercropping maize with cowpea significantly reduced damage caused by *C. orichalcociliellus* and other stemborers in Kenya. Significantly higher yields of maize (27-57%) corresponding to significantly lower numbers (15-25%) of stemborers (Skovgard & Pats 1997).

**Early Planting**
Warui and Kuria (1983) found that early planted maize had lower infestation levels than late-planted maize.

**Means of Movement**
The most likely means of entry of this species into Australia would be by the introduction of infested planting material. The chance of the introduction of moths or eggs on aircraft, in luggage, or on people is much smaller, though still significant.

**Phytosanitary Risk**
***Entry potential:*** Medium - isolated from Australia, but readily transmitted on infected planting material.
***Colonisation potential:*** High in all sugarcane-growing areas.
***Spread potential:*** High, unless strict controls imposed over movement of infested material.
***Establishment potential:*** Depends on biotype introduced (see Match Indexes for climates at selected locations and principal Australian areas below).


Brazzaville, Congo
Match Index
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55
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40
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Cairns
Ingham
Ayr
Mareeba
Innisfail
Mackay
Kununurra
Bundaberg
Murwillumbah
Nambour
Grafton
Kisumu, Kenya
60
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Cairns
Innisfail
Mareeba
Ayr
Ingham
Mackay
Bundaberg
Murwillumbah
Nambour
Grafton
Kununurra
Moshi, Tanzania
70
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Ingham
Mareeba
Ayr
Cairns
Innisfail
Mackay
Bundaberg
Murwillumbah
Nambour
Grafton
Kununurra
Mt Edgecombe, South Africa
Match index
70
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Murwillumbah
Nambour
Grafton
Mackay
Mareeba
Innisfail
Ayr
Ingham
Cairns
Kununurra
Mahajanga, Malagasy
55
50
45
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25
Cairns
Kununurra
Ingham
Ayr
Innisfail
Mareeba
Mackay
Bundaberg
Murwillumbah
Nambour
Grafton

***Chilo partellus* (Swinhoe)**

*Crambus zonellus* Swinhoe 1884: 528 [preoccupied by *Crambus zonellus* Zeller].
*Crambus partellus* Swinhoe 1885: 879.
*Chilo simplex* (Butler): Hampson 1896a: 957; Hampson 1896b: 26; Rebel 1901: 259; Fletcher & Ghosh,1920: 285 (misidentification).
*Diatraea calamina* Hampson 1919: 544 [in part].
*Chilo zonellus* (Swinhoe) Fletcher, 1928.
*Argyria lutulentalis* Tams 1932: 127 [syn. Martin 1954].
*Chilo zonellus* (Swinhoe): Gupta 1940: 806; Isaac & Venkatraman 1941: 810 [larva, pupa]; Kapur 1950: 399.
*Chilo partellus* (Swinhoe): Bleszynski & Collins 1962: 243; Bleszynski 1965: 119; 1970: 126.

**Types**
*zonellus*: Lectotype male, Karachi, Pakistan, in Natural History Museum, London.
*partellus*: Lectotype male, Poona, India, in Natural History Museum, London.
*lutulentalis*: Holotype female, Fort Johnson, Malawi, in Natural History Museum, London.

**Common Names**
Spotted stemborer, spotted stalk borer, sorghum borer, sorghum stemborer, maize and sorghum stemborer, corn borer, jowar stem borer.

**Distribution**
Afghanistan, Bangladesh, Botswana, Cambodia, Cameroon, Comoros, Congo, Ethiopia, India, Indonesia, Kenya, Laos, Madagascar, Malawi, Mozambique, Nepal, Pakistan, Rwanda, Somalia, South Africa, Sri Lanka, Sudan, Swaziland, Tanzania, Taiwan, Thailand, Togo, Uganda, Vietnam, Zambia, Zimbabwe

Reports from West Africa are doubtful though further invasion of the region is possible. (Bleszynski 1970; IAPSC 1985; Harris 1989; Maes 1998; Overholt 1998).

*Chilo partellus* was first recorded in Africa from Malawi in 1932 (Tams 1932), since then, it has spread in most countries of East and Southern Africa, and there is evidence that it is displacing native African stemborer species (Overholt *et al.* 1994). In Africa, *C. partellus* has become the predominant and most economically important stem-borer species in maize and sorghum at elevations below 1800 m (Seshu Reddy 1983). Evidence over a 30-year period in East Africa indicates that the indigenous stem borer *C. orichalcociliellus* is being gradually displaced by *C. partellus*. Studies in Kenya showed that *C. partellus* has a higher fecundity and egg fertility than *C. orichalcociliellus*. In addition, larvae of *C. partellus* develop faster than *C. orichalcociliellus* in maize and sorghum and consumes more maize than *C. orichalcociliellus* (Ofomata *et al.* 2000).

**Host plants**
*Chilo partellus* is mainly a significant pest of maize, sorghum and rice, but also attacks sugarcane when it is grown in the neighborhood of infested rice or maize fields (Bleszynski 1970). Other hosts include pearl millet (*Pennisetum glaucum*), finger millet (*Eleusine coracana*), foxtail millet, wheat, Sorghum (*Sorghum bicolor*), *S. arundinaceum*, *S. sudanense*, *S. vulgare*, *S. halepense*, *S. verticilliflorum*, *Eleusinae coracaua* (Nachini), *Hyparrhenia rufa*, *Rottboelia compressa*, *Saccharum officinarum*, *Vossia cuspidate*, *Zea mays*, *Oryza sativa*, *Panicum maximum*, *Pennisetum purpureum*, (Bleszynski 1970; Chundurwar 1989; Maes 1998).

In the Chitwan Valley, Nepal, Neupane *et al.* (1985) observed that *Chilo partellus* preferred maize and sorghum to rice, teosinte (*Zea mexicana* [*Euchlaena mexicana*]), finger millet (*Eleusine coracana*) and sugarcane. In southern Asia, *C. partellus* is a major pest of maize, sorghum and rice, but is considered less important in sugar cane (David & Easwaramoorthy 1990; Neupane 1990). Similar observations were made in Southern Africa, where in a field study in Swaziland, *C. partellus* was identified in sugarcane plants causing only leaf damage. It was suggested that host unsuitability and natural enemies could be the reason why *C. partellus* is not a major pest of cane (Way & Kfir 1997).

**Symptoms**
Infestation on young maize plants causes dead-hearts and it reduces growth on older plants, and sometimes prevents cob formation. Larvae tunnel in stems and produce frass that can be seen at the opening of the tunnel. Infested stems are easily broken by wind.

**Economic Impact**
*Chilo partellus* can be devastating to maize plantations, and records of damage range from 10 – 100%, as seen in the Maputo and Gaza province of Mozambique (Nunes *et al.* 1985). In Nepal, yield reduction in some maize cultivars reached 60%, and stem infestation levels reached 98%. On rice, larvae caused dead-hearts in young plants and white-heads in older ones (Neupane *et al.*, 1985).

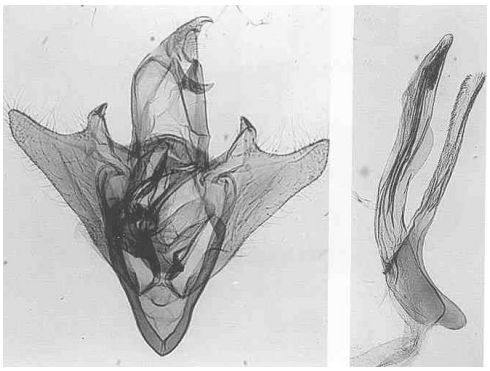
In India, the most significant crop losses in sorghum often result from infestations developing during the early stage of crop growth leading to the formation of dead heart (Taneja & Nwanze 1989). Due to the nature of infestation, larvae are difficult to kill once they are inside the stem, and the overlapping nature of *C. partellus* generations allow for reinfestation throughout the season.

In Paiyur, Tamil Nadu, India, Suresh *et al.* (2001) showed that sorghum genotypes with high stem sugar content were susceptible to *C. partellus* incidence, and that total soluble solids, sucrose and purity of the juice were positively correlated with stem borer incidence. However, no data on damage to sugarcane plantations as a result of *C. partellus* are available.

**Morphology**
***Adults***
Bleszynski (1970) gives the following description of *C. partellus*: Ocellus well developed. Face distinctly conical, with distinct corneous point; ventral ridge slight. Labial palpus 3 (male) to 3.5 (female) times as long as diameter of eye. Fore wing: length 7.0-17.0 mm; $R_1$ free; ground-colour varying from yellow to brown, variably dusted with fuscous scales; subterminal line a delicate brown line; median line ill-defined; discal dot present; metallic scales absent. Hind wing dirty white to grey.

*Chilo partellus* adult moth (after Polaszek 1998).

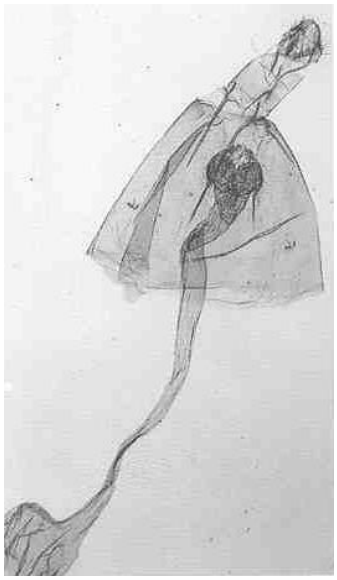
***Male genitalia*** (Fig. 26): Costa with median, strong tapering projection; juxta-plate symmetrical, with large central part, projected caudad, base with two notches; arms stout, not extended beyond costa of valva, each with a strong sub-apical tooth; aedeagus with bulbose basal projection and ventral arm.



*Chilo partellus* male genitalia (after Polaszek 1998).

***Female genitalia*** (Fig. 28): Ostial pouch very heavily sclerotized; delicately longitudinal wrinkled; well demarcated from ductus bursae; deeply notched caudally; signum lamellate with median ridge.

Bleszynski (1970) states that, judging by the female genitalia, *C. partellus* is close to *C. tamsi*, but the latter is easily separated by its elongate, much smaller ostial pouch, which is rounded in *C. partellus*.



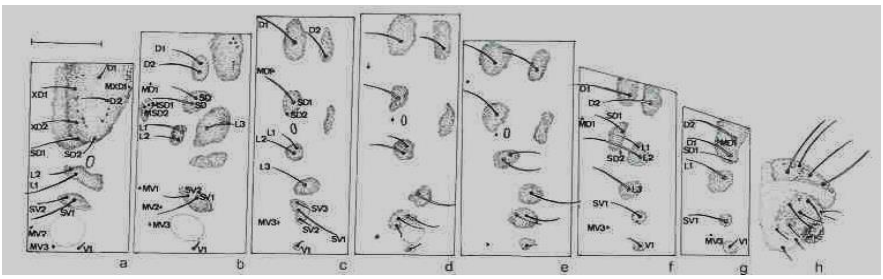
*Chilo partellus* female genitalia (After Polaszek 1998).

***Larvae***

Non-diapause larvae cream-coloured with a spotted appearance caused by large brown pinacula, four longitudinal stripes along the body. Diapause larvae either completely pale or striped. Head capsule, prothoracic shield and suranal plate brown. Spiracle oval-shaped, black. Internal tracheal system visible. Dorsal surface of the body with four reddish brown or purple longitudinal stripes. Larger number of asetose tubercles compared with other *Chilo* larvae. In addition to the pinacula-bearing setae, one large dorsal and a smaller subventral asetose tubercle on the meso- and metathorax, and lateral asetose tubercles on the first to seventh abdominal segment. Crochets on abdominal prolegs at least partly triordinal, in a complete circle, sometimes smaller towards the lateral side than towards the meson. Very young larvae also biordinal (Meijerman & Ulenberg 1998).

*Chilo partellus* non-diapausing larva (after Polaszek 1998)

*Chilo partellus* diapausing larva (Polaszek 1998)




Setal map of *Chilo partellus* larva (after Polaszek 1998).

**Pupae**

*Chilo partellus* pupa (after Sallam 1998)

**Detection methods**

Check the underside of leaves for egg patches. Inspect leaf whorls for young larvae and split stems to look for medium-large larvae and pupae.

**Biology and Ecology**

In South Africa, where *C. partellus* was first detected in 1958, *C. partellus* mainly attacks maize and grain sorghum. Studies showed that adults emerge from pupa during late afternoon and early evening and they are active at night. Females mate soon after emergence and lay about 10 batches of 10-80 eggs parallel to the midrib on the underside of the leaf. Adults are generally short lived (2-5) days and do not seem to disperse far from emergence site, though there are records of movements of up to a few kilometers (Harris 1989). Eggs hatch after about 4-8 days, and larvae disperse to adjacent plants before they move up to the leaf whorl to feed on the young leaves. Larval duration is about 25 – 45 days in favourable conditions, and late instar larvae only enter diapause in cold or dry conditions, where they may spend up to six months in stems, stubble or other crop residues (Maes 1998). Up to five or more successive generations may develop

annually (Harris 1989). Van Rensburg and van den Berg (1992) found that a large percentage of young larvae feed behind leaf sheath (in sorghum) where they are not reached by pesticides. They later penetrate into the stem and make tunnels, and are able to infest maize ears. Larvae pupate in the tunnels after excavating emergence windows for the exit of moths. *Chilo partellus* larvae diapause in winter. In southern Africa, this takes place during the cold dry season (April-October). Larvae start emerging around mid August until the first week of November (Kfir 1998).

In Nepal, Neupane *et al.* (1985) showed that, the egg, larval and pupal stages lasted 4-5, 16-41 and 4-8 days, respectively, during April-September. A complete generation took 28-48 days under field conditions in summer and up to 233 days during October-May.

**Biological Control**

***Parasitoids***

***Allorhogas pyralophagus* Marsh (Hymenoptera: Braconidae):** Gregarious larval ectoparasitoid. This species was imported from Mexico and released for the control of *C. partellus* on sorghum in Uttar Pradesh, India, in 1985. The parasitoid proved to be capable of searching for and ovipositing in overwintering *C. partellus* larvae in standing stalks (Varma *et al.* 1987; Varma & Saxena 1989).

***Apanteles chilonis* (Hymenoptera: Braconidae):** Larval parasitoid, recorded on *C. partellus* in Pakistan. (Sharma *et al.* 1966).

***Apanteles schoenobii* Wilkinson (Hymenoptera: Braconidae):** Larval parasitoid, recorded on *C. partellus* in India (Butani 1972).

***Apanteles sesamia* (Cameron) (Hymenoptera: Braconidae):** Gregarious larval endoparasitoid, recorded in Madagascar (Breniere *et al.* 1985).

***Aprostocertus* sp. (Hymenoptera: Eulophidae):** Pupal parasitoid, recorded on *C. partellus* in (Hymenoptera: Eulophidae): India (Butani 1972).

***Bracon albolineatus* Cam. (Hymenoptera: Braconidae):** Recorded attacking *C. partellus* in Sri Lanka (Box 1953) and India (Kishore 1986).

***Bracon chinensis* Szépl. (Hymenoptera: Braconidae):** Larval parasitoid, recorded on *C. partellus* in Pakistan (Carl 1962) and India (Box 1952; Butani 1958; Butani 1972).

***Bracon sesamiae* (Hymenoptera: Braconidae):** Larval parasitoid. Recorded by Ebenebe *et al.* (2001) in Lesotho.

***Centeterus alternecoloratus* Cushman (Hymenoptera: Ichneumonidae):** Recorded from India (Chacko & Rao 1966, Butani 1972).

***Chelonus heliopae* Gupta (Hymenoptera: Braconidae):** Larval parasitoid, recorded attacking *C. partellus* in India (Butani 1972).

***Chelonus narayani* Subba Rao (Hymenoptera: Braconidae):** Recorded attacking *C. partellus* in India (Butani 1972).

***Cotesia* (*Apanteles*) *flavipes* Cameron (Hymenoptera: Braconidae):** Gregarious larval endoparasitoid on a wide range of pyralid and noctuid stemborers, and is the main parasitoid of *C. partellus* in South East Asia. Female parasitoids attack medium to large size larvae inside the stem. The female stings host larvae and lays about 40 eggs inside its body. The female's egg load is about 160 eggs, therefore it is capable of parasitizing four host larvae. In Coimbatore, Southern India, *Cotesia flavipes* is recorded attacking *C. partellus* as well as *C. infuscatellus* and *C. sacchariphagus indicus*. Levels of parasitism up to 17.9% were recorded on *C. partellus*, followed by *C. sacchariphagus indicus* (8.3%) and *C. infuscatellus* (1.1%). Parasitism rates were negatively correlated to minimum temperature. *Cotesia flavipes* was the only larval parasitoid recorded from the borers both at Coimbatore and the seven sugar factory areas surveyed in Tamil Nadu (Srikanth *et al.* 1999). *Cotesia flavipes* was imported from Asia and released against stemborer pests in many parts of the world. In the early 1990s, *C. flavipes* was imported from Pakistan and released in a number of countries in East and Southern Africa against the introduced *C. partellus* and other borers. The parasitoid is well established and is responsible for high rates of mortality of *C. partellus* in Kenya (Overholt *et al.* 1997).

***Cremastus flavoorbitalis* Cam. (Hymenoptera: Ichneumonidae):** Larval parasitoid, recorded on *C. partellus* from Sri Lanka (Box 1953).

***Goniozus indicus* Muesebeck (Hymenoptera: Bethylidae):** Gregarious larval ectoparasitoid, Recorded attacking *C. partellus* in India (Kurian 1952).

***Hyperchalcidia soudanensis* Steffan (Hymenoptera: Chalcididae):** Nepal (Neupane *et al.* 1985).

***Iphiaulax spilocephalus* Cameron (Hymenoptera: Braconidae):** Larval parasitoid, recorded attacking *C. partellus* in India (Butani 1958, Butani 1972).
***Merinotus* sp. (Hymenoptera: Braconidae):** Recorded on *C. partellus* in India (Butani 1972).
***Microplitis* sp. (Hymenoptera: Braconidae):** Larval parasitoid, recorded on *C. partellus* in India (Butani 1972).
***Microbracon chilocida* Ram. (Hymenoptera: Braconidae):** India (Butani 1972).
***Pediobius furvus* (Gahan) (Hymenoptera: Eulophidae):** Pupal parasitoid. This parasitoid was introduced from Uganda and released in Madagascar, Reunion and the Comoros, where it has been established and recovered from *C. partellus* (Appert 1973; Brenière *et al.* 1985; Betbeder-Matibet 1989).
***Rhaconotus scirpophagae* Wilkinson: (Hymenoptera: Braconidae):** Larval parasitoid, recorded attacking *C. partellus* in India (Butani 1958, Butani 1972).
***Stenobracon deesae* (Cameron) (Hymenoptera: Braconidae):** Pupal parasitoid, Recorded attacking *C. partellus* in Africa (Achterberg & Walker); Pakistan (Carl 1962) and India: (Box 1953; Butani 1958).
***Stenobracon nicevillei* (Hymenoptera: Braconidae) (Bingham):** Larval parasitoid, recorded attacking *C. partellus* in India (Butani 1957; Butani 1958) and Nepal (Neupane *et al.* 1985).
***Sturmiopsis inferens* Townsend (Diptera: Tachinidae):** India (Butani 1972).
***Sturmiopsis* (*Winthemia*) *semiberbis* Bezzi (Diptera: Tachinidae):** Larval parasitoid, recorded on *C. partellus* in India (Butani 1958).
***Tropobracon schoenobii* (Viereck) (Hymenoptera: Braconidae):** Gregarious larval ectoparasitoid, recorded on *C. partellus* in India (Butani 1972).
***Tetrastichus ayyari* Rohwer (Hymenoptera: Eulophidae):** Pupal parasitoid, recorded on *C. partellus* in India (Butani 1958; Butani 1972).
***Trathala flavoorbitalis* (Hymenoptera: Ichneumonidae):** Larval parasitoid, recorded on *C. partellus* in Nepal (Neupane *et al.* 1985).
***Trichogramma chilonis* Ishii (Hymenoptera: Trichogrammatidae):** Egg parasitoid. Recorded in Nepal (Neupane *et al.* 1985), where it was responsible for 70% egg parasitism. Inundative releases of this parasitoid were effective against *C. partellus* in maize plantations of Himachal Pradesh, India (Chundurwar 1989; Rawat *et al.* 1994).
***Trichogramma chilotraeae* (Hymenoptera: Trichogrammatidae):** Egg parasitoid, India (Maninder & Varma 1981).
***Trichogramma exiguum* (Hymenoptera: Trichogrammatidae):** Egg parasitoid, India (Jotwani 1982).
***Trichogramma evanescens minutum* Riley (Hymenoptera: Trichogrammatidae):** Egg parasitoid, India (Butani 1958).
***Vipio deesae* (Cameron) (Hymenoptera: Braconidae):** Larval parasitoid, recorded on *C. partellus* in India (Butani 1972).
***Vipio* sp. (Hymenoptera: Braconidae):** India (Butani 1972).
***Xanthopimpla punctator* Linnaeus (Hymenoptera: Ichneumonidae):** Pupal parasitoid, India (Butani 1972).
***Xanthopimpla stemmator* Thunberg (Hymenoptera: Ichneumonidae):** A solitary pupal endoparasitoid, recorded in India (Box 1953; Butani 1972) and Sri Lanka (Box 1953). Also recorded from Pakistan as *Xanthopimpla stemmator* Timberlake (Carl 1962). This parasitoid was introduced from Mauritius for the control of the stemborer species complex in South Africa but did not seem to have established (Moore & Kfir 1996). Also recorded from Nepal (Neupane *et al.* 1985).
***Xanthopimpla predator* Fabricius (Hymenoptera: Ichneumonidae):** Pupal parasitoid, India (Butani 1958).
***Xanthopimpla nursei* Cameron (Hymenoptera: Ichneumonidae):** India (Butani 1958).

***Predators***
***Acanthaspis quinquespinosa* (Coleoptera: Reduviidae) Fabricius:** India (Butani 1958).
***Dorylus helvolus* (Linnaeus) (Hymenoptera: Formicidae):** Found to be an important predator of *C. partellus* as well as *Busseola fusca* in Lesotho (Ebenebe *et al.* 2001).
***Menochilus sexmaculatus* (Fabricius) (Coleoptera: Coccinellidae):** India (Jotwani & Verma 1969).
***Paedrus fucipes* Curtis (Coleoptera: Staphylinidae):** Pakistan (Mohyuddin *et al.* 1972).

***Pathogens***

***Beauveria* nr. *bassiana*:** Fungal pathogen. Results from India showed susceptibility of *C. partellus* larvae to infection (Sivasankaran *et al.* 1990).

***Hexamermis* sp.:** A species of Nematoda, similar to *H. albicans*, was found in 3.0% of *C. partellus* larvae during a survey of maize fields at Swat, Pakistan (Hamid & Aslam, 1987). Only one nematode/larva was present. The nematodes emerged through the intersegmental membrane, killing the larvae on emergence.

***Metarhizium anisopliae*:** Entomopathogenic fungus, resulted in good control of *C. partellus* in sorghum in Kenya, depending on the volume sprayed and the cultivar (Maniania *et al.* 1998).

***Nosema marucae*:** A foliar spray of an aqueous spore suspension and a spore suspension incorporating 10% v/v molasses solution (both at 1.5 X $10^6$ spores/mL) gave a high level of control of *C. partellus* on sorghum in East Africa. A granular formulation based on flour waste and a sand-carrier formulation gave sustained levels of infection (Odindo & Opondo-Mbai 1900).

**Management**

***Chemical Control***

In India, data on egg mortality of *C. partellus* showed the following descending order of mortality rates using different pesticide concentrations: fenitrothion 0.05% (94.4), phenthoate 0.1% (93.1), dimethoate 0.1% (91.5), carbaryl 0.1% (89.8), phosalone 0.1% (86.6) and chlorpyrifos 0.1% (86.0) (Singh & Marwaha 2001), while Sharma *et al.* (1999) showed that extracts from neem (*Azadirachta indica*) and custard apple (*Annona squamosa* L.) kernels were effective against *C. partellus*. In Hisar, India, three neem products (Achook 1000 g/ha, Nimbecidine 1000 ml/ha and Neemguard 1000 ml/ha) as well as *Bacillus thuringiensis* 1000 g/ha and endosulfan 1250 mL/ha, sprayed at 7, 20 and 30 days post-emergence, reduced the proportion of dead fodder-sorghum hearts and the total sorghum stem length tunnelled by *C. partellus*, with endosulfan and Bt being the most effective treatments and Achook being the least effective. Emulsifiable concentrate formulations, Nimbecidine and Neemguard, also proved effective (Singh 1998). Other studies in India showed that Carbofuran 3G (7.5 kg/ha) was the most effective control treatment, followed by endosulfan 35 EC 0.035% (Ganguli & Ganguli 1998).

In Southern Africa, Revington (1986) reported that deltamethrin alone or in a mixture with endosulfan gave effective control against *C. partellus* in maize and grain sorghum when applied 10-14 days after crop germination. Other pesticides used in Africa include trichlorfon and pyrethroids, but chemical control is considered a costly practice in many parts of the African continent (Sithole 1989; Kfir 1998).

In Pakistan, Padan 4G (cartap) gave the highest mortality of *C. partellus* in maize, followed by Advantage (carbosulfan), Fenom-N (cypermethrin + monocrotophos), Repelin [containing Azadirachta indica extract], neem oil and neem cake. In New Delhi, India, quinalphos (0.05%) spray, fenvalerate (0.04%) dust at 20 kg ha-1, endosulfan (0.7%) spray, lindane (1.3%) dust at 20 kg ha-1 and neem seed kernel suspension (5%) all gave good control of *C. partellus* in pearl millet (Kishore & Rai 1999), while Ahmed and Young (1969) showed that granular formulations of endrin, lindane and carbaryl result in effective control of *C. partellus* in sorghum. Similarly, in Kenya, Seshu Reddy and Sum (1992) found granular application of trichlorfon in the whorls of maize and sorghum to be the most economic method. In South Africa, granular formulations of beta-cyfluthrin at a very low concentration of 0.5 g a.i. was found to be highly effective against *C. partellus*. Whorl application of pesticides can be done using a tractor-mounted applicator (van den Berg & Nur 1998). In commercial farming systems, foliar sprays by means of ground or aerial application are the most common method of control, with the addition of pyrethroids being essential for effective control (van den Berg & Nur 1998). Foliar spray of endosulfan was reported to be effective in finger millet in Zimbabwe (Leuschner 1990).

Methanolic extracts of *Bougainvillea spectabilis* flowers and distilled water leaf extracts of *Nerium oleander* were highly toxic to *C. partellus* larvae. Extracts of seeds and leaves of *Annona squamosa* and *Nerium oleander* at 20% remained toxic for 5 days. Chloroform and methanol leaf extracts of *Cymbopogon martinii* and *Eucalyptus globulus* were also effective and killed larvae up to 5 days after treatment (Bhatnagar & Sharma 1999).

***Plant Resistance***

Studies in Kenya by Torto *et al.* 1990 showed that the feeding behaviour of third-instar larvae of *C. partellus* on sorghum is mediated by a complex profile of chemicals present in the plant whorls.

Phagostimulatory compounds present in ethyl acetate and methanolic extracts included phenolics and sugars, respectively, and the combinations of these compounds gave enhanced feeding activity of third-instar larvae. More susceptible sorghum cultivars had higher phenolic and sugar contents than less susceptible ones, which suggests that chromatographic quantification of the different sets of phagostimulants might constitute a basis for resistance screening.

In India, the use of maize plant materials as food for rearing *C. partellus* from the germplasm of the varieties Antigua Gr. 1, A1 X Antigua Gr. 1, Antigua Compuesto, Ganga 5, J22, J605 and Mex reduced larval survival, larval and pupal weight, fecundity and egg viability, prolonged the larval and pupal period and ultimately reduced the progeny of the pest. In addition, antixenosis for oviposition occurred in Antigua Gr. 1, A1 X Antigua Gr. 1, Ageti 76, Caribbean Flint Composite and Cuba 11J. Four-week-old plants were less preferred than 2-week-old plants. Germplasm with high resistance had high contents of silica and iron but low contents of nitrogen, phosphorus, potash and sugar. Results also implied that some aspects of resistance may be due to toxins (Sekhon *et al.* 1997).

***Pheromones***

*Chilo partellus* males were tested in a flight tunnel for their response to variation in the two major female sex pheromone gland components, (Z)-11-hexadecenal and the corresponding alcohol (OH). Variation of the alcohol in seven levels from 2 to 29% OH showed the highest male response for 17% OH. For all behavioural steps, the peak of male response was near *MU* = 0.14, while the window width fell from 2sigma = 0.5 to 0.2 for eight sequential behavioural steps from take-off to copulation. Female production had a similar peak location (*MU* = 0.13) but a narrower width, 2sigma = 0.14. (Schlyter *et al.* 2001). In another study by Hansson *et al.* (1995), electroantennographic measurements showed that the 2 pheromone components, (Z)-11-hexadecenal and (Z)-11-hexadecenol, elicited the highest responses together with a third potential pheromone component, (Z)-10-pentadecenal. The effect of proximity of the release points of the two components on trapping efficiency was investigated by (Lux *et al.* 1994) in Western Kenya. Separating the dispensers of the two components in the trap by a mere 3 cm resulted in a 3-fold decrease in trap performance, compared to very close release of the components. The result is attributed to possible distortion of the pheromone signal, resulting in confused behaviour of *C. partellus* males in the vicinity of the trap.

***Farming Practices***

In South Africa, it was found that conservation (minimal) tillage, especially in sorghum fields, did not confer any advantage over conventional tillage. *Chilo partellus* larvae are able to survive in sorghum volunteers that are continuously produced over winter (van den Berg & Nur. 1998).

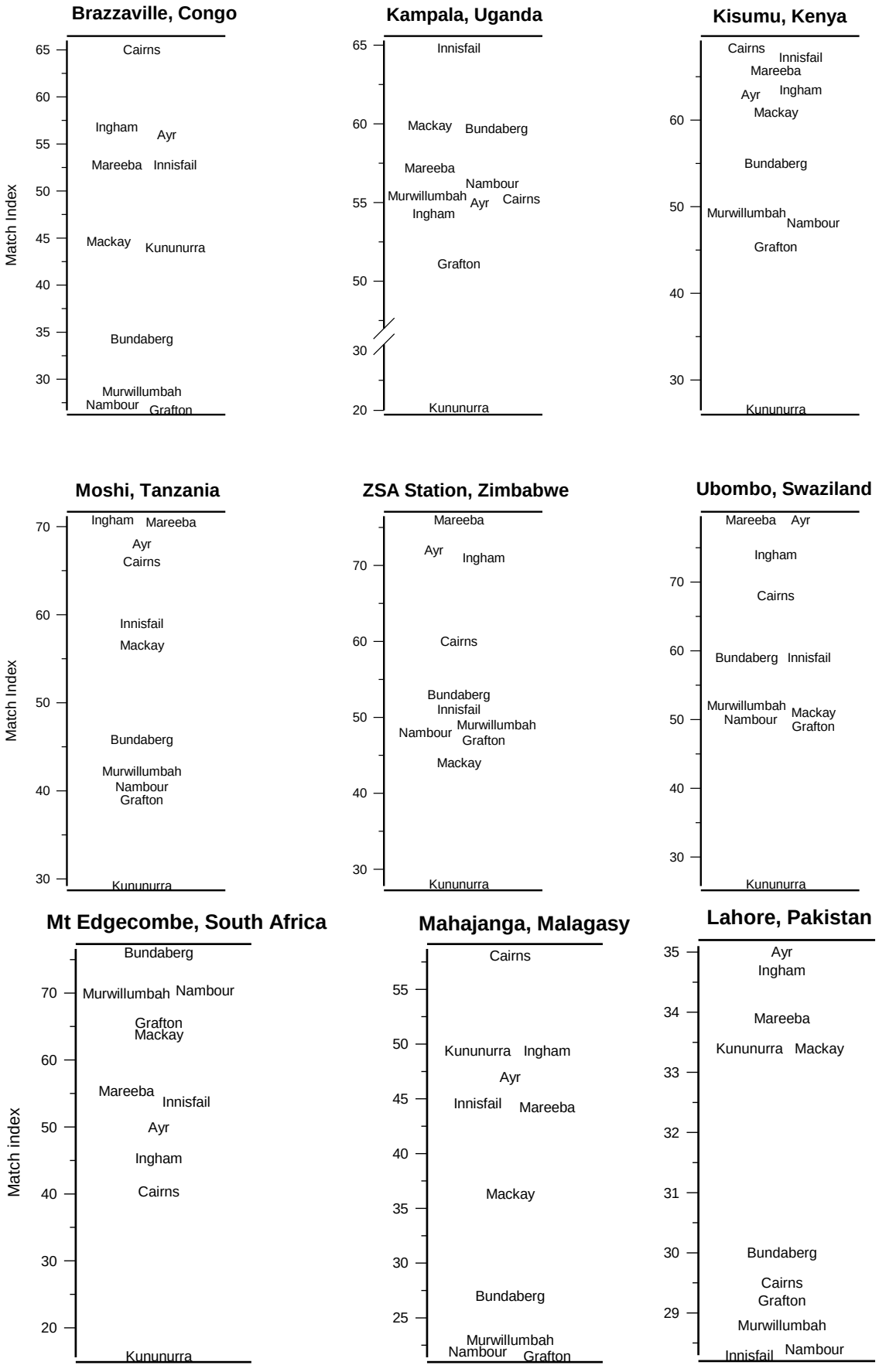
In Tanzania and Botswana, burning of crop residues was found to give excellent control of *C. partellus* in maize and sorghum (Duerden 1953; Ingram *et al.* 1973). In Gambia, crop rotation proved successful against *C. partellus* when sorghum and millet were rotated with groundnut, while in Kenya, intercropping maize with a non-host plant, such as cowpea, gave good control of the pest (Päts, 1992). Van den Berg & van Rensburg (1991) indicated that sorghum plants that did not receive fertilizers or irrigation were less preferred by *C. partellus* adult females for oviposition.

**Means of Movement**

The most likely means of entry of this species into Australia would be by the introduction of infested planting material. The chance of the introduction of moths or eggs on aircraft, in luggage, or on people is much smaller, though still significant.

**Phytosanitary Risk**

***Entry potential:*** Medium - isolated from Australia, but readily transmitted on infected planting material.
***Colonisation potential:*** High in all sugarcane-growing areas.
***Spread potential:*** High, unless strict controls imposed over movement of infested material.
***Establishment potential:*** Depends on biotype introduced (see Match Indexes for climates at selected locations and principal Australian areas below).


Brazzaville, Congo
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Cairns
Ingham
Ayr
Mareeba
Innisfail
Mackay
Kununurra
Bundaberg
Murwillumbah
Nambour
Grafton
Kampala, Uganda
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Ayr
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Ingham
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Kununurra
Moshi, Tanzania
Match Index
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Ubombo, Swaziland
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Match index
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Mahajanga, Malagasy
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Lahore, Pakistan
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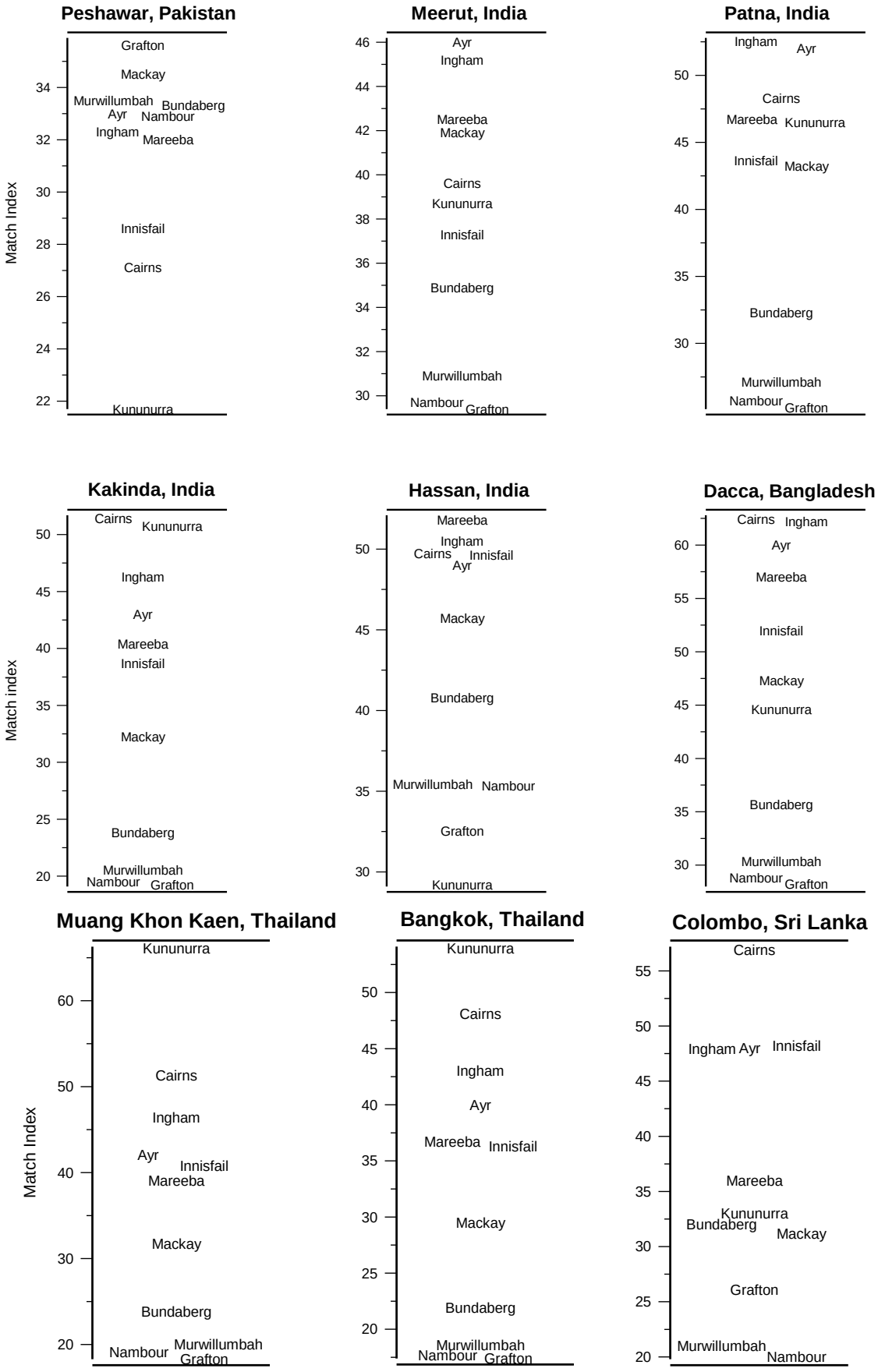
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Match Index
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Grafton
Muang Khon Kaen, Thailand
Match Index
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Bundaberg
Murwillumbah
Nambour
Grafton
Colombo, Sri Lanka
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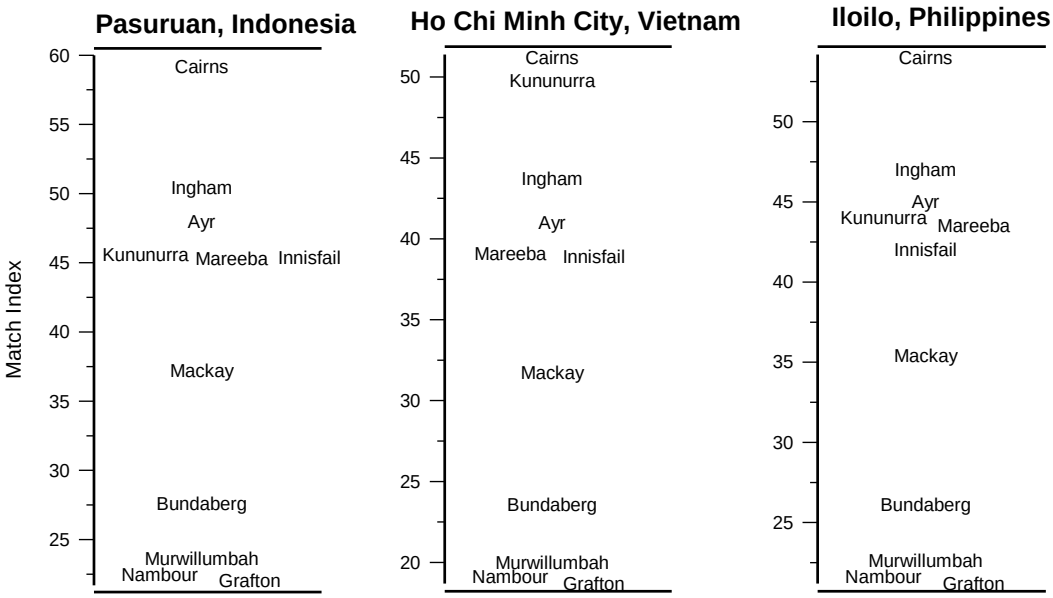
Grafton
Murwillumbah
Nambour


Pasuruan, Indonesia
Ho Chi Minh City, Vietnam
Iloilo, Philippines
Match Index
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Mareeba
Innisfail
Mackay
Bundaberg
Murwillumbah
Nambour
Grafton

***Chilo polychrysus* (Meyrick)**

*Diatraea polychrysa* Meyrick 1932: 321.
*Proceras polychrysa* (Meyrick): Kalshoven 1950: 413.
*Chilotraea polychrysa* (Meyrick): Martin 1954: 120.
*Chilo polychrysa* (Meyrick): Bleszynski 1962: 115.

**Types**
Lectotype male, Malacca, Malaysia, in Natural History Museum, London.

**Common names**
Dark headed stemborer (DHS), dark-headed rice stemborer of southeastern Asia.

**Distribution**
Bangladesh, Burma, China, India, Indonesia, Malaysia, Papua New Guinea, Philippines(?), Thailand, Vietnam (Hattori & Siwi 1986, van Verden & Ahmadzabidi 1986, Harris 1990, Li 1990). Li (1970) recorded this species as a minor pest of rice at Tortilla Flats in the Northern Territory, Australia. However, the occurrence of this species in Australia is an area that needs further investigation, as it was recently thought that the species identified earlier as *C. polychrysa* (Meyrick) may have actually belonged to an unidentified species that is very similar to *C. polychrysus* (Ted Edwards, personal communication).

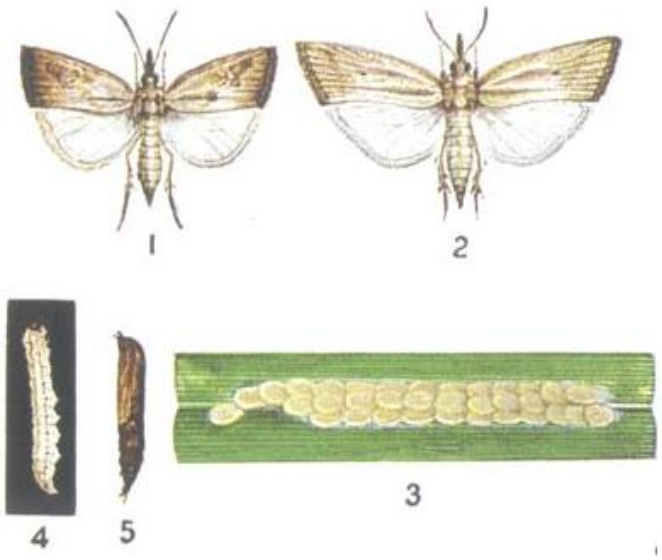
*Chilo polychrysus* a very similar species to *C. auricilius*. In a survey of the complex of *Chilo* species on rice in the Philippines, *C. auricilius* accounted for 73% of the total number of specimens of the genus collected, while *C. polychrysus* was not recorded. The morphological similarity of the larvae and adults of these two species had led to earlier erroneous records of *C. polychrysus* in the Philippines, similar confusion may exist in other countries where the distributions of the two species overlap (Barrion *et al.* 1990). Bleszynski (1970) states that the ranges of this species overlap in Indonesia, Thailand and India, however the two species can be easily separated by the genitalia of both sexes.

**Host plants**
Rice is the main host but the species also attacks maize and sugarcane, although it may be of limited importance on those crops (David & Easwaramoorthy 1990). Hosts also include *Setaria* and *Cyperus* species. In Malaysia, this species is found on *Oryza latifolia*, *Eriochola* sp., *Scirpus grossus* and *Panicum* sp. (Kalshoven 1981).

**Symptoms**
Irregular holes are formed on the leaf sheath of plant cane, and older larvae bore into the stems.

**Economic impact**
Frequent outbreaks in Peninsular Malaysia used to occur in rice fields before the introduction of double cropping of short-maturing varieties, currently *C. polychrysus* has ceased to be a major pest (Khoo 1986). Li (1990) states that the incidence of *C. polychrysus* is low in rice crops at Tortilla Flats in the Northern Territory during both dry and wet seasons. This species does not seem to inflict high rates of damage to rice, and is apparently of far less importance in sugarcane.

**Morphology**
***Adult***
Bleszynski (1970) gives the following description of *Chilo polychrysus* (Meyrick): Head similar to *auricilius*, except for labial palpus which is proportionately slightly shorter in *polychrysus*. Fore wing: length 6.7-7.5 mm; $R_1$ confluent with *Sc*; ground-colour varying from whitish to yellow variably suffused with ochreous brown scales; median line a distinct, oblique, ochreous brown shade with median line represented by shiny silvery scales; discal dot reduced; subterminal line ill-defined, white, with a few silvery scales; area between both transverse lines darkened with ochreous brown below costa; subterminal area darkened; terminal dots ill-defined or absent; fringes slightly glossy. Hind wing varying from white to dirty cream, with apical area slightly suffused with darker colour; fringe whitish. The adult moths have characteristic silvery scales on the forewings (Kalshoven 1981).



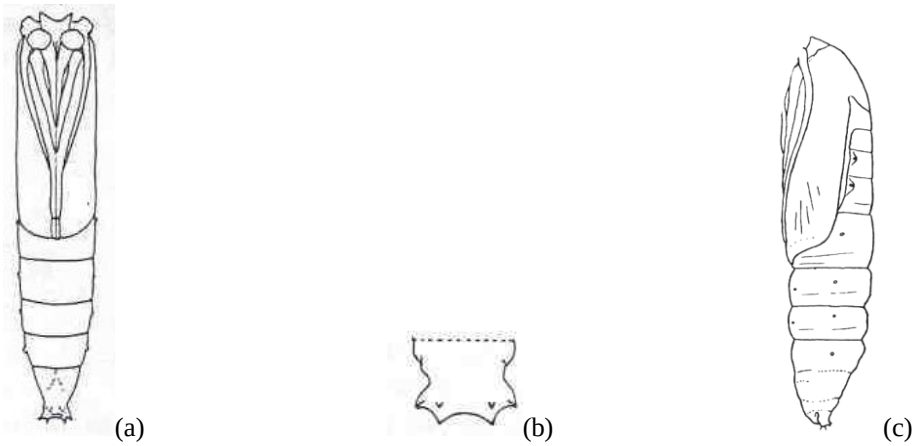

Life cycle of *Chilo polychrysus* (After Kalshoven 1981):(1) male; (2) female; (3) eggs; (4) larva; (5) pupa.

***Male genitalia*** (Figs 46-47): Valva decidedly tapering to a narrowly rounded apex; bunch of stout hairs close to ventral margin at one-third distance from base; distinct, rather heavily sclerotized, notched pars basalis; juxta-plate with arms short, tapering, nearly symmetrical; aedeagus a little longer than valva; ventral process of aedeagus bifurcate into two long, narrow arms, each arm with subbasal flap and minute subapical dentation; cornuti absent.

***Female genitalia*** (Fig. 52): Seventh sternum with rather heavily sclerotized area surrounding ostium bursae, with long band posteriorly divided longitudinally in some specimens; ostial pouch slightly demarcated from ductus bursae, armed with small sclerite at either side; ductus bursae behind ostial pouch with a short, rather heavily sclerotized portion, then lightly sclerotized, sometimes swollen in caudal portion; signum absent.

***Pupae***

The pupa has four apical protuberances and there are indented lines around segments 5-7.



(a) (b) (c)

*Chilo polychrysus* pupa: (a) ventral view (after Hattori & Siwi 1986); (b) cremaster, dorsal view (after Hattori & Siwi 1986); (c) lateral view (after Kalshoven 1981).

**Detection Methods**

Female moths lay egg clusters (30-200 eggs) on either side of the leaf. Eggs are shiny white but darken later. Larvae are dirty white with five longitudinal grey- violet stripes, with a dark head and cervical shield.

**Biology and Ecology**
Larvae about 6 mm in size bore downwards through the leaf sheath to the leaf base where they penetrate the stem just above a node, then they bore upward. Larvae are not affected with irrigation and can be found in stems below water level (Kalshoven 1981).

*Chilo polychrysus* constitutes about 13.0% of the total stemborer species complex in Indian rice fields, and is more commonly found in Tirunelveli, Kanyakumari and Vellore where abundance ranges between 17.2 to 39.7% of the total stemborer complex (Ragini *et al.* 2000). In Bangladesh, *Scirpophaga incertulas* constituted 60-97% of the stem borer population in rice fields from July to October, but from January-May and November-December, *Chilo polychrysus* and *C. auricilius* constituted 19-85% of the population (Husain & Begum 1985). In a survey by Catling *et al.* (1984), the incidence of stemborers in deepwater rice in Bangladesh and Thailand where fields are flooded deeply during the monsoon is very similar, with *Scirpophaga incertulas* comprising more than 90% of the borer population and was almost exclusively present during the main flooding period, whilst *Chilo polychrysus* comprised 11% and *Sesamia inferens* 6% of the population in the preflood and ripening stages.

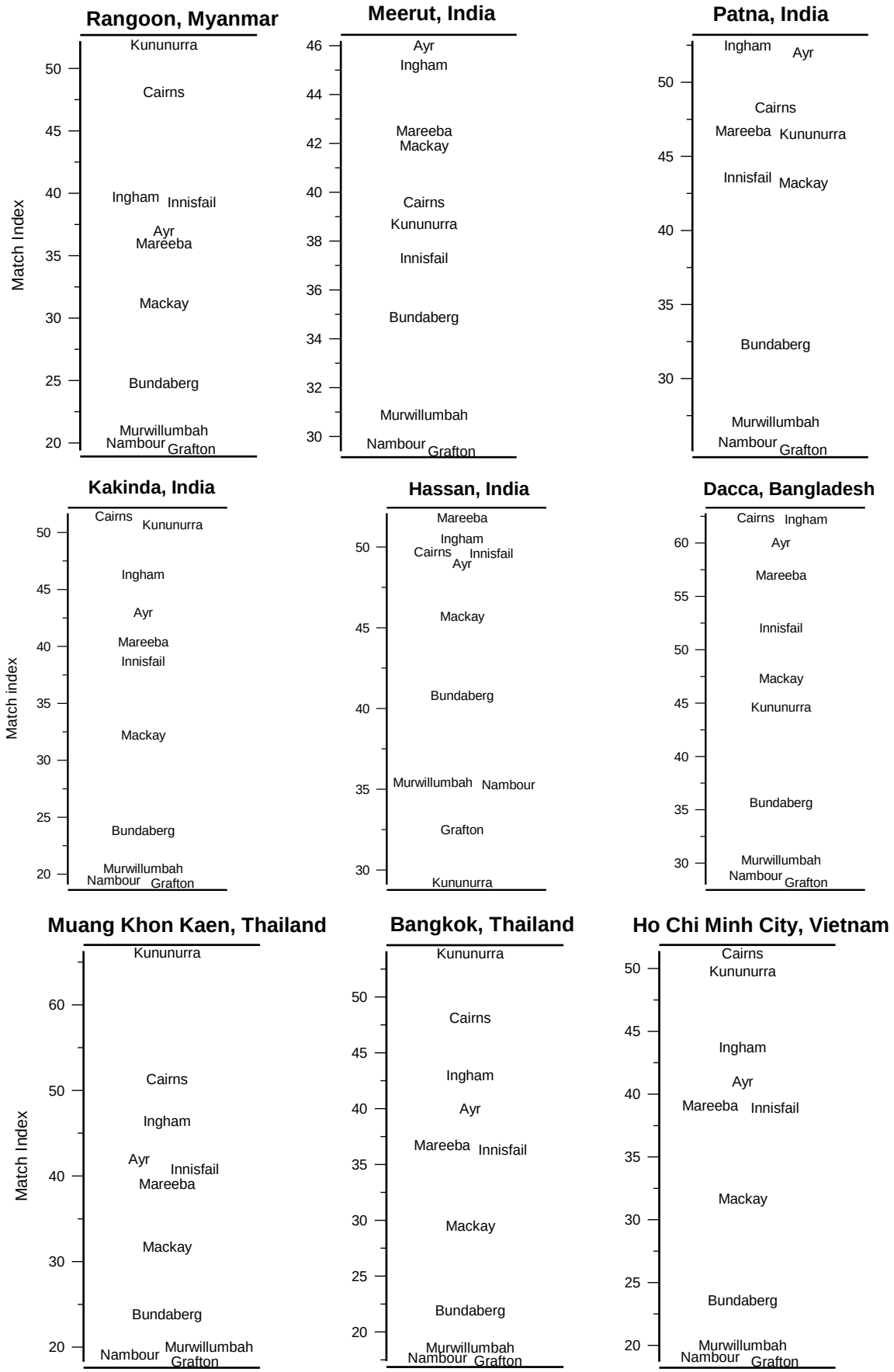
In the Northern Territory, the life cycle of *C. polychrysus* takes about 54 days and the insect completes six overlapping generations per year if rice is grown all year round (Li 1990).

**Biological control**
**Parasitoids**
***Anagrus* sp. (Hymenoptera: Mymaridae):** Egg parasitoid, Malaysia (Kalshoven 1981).
***Cotesia flavipes* (Cameron) (Hymenoptera: Braconidae):** Larval parasitoid, recorded from Malaysia (Kalshoven 1981).
***Cotesia flavipes (nonagriae)* (Cameron) (Hymenoptera: Braconidae):** Recorded attacking C. polychrysus larvae in Australia (NT) (Li 1970).
***Euchalcidia* sp. (Hymenoptera: Chalcididae):** Pupal parasitoid, recorded attacking *C. polychrysus* in Australia (NT) (Li 1970).
***Dichaetomyia pallitarsus* (Stein) (Diptera: Tachinidae):** Recorded as a pupal parasitoid, Malaysia (Kalshoven 1981).
***Sturmiopsis inferens* Towns. (Diptera: Tachinidae):** Recorded from the pupal stage in Malaysia (Kalshoven 1981).
***Trichogramma* sp. (Hymenoptera: Trichogrammatidae):** Egg parasitoid, Malaysia (Kalshoven 1981).
***Telenomus* sp. (Hymenoptera: Scelionidae):** Egg parasitoid, Malaysia (Kalshoven 1981).

**Management**
In Pakistan, Cartap, carbofuran, diazinon, thiofanox, chlorfenvinphos and chlorpyrifos were tested for the control of the stemborer complex, including *C. polychrysus*, during the 1980s. Cartap proved to be was the most effective, followed by carbofuran and diazinon (Khan & Khaliq 1989). However, infestation by *C. polychrysus* may not require chemical treatment due to the low economic importance of the pest.

**Means of Movement**
The most likely means of entry of this species into Australia would be by the introduction of infested planting material. The chance of the introduction of moths or eggs on aircraft, in luggage, or on people is much smaller, though still significant.

**Phytosanitary Risk**
***Entry potential:*** May already be in Australia or possibly a very similar species. Further confirmation required. The possibility of the Northern Territory population surviving on cane plants should be investigated.
***Colonisation potential:*** High in all sugarcane-growing areas.
***Spread potential:*** High, unless strict controls imposed over movement of infested material.
***Establishment potential:*** Possibly established in the Northern Territory. Establishment of 'true' *C. polychrysus* depends on the biotype involved (see Match Indexes for climates at selected locations and principal Australian areas below).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Mareeba
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Bundaberg
Murwillumbah
Nambour
Grafton
Meerut, India
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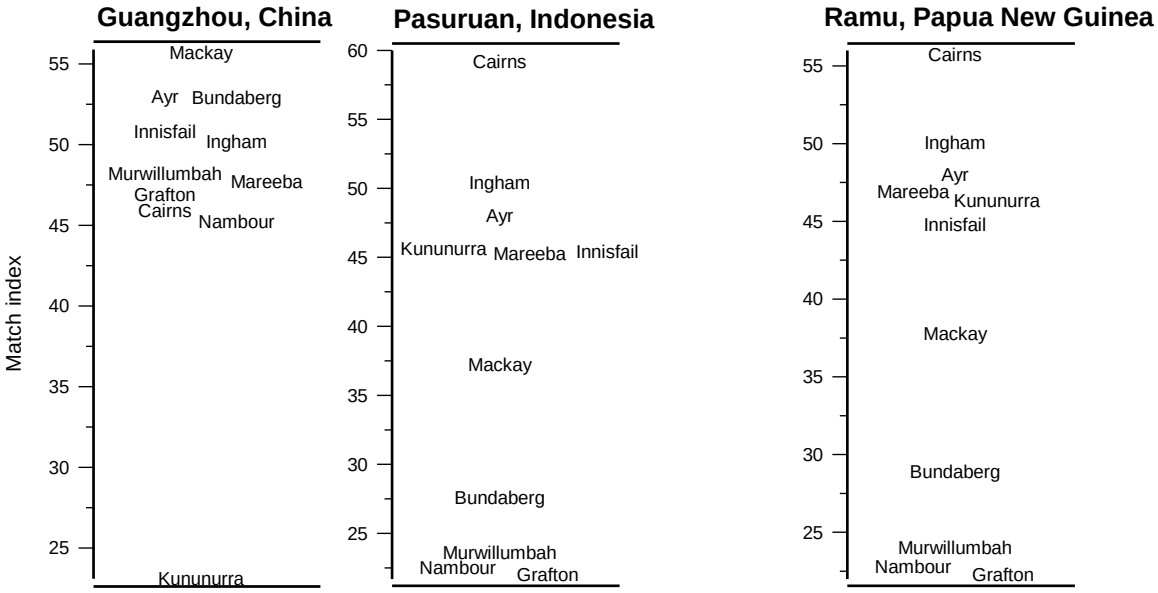
Guangzhou, China
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Mackay
Bundaberg
Murwillumbah
Nambour
Grafton

***Chilo sacchariphagus sacchariphagus* (Bojer)**

*Proceras sacchariphagus* Bojer 1856: unnumbered; Tams 1942: 67; Kapur 1950: 412; Kalshoven 1950: 411.
*Borer saccharellus* Guenée 1862: unnumbered [syn. Tams 1942].
*Chilo mauriciellus* Walker 1863: 141. [syn. Tams 1942].
*Chilo venosatus* Walker 1863: 144 [syn. Bleszynski 1970].
*Diatraea striatalis* Snellen 1890: 98; 1891: 349 [syn. Hampson 1896b]
*Diatraea mauriciella* (Walker): Hampson 1896b: 953.
*Diatraea venosata* (Walker): Hampson 1896b: 954.
*Diatraea mauriciella* (Walker); Vinson 1941: 39; 1942: 39.
*Proceras venosatus* (Walker): Kapur 1950: 413; Bleszynski 1962a: 9.
*Chilo sacchariphagus* (Bojer): Bleszynski 1966: 494; 1969: 18; 1970: 182.

**Types**
*sacchariphagus*: Neotype male, Mauritius, in Museum National d'Histoire Naturelle, Paris.
*striatalis:* Lectotype male, Tegal, Java, Indonesia, in Museum van Natuurlijke Historie, Leiden.

*Chilo sacchariphagus* is often treated as three subspecies: *Chilo sacchariphagus sacchariphagus* (Bojer), *Chilo sacchariphagus stramineellus* (Caradja) and *Chilo sacchariphagus indicus* (Kapur). There are slight differences in the genitalia of the three subspecies, although the latter two are sometimes referred to simply as *C. sacchariphagus*. After examining several specimens, Bleszynski (1970) concluded that all populations belong either to one widely spread species, or to several phylogenetically very young species. Apparently geographical isolation of populations resulted in slight variations in the genitalia, however the differences can not be considered diagnostic. Only the name *Chilo sacchariphagus* is used here to refer to the different populations.

**Common names**
Sugar-cane stalk borer; sugar cane internode borer, striped sugar cane borer, the spotted borer, spotted stem borer, internode borer, internodal borer, stalk borer, sugarcane spotted borer.

**Distribution**
Bangladesh, China, Comoros, India, Indonesia, Japan, Madagascar, Malaysia, Mauritius, Mozambique, Philippines, Reunion, Singapore, Sri Lanka, Taiwan, Thailand (Bleszynski 1970; Williams 1983; Facknath 1989; David & Easwaramoorthy 1990; Leslie 1994; Ganeshan & Rajabalee 1997; Suasa-ard 2000).

*Chilo sacchariphagus* is originally an Asian species. Populations in Madagascar, Mauritius and Reunion have probably been introduced by humans in the mid 1800s (Bleszynski 1970; Williams 1983). On mainland Africa, the pest was first recorded in Mozambique in 1991 in sugarcane (Way 1998).

**Host plants**
Sugarcane, wild *Saccharum* spp., maize, sorghum.

*Chilo sacchariphagus* is mainly a pest of sugarcane. Reported to rarely attack maize and sorghum in Madagascar, Mauritius and Reunion (Betbeder-Matibet & Malinge 1968; Williams 1983). Mallik *et al.* (2003) reports it as a pest of rice in eastern India, however the extent to which this species could be found in rice fields is not clear.

**Symptoms**
*Chilo sacchariphagus* infests the plant from when it starts forming internodes until harvest time. Female moths lay their eggs in clusters on both surfaces of the leaves of sugarcane. Kalshoven (1981) reported that 7-30 eggs are laid in two parallel rows, mostly attached to the upper side of the leaf, and that an adult female lays about 80 eggs. Young larvae are very active and sometimes drop from the plant on silken threads, and can then be carried by wind. About 5-15 larvae penetrate one leaf sheath together. First instars feed mainly on leaves and leaf sheaths then later borrow inside the soft growing point of stalks resulting in dead hearts (David 1986). Larvae enter and eventually kill the spindle region near the

growing point, leading to the sprouting of auxiliary buds and the formation of bunchy top. The migrating larva can attack the sprouts and cause more than one dead heart in the bunchy top. Early and late maturing varieties did not differ in their susceptibility, as they sustained equal losses in weight and recoverable sugar.

**Economic Impact**

*Chilo sacchariphagus* is a major pest of sugarcane in Indonesia, India, China and Taiwan, and in Madagascar, Reunion and Mauritius (where it was accidentally introduced probably from Java in 1850). *Chilo sacchariphagus* also attacks sorghum and is considered to be one of its key pests in some parts of China (Chundurwar 1989). In Reunion, Goebel *et al.* (1999b) recorded losses up to 40 tons/ha of cane due to *C. sacchariphagus* infestation.

Kalaimani (1995) found that sprouting of side buds was promoted by the attack of the borer, in addition, smut incidence, bud size and internode borer incidence were found to be positively correlated. Similarly, Viswanathan *et al.* (2006) found that infestation by *C. sacchariphagus* increased incidence of sugarcane wilt (caused by *Fusarium sacchari*) in different growing regions of India. In Mauritius, it was found that the borer mainly reduced cane yield but had no effect on the sugar content (Anon. 1987). This was also confirmed later by (Rajabalee *et al.* 1990) who found that infestation was positively correlated with yield loss, especially in dry as compared to more humid regions, though juice purity was not affected. Similar observations are also reported from Reunion where no reduction of cane quality was recorded due to infestation (Anon. 1986). Goebel and Way (2007) compared *C. sacchariphagus* damage in the Reunion to that caused by *Eldana saccharina* (which mainly affects the sugar contents), and stated that the difference in the nature of damage is the result of the timing of infestation; since *E. saccharina* attacks the crop early during the main period of biomass accumulation while *C. sacchariphagus* attacks the plant later during the maturation phase.

In Taiwan, Cheng *et al.* (1997a) conducted biweekly surveys of damage in spring cane during 1984-94 and recorded 6.18% borer infestation, of which *Tetramoera schistaceana* constituted 46.1%, *C. infuscatellus* 33.8% and *C. sacchariphagus* 19.7%. *Sesamia inferens* and *Scirpophaga nivella* were also recorded. Damage by *C. sacchariphagus* appeared in the first half of June and increased during July and August. Cheng (1999) observed that the greatest damage was caused by *Tetramoera schistaceana*, which infested 8.20±1.25% internodes of the autumn cane and 4.42±0.55% internodes of the spring cane, while *C. sacchariphagus* was the second major pest which caused 0.87±0.17% internode infestation in the autumn cane and 1.40±0.25% in spring cane.

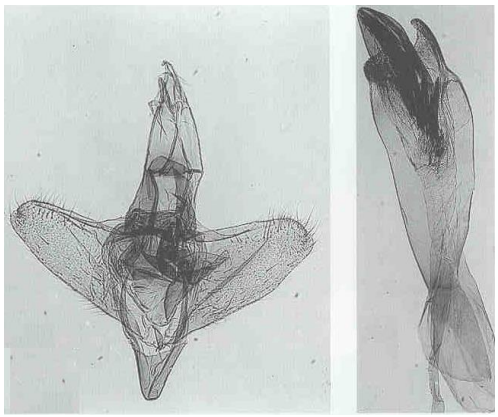
In India, *C. sacchariphagus* was reported to cause 10.7% loss in cane yield (Agrawal 1964). Later damage reports from spring sorghum are up to 65% and 35% in summer sorghum (Chundurwar 1989).

**Morphology**

***Adults***

Bleszynski (1970) gives the following description of *C. s. sacchariphagus*: Ocellus reduced. Face rounded, not protruding forward beyond eye; corneous point and ventral ridge both absent. Labial palpus 3 (male) to four (female) times as long as diameter of eye. Fore wing: $R_1$ confluent with *Sc*; length 12.0-18.0 mm, maximum width 4.5-6.0 mm; apex acute; ground-colour dull light brown; veins and interneural spaces outlined with whitish beige; discal dot distinct, often double; terminal dots present; transverse lines absent; fringes slightly glossy, concolorous or lighter than the ground-colour. Hind wing dirty white to light brown in male, silky whitish in female.

***Male genitalia*** (Figs 119-121): Valva slightly tapering to a rounded apex, which is very slightly concave; pars basalis absent; juxta-plate short, broad, deeply notched, arms tapered without teeth ; saccus V-shaped; aedeagus variable in width; ventral arm and basal process both absent; row of strong tapering cornuti present and subapical large patch of scobinations absent.



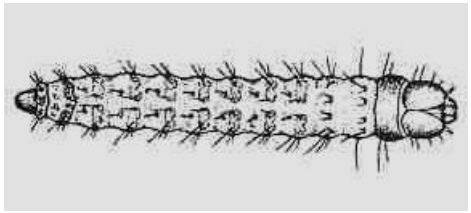
Male genitalia of *C. sacchariphagus* (after Polaszek 1998).

***Female genitalia*** (Figs 125-126): Ostial pouch rather well demarcated from ductus bursae, heavily sclerotized longitudinal ribs; corpus bursae greatly elongate, longer than ductus bursae, with large area of scobinations.

Female genitalia of *C. sacchariphagus* (after Polaszek 1998).

***Larvae***

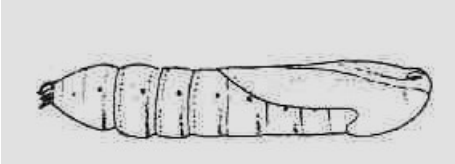
Newly hatched larvae are marked by distinct red transversal stripes, while older larvae have four longitudinal stripes formed by the spots on the dorsal sides of the segments. Development takes about 2 months (Kalshoven 1981).



*C. sacchariphagus* larvae (after Kalshoven 1981).

Differing forms of *C. sacchariphagus* larvae (after Polaszek 1998).

***Pupae***



*C. sacchariphagus* pupa (After Kalshoven 1989).

**Detection methods**

Initial damage is easily identified by the way the unfolded leaf has been shaved and bored. White stripes and spots mottled with fine debris can be seen after leaves unfold, by the time which the larvae have already left the sheath and started boring inside the stem. Larvae then move upwards and may destroy the growing point causing dead heart. The pupa is found near the exit hole (Kalshoven 1981).

**Biology and Ecology**

In a survey of sugarcane borers in Gujarat, India, both *C. sacchariphagus* and *C. auricilius* were recorded only from June to December, while *Scirpophaga excerptalis* and *Emmalocera depressella* (*Polyocha depressella*) were recorded to be active throughout the year, and *C. infuscatellus* was observed from January to June and November to December (Pandya *et al.* 1996). Chundurwar (1989) recorded that *C. sacchariphagus* has two generations per year in South East Asia, with peak ovipositions taking place in mid June and mid August for the first and second generations, respectively.

Easwaramoorthy & Nandagopal (1986) studied the population dynamics of *C. sacchariphagus* in Tamil Nadu, India, where they recorded high mortality of the early stages, which was attributed to parasitism by Hymenoptera, arthropod predation, desiccation, egg infertility and losses during dispersal of the first-instar larvae. Parasitism and granulosis virus infection were among the limiting factors in the later larval and pupal stages. A K-factor analysis showed that suspected arthropod predation, dispersal losses in the first larval instar, and losses due to migration and unknown causes in later larval instars were the key mortality factors.

In China, the pupation pattern of *C. sacchariphagus* was studied in maize fields, where 83.6% of the larvae pupated inside the leaf sheaths, while 16.4% pupated on maize ears (Wu 1995).

In Java, *C. sacchariphagus* does not occur above altitudes of 800 m (Kalshoven 1981). While in Mauritius, Soma & Ganeshan (1999) recorded the highest *C. sacchariphagus* infestation in the subhumid non-irrigated zone in 1996 and in the humid non-irrigated zone in 1997.

**Natural Enemies**

***Parasitoids***

***Agathis stigmatera* Cresson (*Alabagrus stigma* Brullé) (Hymenoptera: Braconidae):** Solitary larval endoparasitoid, final larval stage feeds externally. Introduced into Mauritius where it is reported to attack *C. sacchariphagus* (Ganeshan & Rajabalee 1997; Ganeshan 2000).

***Allorhogas pyralophagus* (Hymenoptera: Braconidae):** Larval parasitoid. This species is native to Mexico. Reported to have been introduced into India for the control of *C. sacchariphagus*, though did not seem to establish (Varma *et al.* 1987; Easwaramoorthy *et al.* 1992). Also introduced into Mauritius and few recoveries were recorded (Facknath 1989). This species does not seem to be effective against stemborers.

***Amauromorpha schoenobii* Vier. (Hymenoptera: Ichneumonidae):** Recorded parasitising *C. sacchariphagus* in sugarcane fields in Indonesia (Box 1953).

***Bracon chinensis* (Hymenoptera: Braconidae):** Larval parasitoid. Introduced from Sri Lanka into Mauritius for the control of *C. sacchariphagus* in sugarcane (Greathead 1971).

***Campyloneurus erythrothorax* Szépl. (Hymenoptera: Braconidae):** Recorded attacking *C. sacchariphagus* in Indonesia (Kalshoven 1981).

***Carcelia* sp. (Diptera: Tachinidae):** Larval parasitoid. The only record of this species on *C sacchariphagus* is from Indonesia (Kalshoven 1981). However, no other records of *Carcelia* sp. on *Chilo* spp. are available.

***Cotesia flavipes* Cameron (Hymenoptera: Braconidae):** Gregarious larval endoparasitoid. Reported to give moderate-high mortality rates of *C. sacchariphagus* in Mauritius (Williams 1983; Facknath 1989; Ganeshan 2000), Madagascar (Betbeder-Matibet & Malinge 1968; Appert *et al.* 1969), Reunion (Greathead 1971), Taiwan (Box 1953; Cheng *et al.* 1987a), Indonesia (Kalshoven 1981; Sunaryo and Suryanto 1986; Mohyuddin 1987) and India (Easwaramoorthy & Nandagopal 1986; Easwaramoorthy *et al.* 1992). During 1990-93, Easwaramoorthy *et al.* (1998a) reported the mass production of a native strain of *C. flavipes* in sugarcane fields at Coimbatore, Tamil Nadu, India, where parasitoids were released at a density of 2,060-561,000 females/ha/month. However, results showed that the parasitoid failed to reduce the progress of borer infestation. In 1993, an Indonesian population of the parasitoid was also released in the field at 2,010-11,300 females/ha/month. Similarly, monthly parasitism rates showed no impact on *C. sacchariphagus* infestation. The authors mentioned that, in the laboratory, the parasitoid gave a male biased sex ratio. This could be a result of imperfect copulation between adults.

***Diatraeophaga striatalis* Tns. (Diptera: Tachinidae):** Larval parasitoid. Known as the silver-head tachinid fly. Recorded in Indonesia (Box 1953). Mass released at the Kadhipatan Sugar Estate in Indonesia and reported to have reduced borer losses from 20 % to 8% (Boedyono 1973).

***Enicospilus antankarus* Sauss. (Hymenoptera: Ichneumonidae):** Larval parasitoid, recorded in sugarcane in Mauritius (Box 1953).

***Gambroides rufithorax* Uchida (Hymenoptera: Ichneumonidae):** Recorded parasitising *C. sacchariphagus* in sugarcane in Taiwan (Box 1953).

***Goniozus indicus* Ashmead (Hymenoptera: Bethylidae):** A gregarious larval endoparasitoid. Recorded on *C. sacchariphagus* in India (Box 1953; Butani 1958; Butani 1972). This species has a very wide range of stemborer species, and it is found in all of sub Saharan Africa, Mauritius, Madagascar, Bangladesh, India and Pakistan (Polaszek 1998).

***Goryphus basilaris* Holmgren (Hymenoptera: Ichneumonidae):** Recorded as *Mesostenus longicornis* Ishida on *C. sacchariphagus* in India by Box (1953), later as *Goryphus basilaris* Holmgren on both *C. sacchariphagus* and *Tryporyza nivella* (see Butani 1972).

***Goryphus ornatipennis* Cameron: (Hymenoptera: Ichneumonidae):** Larval parasitoid. Recorded from Tamil Nadu, India, and exported to Taiwan (Butani 1972).

***Goryphus* sp. (Hymenoptera: Ichneumonidae):** Larval parasitoid. Recorded on *C. sacchariphagus* and other sugarcane borer species in India (Butani 1972).

***Macrocentrus jacobsoni* Szépl. (Hymenoptera: Braconidae):** Larval endoparasitoid. Recorded attacking *C. sacchariphagus* in Taiwan (Box 1953).

***Microbracon chinensis* (*Amyosoma chinensis*) (Hymenoptera: Braconidae):** Larval parasitoid. Recorded from Taiwan (Cheng *et al.* 1987).

***Rhaconotus roslinensis* Lal (Hymenoptera: Braconidae):** Gregarious larval ectoparasitoid. Recorded from India on *C. sacchariphagus* (Butani 1958; Butani 1972). Hawkins & Smith (1986) reared this parasitoid successfully on *Diatraea saccharalis* and *Eoreuma loftini* as laboratory hosts.

***Rhaconotus* sp. (Hymenoptera: Braconidae):** Larval parasitoid. Recorded in Indonesia by Kalshoven (1981).

***Rhaconotus signipennis* Walker (Hymenoptera: Braconidae):** Larval parasitoid. Recorded from India (Butani 1972). Shenhmar & Varma (1988) described a rearing technique for this species on the sugarcane pest, *Acigona steniella* (*Bissetia steniella*) in the Punjab, India. Female parasitoids laid eggs in groups of

3-20 after paralysing the host larva. The preoviposition, incubation, larval and pupal periods of the braconid averaged 4, 2, 6.4 and 14.4 days, respectively. The life-cycle was completed in 22.8 ± 0.8 days. The lifespan of adult males averaged 11.6 days and that of females 11.9 days. The ratio of males to females was 1:10.

***Trichospilus diatraea* Chairman & Margabandhu (Hymenoptera: Chalcididae):** Pupal parasitoid. Recorded attacking *C. sacchariphagus* in India (Butani 1972), introduced from India into Mauritius (Facknath 1989).

***Tetrastichus* sp. (near *atriclavus* Waterst.) (Hymenoptera: Eulophidae):** Recorded in Mauritius by Box (1953).

***Tetrastichus articlavus* Waterst (Hymenoptera: Eulophidae):** Pupal endoparasitoid. Recorded in Mauritius (Ganeshan & Rajabalee 1997).

***Tetrastichus ayyari* Rohwer (Hymenoptera: Eulophidae):** Pupal parasitoid. Recorded in India on *C. sacchariphagus* (Butani 1958). This species was introduced from India into Ghana for the control of a complex of stemborer species during 1973-74 (Scheibelreiter 1980).

***Trichospilus diatraeae* Cherian & Margabandhu (Hymenoptera: Eulophidae):** Pupal parasitoid. Recorded on *C. sacchariphagus* in India (Box 1953; Butani 1958) and Mauritius (Greathead 1971; Ganeshan 2000). This species was introduced from India into Senegal for the control of *C. zacconius* in 1972 (Vercambre 1977).

***Meloboris sinicus* (Holmgren) (Hymenoptera: Ichneumonidae):** Larval parasitoid. In Taiwan, Cheng *et al.* (1999) reported this parasitoid attacking *C. sacchariphagus* and *C. infuscatellus* in spring cane in Taiwan.

***Schistochilus aristatum* Aldr. (Diptera: Tachinidae):** Recorded in sugarcane in Java Box (1953).

***Sturmiopsis inferens* (Diptera: Tachinidae):** Larval parasitoid. Recorded on *C. sacchariphagus* in sugarcane in Indonesia (Mohyuddin 1987). This species was introduced from India to many parts of Africa for the control of a number of stemborer species (Kfir 1994; Overholt 1998).

***Telenomus beneficiens* (Zehntner) (Hymenoptera: Scelionidae):** Egg parasitoid. Rajendran (1999) recorded *T. beneficiens* from September to March attacking up to 73.5% *C. sacchariphagus* eggs in the Cuddalore region of Tamil Nadu. Though it was not feasible to mass produce under laboratory conditions, *T. beneficiens* seems to cause a moderate degree of natural control of *C. sacchariphagus* in sugarcane fields in India (Easwaramoorthy *et al.* 1983; Rajendran & Gobalan 1995). Also recorded from Mauritius, Taiwan, Indonesia and China (Box 1953; Cheng *et al.* 1997b).

***Telenomus dignoides* Nixon (Hymenoptera: Scelionidae):** Egg parasitoid. Recorded from India (Bin & Johnson 1982; Easwaramoorthy & Nandagopal 1986).

***Telenomus globosus* n. sp. (Hymenoptera: Scelionidae):** Recorded attacking eggs of *C. sacchariphagus* in India (Bin & Johnson 1982; Easwaramoorthy & Nandagopal 1986).

***Trichogramma australicum* (Hymenoptera: Trichogrammatidae):** Recorded to be a key egg parasitoid of *C. sacchariphagus* in cane fields in Mauritius (Ganeshan & Rajabalee 1997; Ganeshan 2000), also recorded in Madagascar and Taiwan (Box 1953).

***Trichogramma bournieri* Pintureau & Babault (Hymenoptera: Trichogrammatidae):** This species is recorded to parasitise *C. sacchariphagus* eggs in Mozambique (New association) (Conlong & Goebel 2006).

***Trichogramma chilonis* Ishii (*Trichogramma confusum*) (Hymenoptera: Trichogrammatidae):** Egg parasitoid. This species is mass released for the control of *C. sacchariphagus* in India (Rajendran & Hanifa 1998) and China (Liu *et al.* 1987). Selvaraj *et al.* (1994) reported a reduction in *C. sacchariphagus* damage to only 4% as a result of releasing 3 mL of eggs (18000 eggs/mL) in sugarcane fields of Coimbatore, Tamil Nadu, India. Also recorded from Taiwan (Cheng 1986) and Reunion (Goebel *et al.* 2000). Tow *T. chilonis* strains (St Benoît and St Pierre) were tried on *C. sacchariphagus* eggs in the laboratory in the Reunion, and the former strain was shown to have a shorter handling time, therefore may be more appropriate as a biocontrol agent in the field (Reay-Jones *et al.* 2006). In China, this parasitoid is produced on artificial host eggs. The parasitoid was released at 150000 parasitoids/ha for the control of *Chilo sacchariphagus* on sugarcane in 1984. Parasitism rate was similar with parasitoids from artificial and natural host eggs (Dai *et al.* 1988).

***Trichogramma evanescens minutum* (Hymenoptera: Trichogrammatidae):** Egg parasitoid, recorded parasitising *C. sacchariphagus* in sugar cane in India (Butani 1958).

***Trichogramma nanum* Zhnt. (Hymenoptera: Trichogrammatidae):** Recorded parasitising eggs of *C. sacchariphagus* in sugarcane in Taiwan (Box 1953).

***Trichogramma* nr. *nana* (Zehnt.) (Hymenoptera: Trichogrammatidae):** This species is recorded parasitising eggs of *C. sacchariphagus* in sugar cane in Indonesia (Kalshoven 1981).

***Trichogramma nubilale* (Hymenoptera: Trichogrammatidae):** Egg parasitoid. This species was introduced from the USA into Guangdong, China in 1983. Adult parasitoids were released in 800 mu (1 mu = 0.067 ha) of cane at a rate of 55 000/mu for the control of *Chilo sacchariphagus* and *Argyroploce schistaceana* (*Tetramoera schistaceana*). The parasitoid was reported to give better control than the native species *T. confusum* (*T. Chilonis*), and was more active especially during the summer (Liu *et al.* 1987).

***Xanthopimpla stemmator* Thunb (Hymenoptera: Ichneumonidae):** Pupal parasitoid. This species was successfully introduced from Sri Lanka into Mauritius to control *C. partellus*, where it is now well established and reported to parasitize *C. sacchariphagus* and *Sesamia calamistis* (Vinson 1942; Zwart 1998). From Mauritius, it was successfully introduced to Reunion and Mozambique against *C. sacchariphagus* in sugarcane (Caresche 1962; Conlong & Goebel 2002). This parasitoid has a fairly wide range of stemborers, its hosts include *Scirpophaga nivella*, *Sesamia inferens*, *C. suppressalis*, *C. zonellus*, *C. auricilius*, *Scirpophaga incertulas* and *Eldana saccharina* (Townes & Chiu 1970; Facknath 1989; Ganeshan 2000; Conlong & Goebel 2002). Also recorded attacking *C. sacchariphagus* in India (Butani 1972; Ganeshan & Rajabalee 1997), Indonesia (Kalshoven 1981) and Taiwan (Box 1953).

***Xanthopimpla citrina* (Hlmgr.) (*Xanthopimpla luteola*) (Hymenoptera: Ichneumonidae):** Pupal parasitoid. This species is indigenous to Mauritius and the African continent (Zwart 1998). Recorded attacking *C. sacchariphagus* in Mauritius (Moutia & Courtois 1952; Facknath 1989).

***Predators***

Easwaramoorthy and Nandagopal (1986) and Easwaramoorthy *et al.* (1996) provide this list of *C. sacchariphagus* predators recorded in sugarcane fields in India:

**Coleoptera: Carabidae:** *Hexagonia* sp? *insignis* (Bates).

**Hymenoptera: Formicidae:** *Camponotus rufogloucus* (Jerdon), *Camponotus compressus* (F.), *Monomorium aberrans* Forel, *Tetraponera refonigra* Jerdon, *Oecophylla amaragdina* F., *Solinopsis geminala* (F.), *Anoplolepis longipes* Jerdon, *Pheldiogeton* sp.

**Araneae: Glubionidae:** *Oedignatha* sp. **Lycosidae:** *Hippasa greenalliae; Oxyopes shweta; Paradosa* sp. **Oxyopidae:** *Oxyopes* sp. **Salticidae:** *Carrhotus viduus* Koch; *Plexippus paykulli* (Audouin). **Thomisidae**: *Runcinia* sp.

***Pheidole megacephala* Fab. (Hymenoptera: Formicidae):** Recorded as an egg predator of *C. sacchariphagus* in Reunion and Mauritius (Williams 1978; Goebel *et al.* 1999a).

***Micraspis univittata* (Hope) (Coleoptera: Coccinellidae):** Prey range studies in Bihar, India, revealed that both larval and adult stages of this species can feed on eggs and young larvae of *C. infuscatellus* and *C. sacchariphagus* (Easwaramoorthy *et al.* 2001a).

***Pathogens***

***Hyphomycetes***

***Hirsutella nodulosa*:** Fungal pathogen, recorded to give up to 11.4% infection of *C. sacchariphagus* in sugarcane fields of Coimbatore area of Tamil Nadu, India (Easwaramoorthy *et al.* 1998b).

***Metarhizium anisopliae*:** Fungal pathogen, recorded from Mauritius (Ganeshan 2000). In India, *M. anisopliae* var. *anisopliae* was recorded for the first time on *C. sacchariphagus* larvae in cane fields of Coimbatore, Tamil Nadu. In the laboratory, 90% mortality was induced when fourth instar larvae were treated with a $10^9$ spores/ml spore suspension (Easwaramoorthy *et al.* 2001b).

***Paecilomyces* sp.** Fungal pathogen, recorded from Mauritius (Ganeshan 2000).

***Nematodes***

***Mermithidae***

***Mermis* sp.** Entomopathogenic nematodes, recorded from Mauritius by Moutia and Courtois (1952).

***Heterorhabditidae and Steinernematidae***

The entomopathogenic nematodes *Heterorhabditis indica*, *Steinernema siamkayai* and *S. glasieri* were isolated from different areas in Tamil Nadu, India, and were proven pathogenic to *C. sacchariphagus*

(Umamaheswari *et al.* 2004). In addition, laboratory studies showed that *C. sacchariphagus* is a very favourable host for the entomopathogenic nematode *Steinernema feltiae* (Razak & Sivakumar 2001).

***Nosematidae***
***Nosema* sp.** Recorded from Reunion (Fournier & Etienne 1981).
***Nosema furnacalis*:** Recorded on *C. sacchariphagus* in China (Wen & Sun 1988).

**Granulosis virus (GV):** Reported from India to result in up to 31.5% mortality in eight canegrowing district of India (Easwaramoorthy & Nandagopal 1986; Easwaramoorthy & Jayaraj 1987).

**Management**
***Chemical Control***
In Zhanjiang, Guangdong, China, *Tetramoera schistaceana*, *C. infuscatellus* and *C. sacchariphagus* infested sugarcane heavily in the late 1990s, usually at the same time and mainly on internodes 3-15 of sugarcane plants (LiangZhen *et al.* 2000). A mixture of trichlorfon and dimehypo applied to the whirl of sugarcane plants gave 72.1-83% control of the stemborer complex. 80% control of *C. sacchariphagus* was achieved using 0.25% demeton granules in sorghum in China (Anon. 1977).

In 1988, suSCon Fu Ming, a controlled-release granular formulation of 100 g/kg phorate, was registered for use on sugarcane in China. The target pests included *C. infuscatellus* and *C. sacchariphagus* as well as other soil pests. Trials showed that application at planting at 1.8-2.1 kg/ha controlled a range of borer and soil pests, and resulted in significant yield increases (May & Hamilton 1989).

In a field experiment in 1994-96 at Cuddalore, Tamil Nadu, India, Rajendran and Hanifa (1997) showed that the application of 2000 ppm of endosulfan or monocrotophos decreased the emergence of *Trichogramma chilonis* and did not reduce the incidence of *Chilo sacchariphagus* in sugarcane. In a field trial by Pandya (1997) in Gujarat, India, minimum infestation by *C. sacchariphagus* was achieved by the treatment of phorate 10 G at 1 kg a.i./ha.

Deltamethrin is used in Reunion (Goebel *et al.* 1999b).

In Mozambique, where *C. sacchariphagus* was first reported in 1991, Way (1998) recommended that all cane moving between estates is fumigated with methyl bromide.

Thirumurugan *et al.* (2000) showed that though spraying of neem seed kernel extract at 5% on the 30th and 59th day after planting of sugarcane was effective against *C. infuscatellus*, but *C. sacchariphagus* infestation was not reduced.

***Pheromones***
Nesbitt *et al.* (1980) identified (Z)-13-octadecenyl acetate (Z13-18:Ac) and the corresponding alcohol (Z13-18:Alc) as the two main electrophysiologically active components in ovipositor washings from virgin female *C. sacchariphagus*. In field trials in Mauritius, individual components were not attractive to male moths, but traps baited with 7:1 mixtures of the components, which is the naturally occurring ratio, caught as many male moths as did virgin female baited traps. Microencapsulated formulations (ICI Agrochemical, UK) of Z13-18:Ac were similarly affective when applied as a spray at 10, 20, or 40 g/ha, or as spot applications at 1 or 2 m intervals, equivalent to an application rate of 20 g/ha. (see David *et al.* 1985; Beevor *et al.* 1990).

***Transgenic sugarcane***
LiXing *et al.* (2006) produced borer-resistant sugarcanes by placing a synthetic *cry1Ac* gene (*s-cry1Ac*) under the control of maize ubiquitin promoter then introducing it into the embryogenic calli of selected sugarcane lines. Transgenic sugarcane lines expressing high levels of s-Cry1Ac proteins were highly resistant to borer attack, resulting in 100% mortality of the inoculated insects within 1 week after inoculation.

**Means of Movement**

The most likely means of entry of this species into Australia would be by the introduction of infested planting material. The chance of the introduction of moths or eggs on aircraft, in luggage, or on people is much smaller, though still significant.

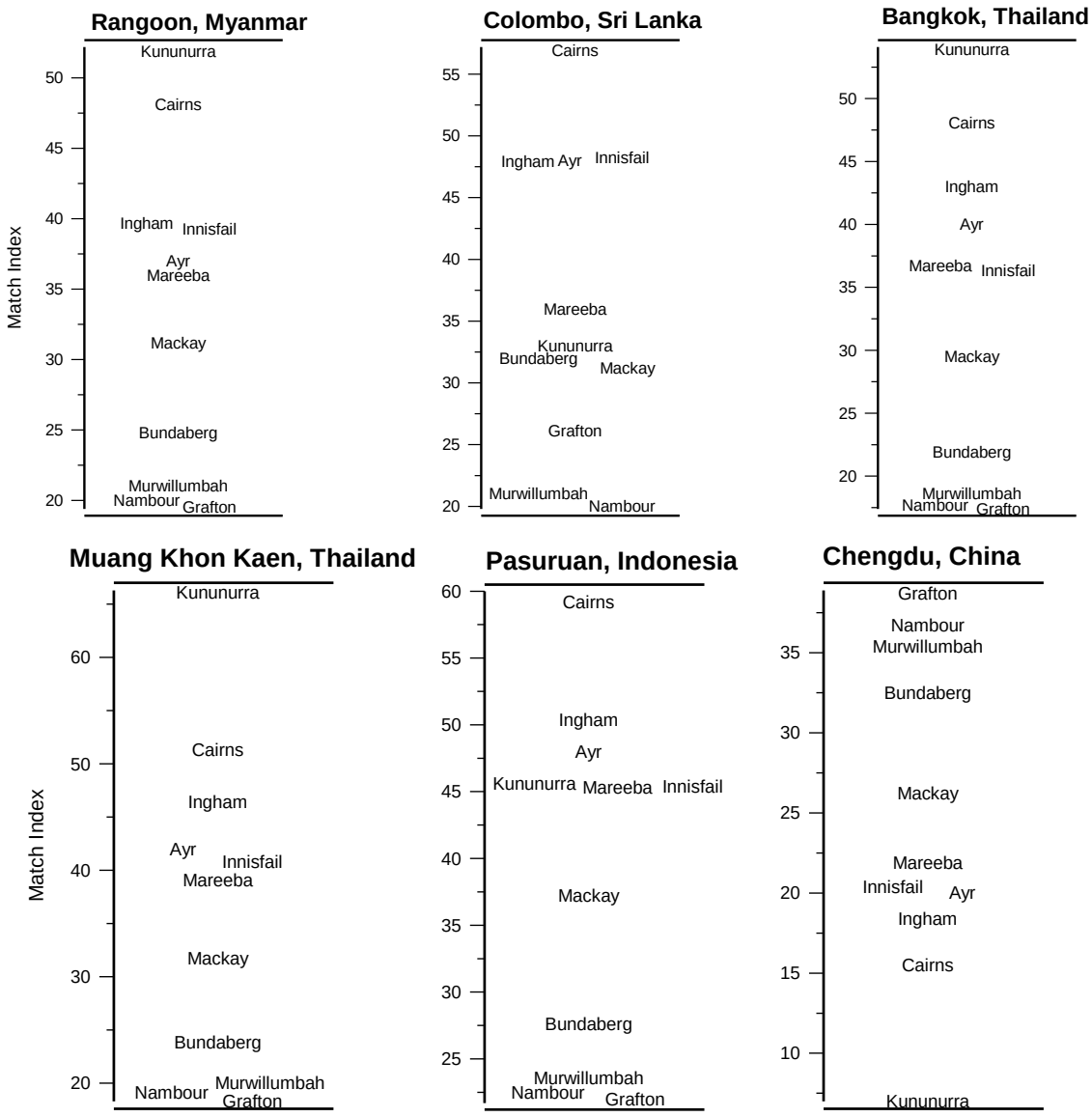
**Phytosanitary Risk**

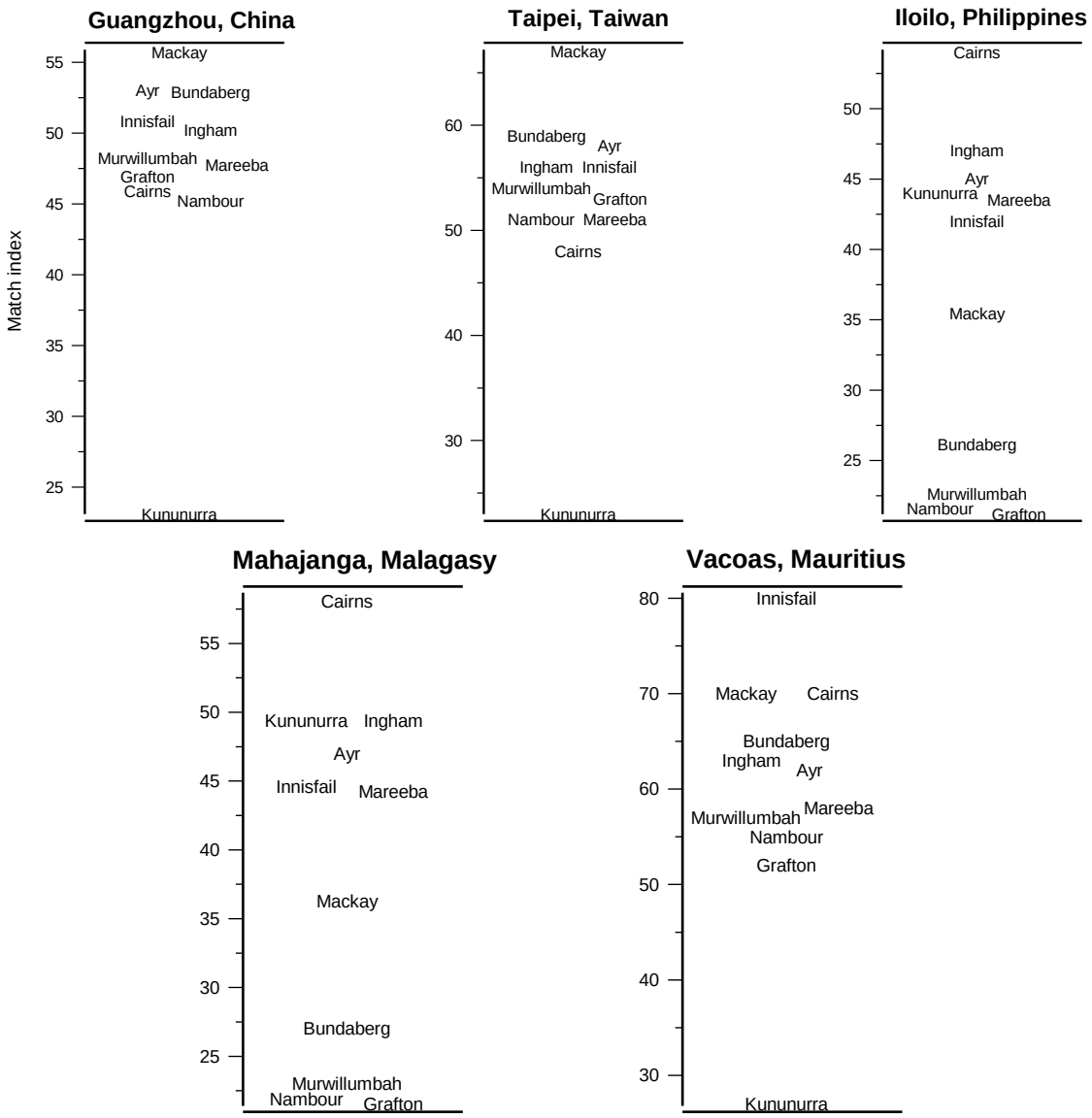
***Entry potential:*** Medium - isolated from Australia, but readily transmitted on infected planting material.

***Colonisation potential:*** High in all sugarcane-growing areas.

***Spread potential:*** High, unless strict controls imposed over movement of infested material.

***Establishment potential:*** Depends on biotype introduced (see Match Indexes for climates at selected locations and principal Australian areas below).

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Match index
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Bundaberg
Innisfail
Ingham
Murwillumbah
Mareeba
Grafton
Cairns
Nambour
Kununurra
Taipei, Taiwan
60
50
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Mackay
Bundaberg
Ayr
Ingham
Innisfail
Murwillumbah
Grafton
Nambour
Mareeba
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Murwillumbah
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Mackay
Cairns
Bundaberg
Ingham
Ayr
Murwillumbah
Mareeba
Nambour
Grafton
Kununurra

***Chilo sacchariphagus stramineellus* (Caradja)**

*Argyria stramineella* Caradja 1926: 168.
*Diatraea venosata* (Walker); Shibuya 1928b: 51;
*Proceras venosatum* (Walker): Kapur 1950: 413; Bleszynski 1962a: 9; Bleszynski 1965; 123.
*Chilo venosatus* (Walker): Bleszynski 1969: 16.
*Chilo sacchariphagus stramineellus* (Caradja): Bleszynski 1970: 186.

**Type**
Holotype male, Tsingtau, China, in Muzeul Grigorie Antipa, Bucharest.

**Distribution**
China, Taiwan.

**Morphology**
***Adults***
Bleszynski (1970) gives the following description of *Chilo s. stramineellus*: Externally strikingly similar to *sacchariphagus sacchariphagus*.

***Male genitalia*** (Fig. 124): Aedeagus broader than in typical subspecies, with apical scobinations which are absent in *C. s. sacchariphagus*. In males from China the saccus s truncate, but in those from Formosa it is V-shaped, similar to typical subspecies. One row of cornuti.

***Female genitalia*** (Figs 128-130): Ductus bursae decidedly twisted with an elongate, distinct sclerite lacking in typical subspecies; ostial pouch always very broad.

***Chilo sacchariphagus indicus* (Kapur)**

*Diatraea venosata* (Walker): Fletcher & Ghosh 1920: 388; Gupta 1940: 803; Isaac & Rao 1941: 800; Isaac & Venkatraman 1941: 808.
*Proceras indicus* Kapur 1950: 414; Bleszynski 1956: 493; Bleszynski 1969: 6.
*Chilo sacchariphagus indicus* (Kapur): Bleszynski 1970: 187.

**Type**
Holotype male, Pusa, Bihar, India, in Natural History Museum, London.

**Distribution**
India.

**Morphology**
***Adults***
Bleszynski (1970) gives the following description of *C. sacchariphagus indicus*: Externally strikingly similar to *C. s. sacchariphagus*.

***Male genitalia*** (Figs 122-123): Aedeagus broader than in *C. s. sacchariphagus*, and terminated in oval, elongate, heavily sclerotized projection; cornuti arranged in two distinct patches.

***Female genitalia*** (Fig. 127): Similar to those in *C. s. sacchariphagus*.

***Chilo suppressalis* (Walker)**

*Crambus suppressalis* Walker 1863: 166.
*Jartheza simplex* Butler 1880: 690 [syn. Kapur 1950].
*Chilo suppressalis* (Walker): Hampson 1896: 957; Leech 1901: 398; Kapur 1950: 397; Zimmerman 1958: 342; Okano 1962: 124; Bleszynski 1965: 109; 1970: 120.
*Chilo simplex* (Butler): Rebel 1901: 257; Leech 1901: 397 [in part]; Shibuya, 1928a: 143; 1928b: 54; Kawada 1930: 145; Marumo 1933: 51.
*Chilo boxanus* Hering 1903: 111 [in part].
*Chilo oryzae* Fletcher 1928: 59 [syn. Kawada 1930].
*Chilo orizae* Fletcher: Rebel 1940: 116 [misspelling].

**Types**
*suppressalis*: Holotype female, Shanghai, China, in Natural History Museum, London.
*simplex*: Lectotype male, Taiwan, in Natural History Museum, London.
*oryzae*: Holotype female, Pusa, India, in Natural History Museum, London.

**Common Names**
Rice *Chilo*, striped stem borer, Asiatic rice borer.

**Distribution**
*Chilo suppressalis* is reported mainly on rice from Bangladesh, Brunei, Burma, China, France, Hawaii, India, Indonesia, Iraq, Japan, Korea, Malaysia, Nepal, Pakistan, Philippines, PNG, Russian Far East, Sri Lanka, Taiwan, Thailand, Vietnam, Zanzibar.

*Chilo suppressalis* was introduced accidentally into Spain and Hawaii probably by humans (Subba Rao & Chawla 1964; Harris 1990). Li (1970) recorded this species on rice in the Northern Territory of Australia (see also CAB 1977); Li (1970) refers to *C. suppressalis* as a minor pest of rice at Tortilla Flats and Humpty Doo in the Northern Territory, and states that the occurrence of the pest is relatively rare in both wet and dry season rice crops, with six or more overlapping generations per year.

*Chilo suppressalis* has been for a long time recorded from the Middle East as *C. simplex*, but all of these records are referable to *C. agamemnon* (Bleszynski 1970).

**Host Plants**
*Chilo suppressalis* is mainly a pest of rice, but it has been recorded feeding on maize, *Scirpus gressus* and *Panicum crusgalli* (Meyrick 1932, Nair, 1958, Alam *et al.* 1993). In addition, David & Easwaramoorthy (1990) referred to this species as a minor pest of sugarcane in Taiwan and Japan. Other hosts include sorghum, *Panicum miliaceum*, *Echinochloa* spp., *Phragmites communis*, *Saccharum fuscum* (?), *Typha latifolia*, water oats (*Zizania latifolia, Z. caduciflora* and *Zizania aquatica*) (Litsinger 1977; Harris 1990; Ishida *et al.* 2000). Occurrence of *Chilo suppressalis* (Walker) in Australia was confirmed recently (Ted Edwards, Personal communication), but not in commercial cane areas. Hence, there is need for a host range study to be carried out on the population from Northern Territory. The possibility of the species surviving on cane, though minimal, should be examined under laboratory conditions.

**Symptoms**
*Chilo suppressalis* infestation result in a wilted sheath that eventually dies. Infestation also causes dead hearts. An important symptom is the existence of (white heads) due to larval feeding.

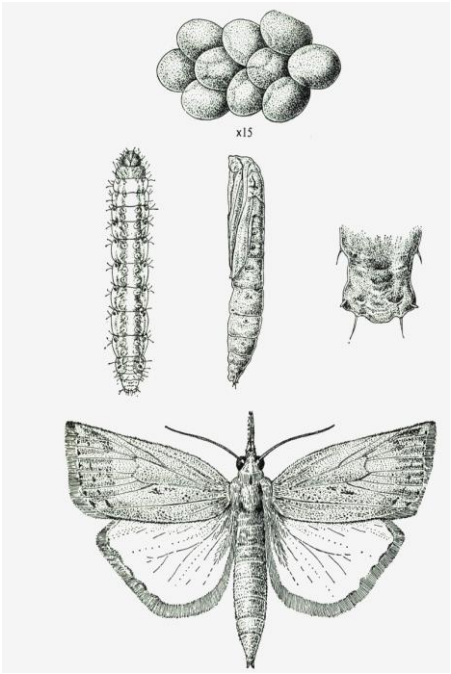
**Economic Impact**
This species is a major pest of rice in East Asia, India, Japan and Indonesia (Hattori & Siwi 1986; Konno & Tanaka 1996; Tripathi *et al.* 1997). *Chilo suppressalis* has gradually resumed its importance as a rice insect pest in Taiwan since 1980 where it occasionally causes severe damage (Cheng 2000). There is no evidence to suggest that this species could be of any significance in sugarcane fields.

**Morphology**

***Adults***
Bleszynski (1970) gives the following description of *C. suppressalis*: Ocellus well developed. Face strongly protruding forward beyond eye, with very distinct corneous point and ventral ridge. Labial palpus 3 (male) to 3.5 (female) times as long as diameter of eye. Fore wing: length 11.0-14.0 mm; $R_1$ free; ground-colour varying from dirty white to yellow-brown, variably sprinkled with grey-brown scales; subterminal line ill-defined or absent; median line oblique, brown, often reduced, particularly in light coloured specimens; metallic scales absent. Hind wing white to yellow brownish.

***Male genitalia*** (Fig. 18): Pars basalis small; juxta-plate symmetrical, arms equally long, very distinctly swollen near apices; subapical teeth absent; aedeagus with long, thin, ventral arm; bulbose basal projection absent.

***Female genitalia*** (Fig. 17): Ostial pouch heavily sclerotized, slightly demarcated from ductus bursae; the latter posterior to ostial pouch distinctly swollen, with heavily sclerotized band; signum distinct, elongate, with median ridge.




Life stages of *C. suppressalis* (after Kalshoven 1981)

**Detection Methods**
Pheromone trapping can be used to attract adult moths. Damage can be detected by checking plant sheath and looking for larval stages or larval damage.

**Biology and Ecology**
Adult moths are active in the evening and females lay 100-550 eggs in 50-80 batches over a 3-5 day period. Egg batches are laid on the basal half of the upper or lower surfaces of leaves and occasionally leaf sheaths. Young larvae cluster under leaf sheaths and later enter the stem, and life cycle is completed in 35-60 days. Up to five generations per year can develop in tropical conditions if cropping is continuous. In temperate regions, however, final-instar larvae remain in dormancy until the following growing season. *Chilo suppressalis* is adapted to temperatures as low as -14°C (Harris 1990). In rice fields of Taiwan, Cheng (2000) recorded five *C. suppressalis* generations a year with three generations in the first cropping season and two generations in the second. The adult population in the first cropping season was higher than in the second due to disruption of the habitat between seasons. High temperature and heavy rainfall in the early growing stage of rice limits the population in the second cropping season. Both non diapausing and diapausing larvae are freeze tolerant with the later being more tolerant. Tsumuki (2000)

found that high levels of glycerol are produced in the haemolymph from glycogen in the fat body as a cryoprotectant in overwintering larvae during pre diapause to diapause stages in the field. The increase in freeze tolerance in the diapausing larvae coincided with an increase in glycerol content in the haemolymph.

**Natural Enemies**

***Parasitoids***

***Apanteles chilonis* (Hymenoptera: Braconidae)**: Larval parasitoid, recorded attacking *C. suppressalis* in Japan (Kajita & Drake 1969; Imamura & Yamazaki 1975; Imamura & Machimura 1976) and China (Jiang *et al.* 1999).

***Bracon chinensis* Szépl. (Hymenoptera: Braconidae)**: Larval parasitoid, recorded attacking *C. suppressalis* in Sarawak, Indonesia (Kalshoven 1981).

***Centeterus alternecoloratus* Cushman (Hymenoptera: Ichneumonidae)**: Pupal parasitoid. Recorded attacking *C. suppressalis* in paddy rice in India (Butani 1972).

***Cotesia flavipes* (*A. nonagriae*) (Hymenoptera: Braconidae)**: Larval parasitoid, recorded by Li (1970) attacking *C. suppressalis* in rice fields in Northern Territory, Australia. The identity of this species in Australia requires verification to clarify if *A. nonagriae* is the same species as *Cotesia flavipes*.

***Cotesia flavipes* Cameron (Hymenoptera: Braconidae)**: Gregarious larval endoparasitoid, recorded attacking *C. suppressalis* in Japan (Kajita & Drake 1969) and Taiwan (Cheng *et al.* 1987a).

***Sturmiopsis inferens* Towns (Diptera: Tachinidae)**: Larval parasitoid recorded in Malaysia (Kalshoven 1981).

***Telenomus dignus* Gah. (Hymenoptera: Scelionidae)**: Egg parasitoid, attacks *C. suppressalis* in rice fields in Indonesia (Kalshoven 1981).

***Tetrastichus israeli* (M.&K.) (Hymenoptera: Eulophidae)**: Pupal parasitoid. Recorded in Indonesia on *C. suppressalis* (Kalshoven 1981)

***Trichogramma* sp. (Hymenoptera: Trichogrammatidae)**: Egg parasitoid. Responsible for up to 100% egg mortality in Indonesia (Kalshoven 1981).

***Xanthopimpla stemmator* Thnb. (Hymenoptera: Ichneumonidae)**: Attacks *C. suppressalis* pupae in Indonesia (Kalshoven 1981).

**Management**

***Chemical Control***

Organophosphorus and pyrethroids are traditionally used in Spain and France, respectively, against *Chilo suppressalis*. More recently, Tebufenozide, which is a moulting accelerating insecticide specific for Lepidoptera, has been recommended in Spain and France (Mattioda & Jousseaume 1999).

Fipronil at 1.2 L/ha, triazophos at 3 L/ha and dimehypo aqueous solution are used in China resulting in good control (Liu *et al.* 1999).

Problems with resistance to certain pesticides were highlighted by Cao *et al.* (2000), who assessed the toxicities of topically applied Monosultap to fourth-instar larvae in 14 populations collected from the provinces of Jiangsu, Zhejiang, Anhui, Jiangxi, Hunan, Guangxi, Heilongjiang and Shanghai City, in China. Resistance was moderate in populations from Jiangxi, Zhejiang, Jiangsu and Shanghai and low in populations from Jiangsu, Zhejiang, Anhui and Guangxi. Populations from Anhui were susceptible to the insecticide, while the population from Zhejiang was moderately resistant to triazophos.

***Pheromone Trapping***

Synthetic female sex pheromone consisting of Z-11 hexadecenal, Z-13 octadecenal and Z-9-hexadecenal (Su *et al.* 2001). Fields results from Chiayi, Taiwan, showed that pheromone traps are more efficient than suction light traps in monitoring the population of rice stem borer (Cheng 2000).

***Plant Resistance***

Extensive research has been carried out into the production of *C. suppressalis* resistant transgenic rice carrying a cry1Ab gene from *Bacillus thuringiensis* (Bt), with good results recorded from a number of available varieties (Alinia *et al.* 2000a,b; Wu *et al.* 2000).

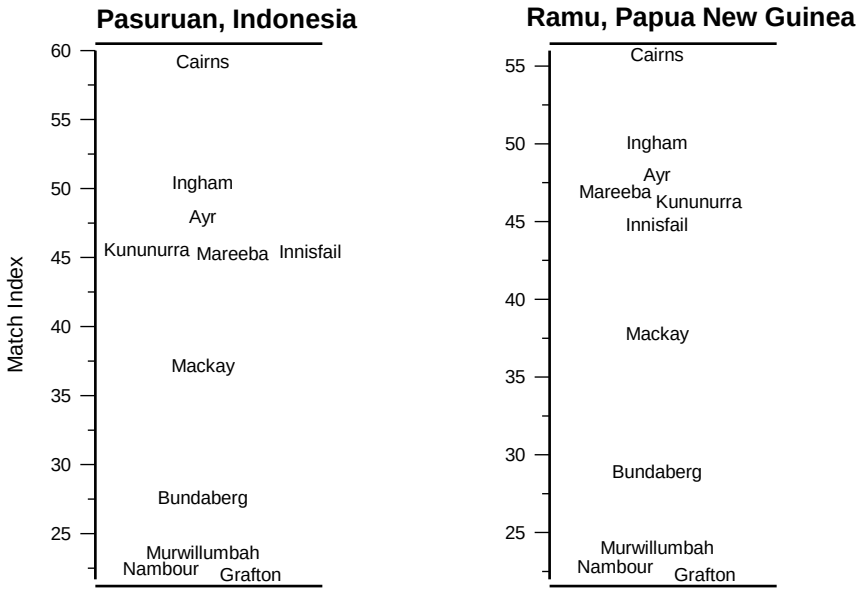
A synthetic gene coding for a winged bean trypsin inhibitor WTI 1B has been introduced and expressed in rice plants. Protein extracts from transgenic rice plants expressing the trypsin inhibitor inhibited the gut proteases of *C. suppressalis* larvae in vitro. Growth of larvae reared on transgenic rice plants expressing WTI 1B at more than 1 ng/10 µg total protein was significantly retarded compared to that on non-transgenic control plants (Mochizuki *et al.* 1999).

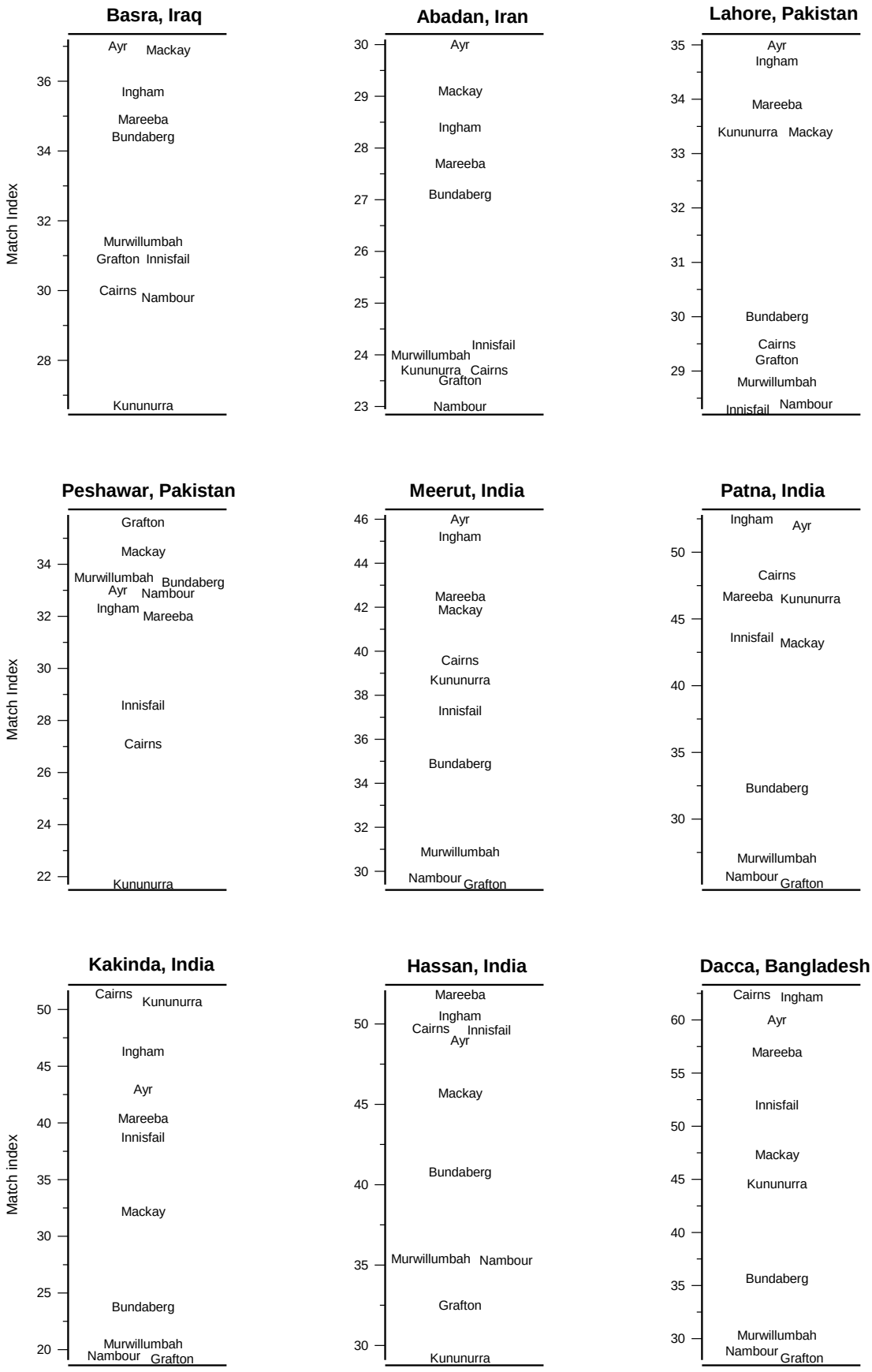
**Means of Movement**

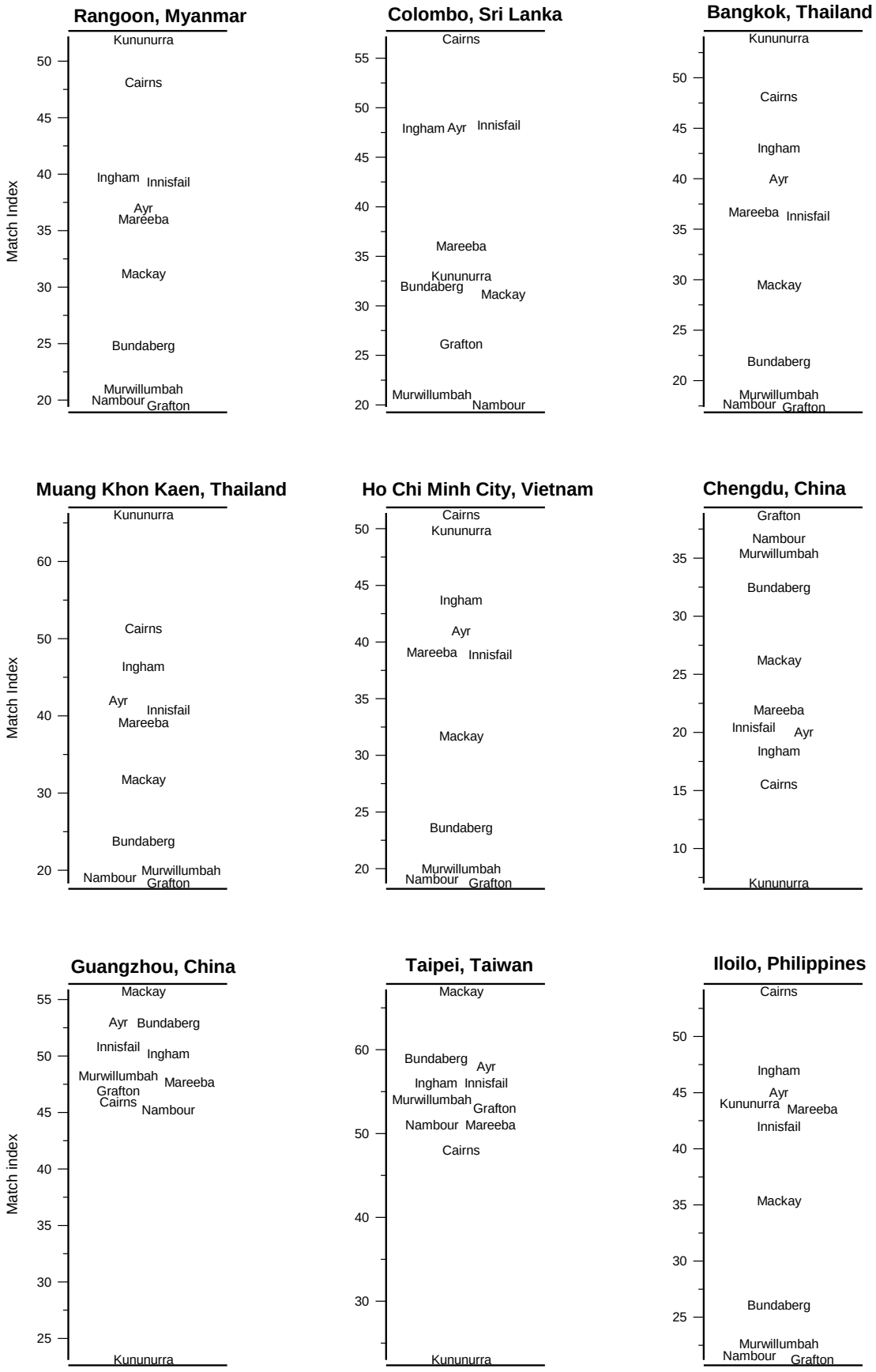
The most likely means of entry of this species into Australia would have been the introduction of infested planting material. The chance of movements of moths or eggs within Australia on aircraft, in luggage, or on people could be significant.

**Phytosanitary Risk**

***Entry potential:*** Confirmed as present in Australia, but not in commercial cane areas.
***Colonisation potential:*** High in all sugarcane-growing areas.
***Spread potential:*** High, unless strict controls imposed over movement of infested material.
***Establishment potential:*** Depends on biotype present (see Match Indexes for climates at selected locations and principal Australian areas below).




Basra, Iraq
Match Index
Ayr
Mackay
Ingham
Mareeba
Bundaberg
Murwillumbah
Grafton
Innisfail
Cairns
Nambour
Kununurra
Abadan, Iran
Ayr
Mackay
Ingham
Mareeba
Bundaberg
Innisfail
Murwillumbah
Kununurra
Cairns
Grafton
Nambour
Lahore, Pakistan
Ayr
Ingham
Mareeba
Kununurra
Mackay
Bundaberg
Cairns
Grafton
Murwillumbah
Innisfail
Nambour
Peshawar, Pakistan
Match Index
Grafton
Mackay
Murwillumbah
Bundaberg
Ayr
Nambour
Ingham
Mareeba
Innisfail
Cairns
Kununurra
Meerut, India
Ayr
Ingham
Mareeba
Mackay
Cairns
Kununurra
Innisfail
Bundaberg
Murwillumbah
Nambour
Grafton
Patna, India
Ingham
Ayr
Cairns
Mareeba
Kununurra
Innisfail
Mackay
Bundaberg
Murwillumbah
Nambour
Grafton
Kakinda, India
Match index
Cairns
Kununurra
Ingham
Ayr
Mareeba
Innisfail
Mackay
Bundaberg
Murwillumbah
Nambour
Grafton
Hassan, India
Mareeba
Ingham
Cairns
Innisfail
Ayr
Mackay
Bundaberg
Murwillumbah
Nambour
Grafton
Kununurra
Dacca, Bangladesh
Cairns
Ingham
Ayr
Mareeba
Innisfail
Mackay
Kununurra
Bundaberg
Murwillumbah
Nambour
Grafton


Rangoon, Myanmar
Match Index
Kununurra
Cairns
Ingham
Innisfail
Ayr
Mareeba
Mackay
Bundaberg
Murwillumbah
Nambour
Grafton
Colombo, Sri Lanka
Cairns
Ingham
Ayr
Innisfail
Mareeba
Kununurra
Bundaberg
Mackay
Grafton
Murwillumbah
Nambour
Bangkok, Thailand
Kununurra
Cairns
Ingham
Ayr
Mareeba
Innisfail
Mackay
Bundaberg
Murwillumbah
Nambour
Grafton
Muang Khon Kaen, Thailand
Match Index
Kununurra
Cairns
Ingham
Ayr
Innisfail
Mareeba
Mackay
Bundaberg
Nambour
Murwillumbah
Grafton
Ho Chi Minh City, Vietnam
Cairns
Kununurra
Ingham
Ayr
Mareeba
Innisfail
Mackay
Bundaberg
Murwillumbah
Nambour
Grafton
Chengdu, China
Grafton
Nambour
Murwillumbah
Bundaberg
Mackay
Mareeba
Innisfail
Ayr
Ingham
Cairns
Kununurra
Guangzhou, China
Match index
Mackay
Ayr
Bundaberg
Innisfail
Ingham
Murwillumbah
Mareeba
Grafton
Cairns
Nambour
Kununurra
Taipei, Taiwan
Mackay
Bundaberg
Ayr
Ingham
Innisfail
Murwillumbah
Grafton
Nambour
Mareeba
Cairns
Kununurra
Iloilo, Philippines
Cairns
Ingham
Ayr
Kununurra
Mareeba
Innisfail
Mackay
Bundaberg
Murwillumbah
Nambour
Grafton

***Chilo terrenellus* Pagenstecher**

*Chilo terrenellus* Pagenstecher 1900: 160; Bleszynski 1962: 7; 1970: 145.
*Chilotraea terrenellus* (Pagenstecher): Martin 1954: 120.

**Type**
Lectotype female, Bismarck Archipelago, in Zoological Institute, Berlin.

**Distribution**
Papua New Guinea (Bleszynski, 1970; Li 1985; Kuniata 2000).

First recorded in Australia on the Torres Strait islands of Saibei and Dauan (Gough & Peterson 1984; Chandler & Croft 1986; Anon. 1996; Grimshaw & Donaldson 2007; see also Li 1990).

**Host plants**
Sugarcane, *Saccharum robustum, S. edule*.

**Symptoms**
Infestation results in death of the growing point and dead hearts. Stalks are tunneled and can be easily broken by wind.

**Economic importance**
*C. terrenellus* is a pest of sugar cane in the Markham Valley and at Ramu (PNG). Its importance is however far less than that of the noctuid *Sesamia grisescens* in PNG (Kuniata 2000). The status of *C. terrenellus* has changed in the late 1980s due to the rapid adoption of cultivars resistant to Ramu stunt, which at the same time were *Sesamia* susceptible. Since 1987, severe cane losses have been sustained due to *Sesamia grisescens* in PNG, while losses in young cane shoots due to *C. terrenellus* is usually less than 10%, but infestation may be exacerbated if diseases such as red rot (*Colletotrichum falcatum*) invades the wounds (Li 1990).

The probability of this species invading commercial sugarcane areas in Australia is high, as it is found on the Torres Strait islands, where it appears intermittently (Grimshaw & Donaldson 2007).

**Morphology**
***Adults***
Bleszynski (1970) gives the following description of *C. terrenellus*: Ocellus vestigial or small. Face similar to that in *louisiadalis*. Labial palpus 3 (male) to 4 (female) times as long as diameter of eye. Fore wing: length 12.5-18.0 mm; $R_1$ confluent with *Sc*; coloration rather similar as in *louisiadalis*, but longitudinal streaks absent; some specimens very dark brown. Hind wing varying from dirty white to grey.

***Male genitalia*** (Figs 50-51): generally similar to those in *louisiadalis*, but with basal edge of the main part of the ventral arm of the aedeagus almost perpendicular to the stem.

***Female genitalia*** (Fig. 54): very similar to those in *louisiadalis*; for more details see under *louisiadalis*.

**Detection methods**
Look for eggs on the underside of leaves. Split cane stalks to see the larvae in tunnels.

**Biology and Ecology**
Li (1985) studied the life cycle of this species in the field and reported six overlapping generations a year. Duration of instars 1-6 is 59, 44-46, 49-76, 46-62, 48-75, and 48-64 days, respectively. According to Li (1985), the borer breeds continuously through the year and egg numbers in the field peak in early October, Early December, mid-February, early May, late July and early October, which coincide with the generations observed. Egg masses are usually found on the underside of green or dried leaves and occasionally on the upper side of the leaves or on the surfaces on the stems. Adult moths can live for 1-6 days and one female is capable of laying up to 24 egg masses in a period of 3 days.

Li (1985) developed a method of rearing larvae of *C. terrenellus* by using 15 cm long sections of cane stalks. A 5 cm section of each piece is cut with a knife and a cork borer to produce a tunnel where a larva is introduced, then the tunnel is sealed with a piece of cotton wool. Cane sections with larvae are then placed in glass jars containing water. The water should be replaced every 2 days, and cane sections are to be renewed fortnightly. Young larvae should first be introduced into tops of young cane standing in water for a few weeks before being transferred to cane sections.

**Natural Enemies**

**Parasitoids**

***Apanteles* sp. (Hymenoptera: Braconidae):** Larval parasitoid, PNG (Li 1985; Li 1990).

***Apanteles* sp. *nr chilonis* Munikata (Hymenoptera: Braconidae):** Larval parasitoid, PNG (Young 1982).

***Carcelia* (*Senametopia*) sp. (Diptera: Tachinidae):** Larval parasitoid, PNG (Li 1990).

***Ceraphron* sp. (Hymenoptera: Ceraphronidae):** Larval parasitoid, PNG (Li 1990).

***Cotesia flavipes* (Hymenoptera: Braconidae):** Larval parasitoid, PNG (Li 1990; Kuniata & Korowi 2005).

***Enicospilus terebrus* (Hymenoptera: Ichneumonidae):** Provides low rates of parasitism in PNG (Kuniata & Korowi 2005).

***Gryon nixoni* Masner (Hymenoptera: Scelionidae):** Egg parasitoid, PNG (Li 1990).

***Telenomus* sp. (Hymenoptera: Scelionidae):** Egg parasitoid, PNG (Young 1982; Li 1990).

***Trichogramma* sp. (Hymenoptera: Trichogrammatidae):** Egg parasitoid, PNG **(**Young 1982; Li 1985).

***Trichogramma* sp. nr. *plasseyensis* Nagaraja (Hymenoptera: Trichogrammatidae):** Egg parasitoid, PNG (Li 1990).

**Management**

***Chemical control***

No data are available. However, pesticides used for the control of *Sesamia grisescens* will probably have similar effect on *C. terrenellus*.

Recent studies in Papua New Guinea showed that the following sugarcane varieties were susceptible to *Chilo terrenellus*: Q151, Q171, Q230, Q246, Q243, Q241 and Q220. Varieties Q113, Q242, Q155, Q224, Q213, Q188, Q138 and Cadmus were found to be intermediate while Q215, Q200, Q182 and Q203 were found to be resistant. A detailed list of ratings is available in the final report of Project BSS331 and in the SRA SPIDNet database.

**Means of Movement**

The most likely means of entry of this species into Australia would be by the introduction of infested planting material. The chance of the introduction of moths or eggs on aircraft, in luggage, or on people is much smaller, though still significant.

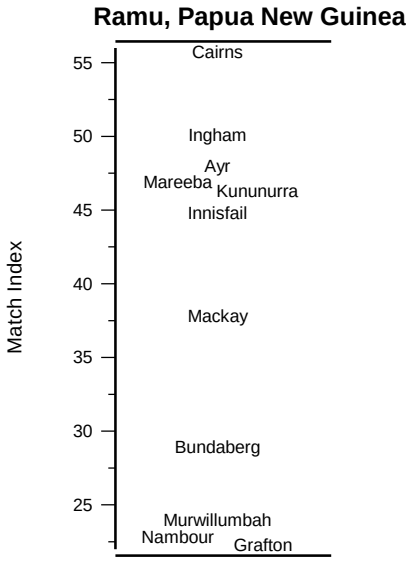
**Phytosanitary Risk**

***Entry potential:*** High – close to commercial Australian areas and readily transmitted on infected planting material.

***Colonisation potential:*** High in northern Queensland.

***Spread potential:*** High, unless strict controls imposed over movement of infested material.

***Establishment potential:*** High in northern Queensland (see Match Indexes for climate at Ramu and principal Australian areas below).


Ramu, Papua New Guinea
Match Index
55
50
45
40
35
30
25
Cairns
Ingham
Ayr
Mareeba
Kununurra
Innisfail
Mackay
Bundaberg
Murwillumbah
Nambour
Grafton

***Chilo tumidicostalis* (Hampson)**

*Argyria tumidicostalis* Hampson 1919: 448.
*Chilo gemininotalis* Hampson 1919: 59. [syn. Fletcher 1928].
*Chilo tumidicostalis* (Hampson): Kapur 1950: 401; Bleszynski, 1969: 14; 1970: 134.

**Types**
*tumidicostalis*: Lectotype male, Pabna, India, in Natural History Museum, London.
*gemininotalis*: Holotype female, India, in Natural History Museum, London.

**Common name**
Bengal borer, Plassey borer.

**Distribution**
Bangladesh, Burma, India, Nepal, Thailand (Bleszynski, 1970; Miah *et al.*, 1983; David & Easwaramoorthy 1990; Suasa-ard 2000).

**Host plants**
Feeds exclusively on sugarcane (Bleszynski 1970).

**Symptoms**
Young larvae tunnel gregariously into the top three to five internodes causing the primary infestation, which is characterized by the production of set-roots and lateral buds and dryness of top leaves. Later, a secondary infestation is characterized by larvae boring individually in separate internodes, but cane tops do not dry (Neupane 1990).

**Economic impact**
In India, *C. tumidicostalis* used to be considered a major pest of sugarcane in Purnea and adjoining parts of Bhagalpur, Munger and Darbhanga districts of Bihar. Earlier records from the Bihar state estimate cane losses to vary from 8.2-48.6% (Khanna *et al.* 1957), other recorded yield losses in the fifties from west Bengal varied from 35 to 100 t/ha (see Neupane 1990). The pest status seemed to have declined during the 1980s (Kumar *et al.* 1987). More recent work by Gupta and Singh (1997) showed that the content of brix in canes damaged by *C. tumidicostalis* was reduced by 4.21%, pol by 10.0%, sucrose by 9.36%, glucose by 5.20% and CCS by 12.28%. While Gupta & Sarma (2007b) recorded that in Golaghat, Assam, India, five – seven damaged internodes resulted in a decrease of 38.0% in cane weight, 42.5% in juice weight and 33.3% of bagasse weight, and that high borer infestation caused reduction in brix, pol, sucrose, glucose and commercial cane sugar (CSS) by 14.1, 19.5, 18.4, 58.1 and 20.4%, respectively. Other studies in Bangladesh record damage levels ranging from 6.95 to 57.21% at Ishurdi and Thakurgaon provinces (Abdullah *et al.* 2006).

On the other hand, *C. tumidicostalis* used to be considered a minor pest of sugarcane in Thailand until the late 1990s, when it unexpectedly became the most damaging pest of cane. Severe outbreaks were reported in the provinces of Sa Kaew and Buri Rum where infestation reached 100% (Suasa-ard 2000). The reasons for such a significant variability in its economic status is unknown.

**Morphology**
Bleszynski (1970) gives the following description of *C. tumidicostalis*: Ocellus well developed. Face moderately produced forward, with corneous point, which, in some specimens, is only poorly developed; ventral ridge absent. Labial palpus 2.5 (male) to 3.5 (female) times as long as diameter of eye. Fore wing: length 9.0-10.5 mm; $R_1$ free; ground-colour dull grey to brown; with dark shade from base to short distance beyond cell; number of dark scales scattered irregularly over wing except on area immediately below longitudinal shade and along margin; transverse lines absent; terminal dots present, alternating with small white dots; fringe shiny brown. Hind wing silky white.

***Male genitalia*** (Fig. 32): Valva with apex broadly rounded; apical portion more heavily sclerotized than the remainder of the area; costal portion densely clothed with minute hairs; pars basalis absent; juxta plate

symmetrical, arms long, apically rounded, each armed with strengthening, provided with two distinct, widely separated teeth; ventral arm of aedeagus deeply notched, rounded, its dorsal margins clothed with minute hairs subapically and near base; vesica with numerous tiny spikes, but without distinct cornutus.

***Female genitalia*** (Fig. 36): Ostium pouch poorly demarcated from ductus bursae, with heavily sclerotized caudal ring and two rather heavily sclerotized bars at sides; signum absent.

**Detection methods**

Light trapping was found to be a good monitoring tool in India. Early examination of growing points in young cane for detection of primary infestation is probably the most reliable method.

**Biology and Ecology**

Studies in Thailand reported that adult moths live for 5-7 days, and females lay an average number of 287 eggs, and the incubation period is about 4.6 days. Eggs can be laid on either side of the leaf. Larvae are creamy white with large dark spots on the dorsal side of the body and a dark brown head. Neupane (1990) reports that larvae soon tunnel into the soft tissues of the growing point larvae do severe tunneling in the top three to five internodes, and infested internodes produce set-roots and lateral buds which is evidence of primary infestation. Larvae then disperse either to another healthy plant or to the lower healthier parts of the same stalk causing a secondary infestation. Suasa-ard (2000) records that larvae prefer to feed on the stalks rather than cane shoots, and he reports that more than 100 larvae can be found living gregariously in one stalk. Larvae molt five to seven times before pupation during a larval period of about 26 days. Pupation period is about 7.5 days and takes place inside the stalk. Borah & Sarma (1995) studied the seasonal incidence of *C. tumidicostalis* in first-ratoon cane in Buralikson, Assam, India, where the pest was firstly detected at low levels in late April, when the plants were 4 months old. The population increased sharply from the middle of July reaching a peak by the end of September, then declined slightly towards harvest. High relative humidity was regarded as a contributory factor for multiplication of the pest. While Gupta & Sarma (2007a) studied the life cycle of *C. tumidicostalis* in the rainfed agroecosystem of Assam and recorded six larval instars on both plant and ratoon canes, with longer larval and pupal durations in December-February compared to July-August on both plant and ratoon canes. Gupta & Rabha (2003) recorded that *C. tumidicostalis* larval duration (53.3 days), pupal duration (10-12 days) and total life cycle (61-72 days) were considerably shorter and growth index (101.3%) was higher when reared on internodes taken from plant cane compared to those taken from a second ratoon crop and held in the laboratory under $30C^0$ and relative humidity 80% (63.5, 10-20, 70-90 days and 80.3%, respectively). Higher level of nitrogen, phosphorous and potash and late maturity and accumulation of sugar in plant cane seem to favour growth of borer.

In a study in Jorhat, Assam, India. Gupta *et al.* (2003) showed that *C. tumidicostalis* underwent facultative diapause in full-grown larval stage, and that diapaused larvae were most abundant in the field during November and December. Diapaused larvae increased from 3.3% in July to 95.2% in December and then decreased to 46.2% in January and 4.7% by March. Diapause incidence was negatively correlated with mean temperature and photoperiod length.

**Natural Enemies**

***Parasitoids***

***Anostectus* sp. (Hymenoptera: Eulophidae):** Larval parasitoid, recorded on *C. tumidicostalis* in India (Butani 1958; Butani 1972).

***Apanteles* sp. (Hymenoptera: Braconidae):** Larval parasitoid, India (Butani 1972).

***Campyloneurus mutator* Fabricius (Hymenoptera: Braconidae):** Recorded as a larval parasitoid from Assam, India (Butani 1972).

***Cotesia flavipes* Cameron (Hymenoptera: Braconidae):** Gregarious larval endoparasitoid. Recent studies in India showed that *C. flavipes* appears in cane fields towards the end of June, with parasitization being low at the beginning of the season. Higher rates of parasitism (up to 31.7%) are reached in September-October. Parasitism rate was shown to have increased with the increase in incidence of *C. tumidicostalis* and a good degree of synchronization in host and parasitoid density was found (Bora & Arya 1995; Bora & Sarma 1995). In a survey in Uttar Pradesh, India, up to 65% parasitism levels were recorded in October 2003 (Pandey *et al.* 2005). A native strain of *C. flavipes* is mass released in cane fields in

Thailand, where 500 adults/ha were shown to boost parasitism rates in the field though were not enough to satisfactorily manage the pest (Suasa-ard 2000; 2001).

***Goniozus indicus* Ashmead (Hymenoptera: Bethylidae):** Larval ectoparasitoid, attacks a fairly wide range of stemborers including *C. tumidicostalis* in India (Bihar, Orissa and Tamil Nadu) (Butani 1972).

***Telenomus rowani* (Hymenoptera: Scelionidae):** Egg parasitoid, recorded in Thailand (Suasa-ard 2000).

***Trichogramma chilotraeae* (Hymenoptera: Trichogrammatidae):** Egg parasitoid, recorded in Thailand (Suasa-ard 2000).

**Unidentified tachinid**: Thailand (Suasa-ard 2000).

***Xanthopimpla* sp. (Hymenoptera: Ichneumonidae):** Pupal parasitoid recorded in Thailand (Suasa-ard 2000).

**Management**

***Chemical Control***

In India, fenvalerate 0.4% dust and malathion 10% dust at 1.5-2.0 kg ai/ha are used successfully for the management of both *Scirpophaga excerptalis* and *C. tumidicostalis* in cane. Soaking cane setts in monocrotophos-36 EC and phosphamidon-85 EC at 1.00% concentration gave effective control of both pests and gave protection for most of the growing season (Deka *et al.* 1999a,b). In Assam, phosphamidon at 0.05% combined with rogueing of affected shoots in July and September gave good control (Borah 1994).

In Bangladesh, where *C. tumidicostalis* attacks cane alongside *Scirpophaga excerptalis*, *C. infuscatellus*, *C. auricilius* and *Sesamia inferens*, application of granules of cartap (Padan) at 3 kg a.i./ha in both July and August gave satisfactory control of the borer complex (Miah *et al.* 1983).

***Plant Resistance***

Cultivars evaluated for resistance to this species in Assam, India, showed damaged internodes rates ranging from 6.9 to 24% (Borah 1993).

**Means of Movement**

The most likely means of entry of this species into Australia would be by the introduction of infested planting material. The chance of the introduction of moths or eggs on aircraft, in luggage, or on people is much smaller, though still significant.

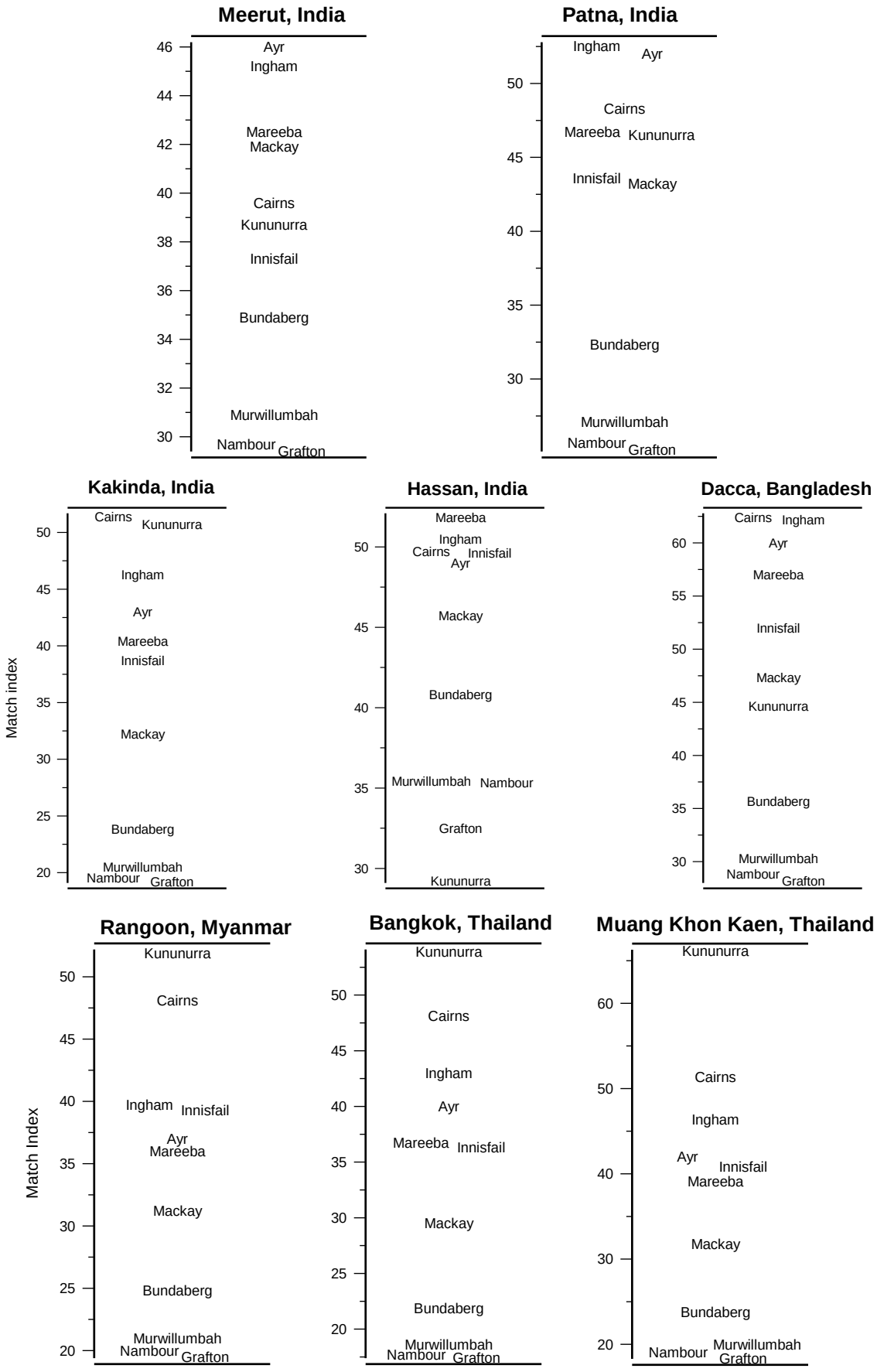
**Phytosanitary Risk**

***Entry potential:*** Medium - isolated from Australia, but readily transmitted on infected planting material.

***Colonisation potential:*** High in all sugarcane-growing areas.

***Spread potential:*** High, unless strict controls imposed over movement of infested material.

***Establishment potential:*** Depends on biotype introduced (see Match Indexes for climates at selected locations and principal Australian areas below).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Bundaberg
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Murwillumbah
Grafton

***Chilo zacconius* Bleszynski**

*Chilo zaconius* Bleszynski 1970: 150.

**Type**
Holotype male, Ziguinchor, Senegal, in Bleszynski collection.

**Common name**
African striped stemborer of rice

**Distribution**
Benin, Burkina Faso, Cameroon, Ghana, Ivory Coast, Mali, Niger, Nigeria, Senegal, Sierra Leone.

The range of *C. zacconius* overlaps that of *diffusilineus* in West Africa, and both species are externally very similar, but easily separated using the genitalia of both sexes (Bleszynski 1970; Heinrichs 1998).

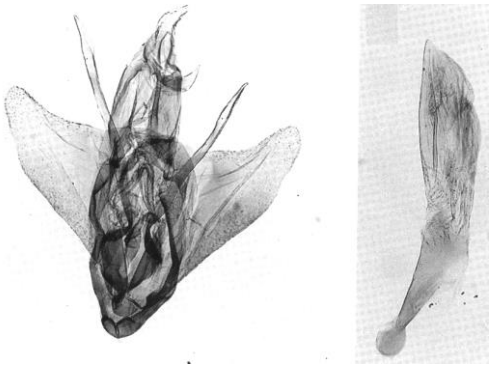
**Host plants**
Rice is the main host. The species also attacks *Echinochloa crus-galli*, *Echinochloa pyramidalis*, *Oryza barthii*, *Sorghum arundinaceum* and *Pennisetum* spp (Heinrichs 1998). Sampson and Kumar (1986) and Kolo *et al.* (1999) recorded it in sugarcane in southern Ghana and Edozhigi, Niger, respectively.

**Symptoms**
Feeding inside rice stems during the vegetative stage prevents the central leaf whorl from opening and the tiller fails to produce a panicle. Larval attack at the panicle growing stage stops panicle formation and instead turns white, which is known as whitehead (Heinrichs 1998).

**Economic impact**
*Chilo zacconius* is the predominant striped rice stemborer in West Africa. The first generation causes dead heart, while damage in the second generation results in whiteheads (Heinrichs 1998). The importance of this pest in sugarcane fields is not clear. In Ghana, Sampson and Kumar (1985) reported sugarcane losses of US$332.10/ha in 1979 due to combined infestations by *Eldana saccharina*, *Chilo zacconius* and *Sesamia* spp.

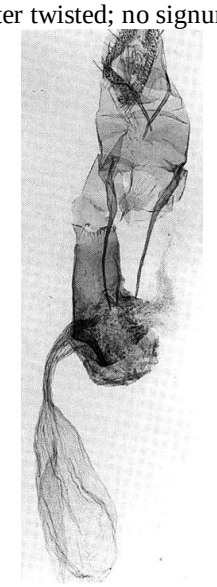
**Morphology**
***Adult***
Bleszynski (1970) gives the following description of *Chilo zacconius*: Ocellus moderately sized but distinct. Face rounded; corneous point and ventral ridge both absent. Labial palpus as in *diffusilineus*. Fore wing: length 10.0-14.0 mm. $R_1$ confluent with *Sc*; ground-colour and maculation very similar to those in *diffusilineus*, but ground-colour less variable, always ochreous yellow.

***Male genitalia*** (Fig. 57): Pars basalis absent; arms of juxta-plate slightly asymmetrical, very long and thin, with slight subapical dentation; aedeagus without ventral arm; bulbose basal projection distinct; a subapical thorn on a long base.



*Chilo zacconius* male genitalia (After Polaszek 1998).

***Female genitalia*** (Fig. 62): Seventh sternum without plate; ostial pouch broad, partly heavily sclerotized, well demarcated from ductus bursae; the later twisted; no signum.



*Chilo zacconius* female genitalia (After Polaszek 1998).

***Larvae***

Non-diapause larvae cream-coloured with large cream-coloured or, especially on the thorax segments, light brown pinacula. Head capsule brown. Prothoracic shield and suranal plate slightly darker than the cuticle. Dorsal surface of the body with five reddish brown longitudinal stripes. Crochets on abdominal prolegs biordinal, in an incomplete circle or mesal penellipes (Meijerman & Ulenberg 1998).

**Detection Methods**

This species is similar in appearance and the damage it causes to *C. diffusilineus* and *C. aleniellus*, but *C. zacconius* is reported to prefer upland rice while *C. diffusilineus* prefers low land rice fields (Bordat & Pichot 1978).

**Biology and Ecology**

Adult females lay about 12-135 eggs in two or three overlapping longitudinal rows on the upper or middle leaves. Eggs are pale yellow, and they hatch in 4-6 days. Young hatchlings feed for a short time on the leaf and then enter the stems by penetrating the leaf sheath. Larval feeding occurs at the upper internodes and larvae move from one stem to another after causing stem decay. Larvae pass through five larval instars and pupation occurs inside the stem. Larval and pupal periods are about 28 and 6 days, respectively. *Chilo zacconius* has five to seven generations a year, depending on the length of the dry season and host availability (Akinsola 1979; Breniere 1982; Heinrichs 1998). In a survey on sugarcane pests in the Niger State, Nigeria, C. *zacconius* Blesz. was found to be the most common species, occurring from the first month after planting until harvest with a peak abundance between June to October. Field infestation was as high as 23.7%, resulting in a loss of expected income by about 30.8%. (Kolo *et al.* 1999; 2006).

**Natural Enemies**

***Cotesia chilonis*** **(Hymenoptera: Braconidae):** Larval parasitoid, introduced from Japan to Senegal and Ivory Coast for the control of *Chilo zacconius*.

***Trichospilus diatraea*** **(Hymenoptera: Eulophidae):** Pupal parasitoid, introduced from India into Senegal the control of *Chilo zacconius*.

Odindo (1990) refers to the use of microsporidian *Nosema* spp. for the control of this pest species in rice.

**Management**

***Chemical control***

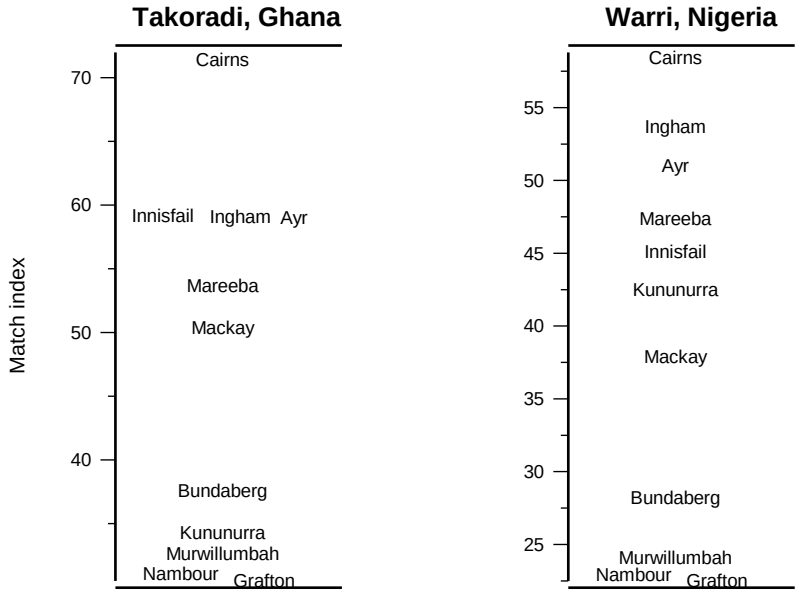
3% carbofuran at 13 kg/ha is used in rice fields in Nigeria (Ukwungwu & Odebiyi 1984).

***Plant resistance***
Several studies are dedicated to producing rice cultivars resistant to infestation. In Nigeria, Ukwungwu (1984) recorded that the percentage of bored stems and larval survival are negatively correlated with silica content in rice cultivars.

***Pheromone trapping***
The combination of Z11-16:Alc: 16Alc :Z13-18:Alc at the ratio of 100:29:14 results in a highly effective pheromone attractant (see Beevor *et al.* 1990).

**Means of Movement**
The most likely means of entry of this species into Australia would be by the introduction of infested planting material. The chance of the introduction of moths or eggs on aircraft, in luggage, or on people is much smaller, though still significant.

**Phytosanitary Risk**
***Entry potential:*** Medium – readily transmitted on infected planting material.
***Colonisation potential:*** High in northern Queensland.
***Spread potential:*** High, unless strict controls imposed over movement of infested material.
***Establishment potential:*** High in northern Queensland (see Match Indexes for climates in Ghana and Nigeria and principal Australian areas below).



The followings species of *Chilo* are of little, if any, economic importance. Their impact on sugarcane would be insignificant.

***Chilo aleniellus* (Strand)**
**Distribution:** Cameroon, Congo, Equatorial Guinea (Rio Muni), Ghana, Ivory Coast, Nigeria, Uganda.
**Host plants:** Maize, rice (Maes 1998).
**Morphology:** Bleszynski (1970) gives the following description of *C. aleniella:* Externally very similar to *C. orichalcociliellus*, except face, which scarcely protrudes forward beyond eye, broadly rounded, without point (Bleszynski 1970).

***Chilo argyrogrammus* (Hampson)**
**Distribution:** Kenya, Tanzania.
**Morphology:** Bleszynski (1970) gives the following description of *C. argyrogrammus*: Ocellus rather well developed, sometimes vestigial. Face rounded; corneous point and ventral ridge both absent. Labial palpus 3 times as long as diameter of eye. Fore wing: length 7.0-9.5 mm; ground-colour dull white, well dusted with grey-brown scales; sub-terminal line shiny silvery, edged with yellow-brown at either side, broadly excurved, without subdorsal tooth; discal dot very distinct; median line traceable, brown; terminal area darkened; area between subterminal and median lines longitudinally streaked; fringes distinctly shiny, unicolorous grey. Hind wing light grey or dirty white.

***Chilo argyropastus* (Hampson)**
**Distribution:** Angola, Kenya, South Africa, Tanzania, Zimbabwe.
**Morphology:** Bleszynski (1970) gives the following description of *C. argyropastus*: Ocellus present. Face rounded, slightly protruding forward beyond eye; corneous point and ventral ridge both absent. Labial palpus 3 (male) to 4 (female) times as long as diameter of eye. Fore wing: length 8.0-11.0 mm; $R_1$ confluent with *Sc*; ground-colour cream, variably dusted with brown scales; sometimes fore wing almost unicolorous brown: transverse lines traceable; silvery scales present; discal dot often absent; terminal dots present; fringes unicolorous shiny golden. Hind wing greyish.

***Chilo bandra* (Kapur)**
**Distribution:** India.
**Morphology:** Bleszynski (1970) gives the following description of *C. bandra*: Ocellus well developed. Face rounded, very slightly protruding forward beyond eye; corneous point and ventral ridge absent. Labial palpus 2 (male) to 2.5 (female) times as long as diameter of eye. Fore wing: length 5.0-8.5 mm; $R_1$ coincident with *Sc*; ground-colour yellowish; subterminal line edged with steely shiny scales; median line yellow with patch of silvery scales; area between lines longitudinally streaked with brown. Hind wing whitish.

***Chilo ceylonicus* Hampson**
**Distribution:** Sri Lanka.
**Morphology:** Bleszynski (1970) gives the following description of *C. ceylonicus*: Ocellus well developed. Face rounded, moderately protruding forward beyond eye; corneous point and ventral ridge both absent. Labial palpus 3 (male) to 3.5 (female) times as long as diameter of eye. Fore wing: length 9.0-12.0 mm; $R_1$ confluent with *Sc*; ground-colour straw-yellow, beige or brown; subterminal line silvery, without sub-dorsal tooth; median line yellowish; edged with brown and silvery scales; some scattered silvery scales in basal and medial areas; holotype of *torquatellus* dark brown with median line reduced but rather distinct discal dot. Hind wing white to dirty white. Bleszynski (1970) suggests that *C. torquatellus* may be an extreme colour variation of *ceylonicus*.

***Chilo chiriquitensis* (Zeller)**

**Distribution:** Guatemala, Mexico, Panama.
**Morphology:** Bleszynski (1970) gives the following description of *C. chiriquitensis*: Ocellus well developed. Labial palpus 2.5 (male) to 3.0 (female) times as long as diameter of eye. Face broadly rounded; corneous point and ventral ridge both absent. Fore wing: length 6.5-8.5 mm; $R_1$ confluent with *Sc*; ground-colour dull white, dusted with dark brown scales; discal dot absent; median line very distinct, almost perpendicular to costa, uniform from costa to termen, metallically shiny, silvery, edged with a equally distinct, but broader, ochreous line distally; subterminal line concolorous with median line, also very distinct, broadly excurved, close to termen, edged at either side with ochreous; terminal dots very distinct; fringes shiny, with golden basal stripe. Hind wing whitish.

***Chilo christophi* Bleszynski**
**Distribution:** Central Asia, North China, Russia.
**Morphology:** Bleszynski (1970) gives the following description of *C. christophi*: Similar to *suppressalis* but much larger and with pattern of fore wing less distinct. Length of fore wing 14.0-19.0 mm.

***Chilo costifusalis* (Hampson)**
**Distribution:** Angola, Congo, Malawi, Tanzania.
**Morphology:** Bleszynski (1970) gives the following description of *C. costifusalis*: Ocellus rather small. Face rounded, slightly protruding forward beyond eye; corneous point and ventral ridge absent. Labial palpus 3 (male) to 4 (female) times as long as diameter of eye. Fore wing: length 7.5-11.5 mm; $R_1$ confluent with *Sc*; ground-colour dull yellow to ochreous, darkened along costa; sometimes veins and intervenular space outlined with brown; subterminal line rather distinct, consisting of brown, rather metallically shiny scales; median line present or absent, concolorous with subterminal line, often reduced in dorsal half of the wing; some patches of rather metallically shiny scales in middle area; in lectotype a large, contrasting spot; in one female median line strongly dilated on costa; terminal specks very distinct; fringes varying from glossy to metallically shiny. Hind wing silky cream to white.

***Chilo crypsimetallus* (Turner)**
**Distribution:** Bleszynski (1970) considered that this species occurs in northern Australia (Northern Territory, Queensland, Prince of Wales Island). He also stated that the female genitalia is similar to those in *terrenellus* and *louisiadalis*.
**Morphology:** Bleszynski (1970) gives the following description of *C. crypsimetallus*: Ocellus well developed. Face broadly rounded; corneous point and ventral ridge both absent. Labial palpus 2.5 (male) to 3.5 (female) times as long as diameter of eye. Fore wing: length 7.5-10.5 mm; ground-colour dull light brown to dirty yellow, variably dusted with brown; discal dot distinct; subterminal line defined, often reduced in costal half, formed by row of metallically shiny silvery scales; a small patch of silvery scales well above dorsum in the middle of wing; terminal dots distinct. Hind wing light brownish to silky white.

***Chilo demotellus* Walker**
**Distribution:** USA (New Jersey, New York, Florida and Georgia).
**Morphology:** Bleszynski (1970) gives the following description of *C. demotellus*: Ocellus light, small, or vestigial. Face strongly produced forward, conical with sharp point; ventral ridge absent. Labial palpus 2.5 (male) to 3.5 (female) times as long as diameter of eye. Fore wing: length 10.5-17.0 mm; $R_1$ free; sexual dimorphism similar to that in *phragmitellus*; female with apex of fore wing distinctly more pointed and termen more oblique than in male; ground colour dull grey, beige or brown, females lighter than males; male with ill-defined subterminal and median lines formed by yellowish specks; female fore wing unicolorous; terminal dots present in both sexes; metallic scales absent; fringes slightly glossy, concolorous with ground-colour. Hind wing light brown in male, creamy white in female.

***Chilo erianthalis* Capps**
**Distribution:** USA (Louisiana and Florida).

**Morphology:** Bleszynski (1970) gives the following description of *C. erianthalis*: Ocellus fully developed. Face strongly protruding forward beyond eye, conical with distinct corneous point; ventral ridge vestigial. Labial palpus about 3.5 times as long as diameter of eye. Fore wing: length 11.0-13.0 mm; $R_1$ free; ground-colour dull brown with very slight violet reddish hue, heavily dusted with fuscous; veins and intervenular spaces edges with light beige, giving the wing a lined appearance; subterminal line very close to termen, slightly dentate in costal portion, consisting of series of silvery metallically shiny scales; median line formed by some patches of metallically cupreous scales; terminal dots distinct; fringes shiny. Hind wing grey-beige.

***Chilo hyrax* Bleszynski**
**Distribution:** China, Japan, Russia.
**Morphology:** Bleszynski (1970) gives the following description of *C. hyrax*: Similar to *suppressalis*, but generally larger: length of fore wing, 12.0-16.0 mm; ground-colour of fore wing yellow to brown, variably dusted with brown scales; subterminal line reduced; median line marked by row of brown specks, or completely reduced; metallic scales absent.

***Chilo incertus* (Sjöstedt)**
**Distribution:** Sudan.
**Morphology:** Bleszynski (1970) gives the following description based on only *C. incertus* adult females: Ocellus present. Face rounded, moderately protruding forward beyond eye, corneous point and ventral ridge both absent. Labial palpus 4 times as long as diameter of eye. Fore wing: length 12.0 mm (type in poor condition, but obviously smaller); $R_1$ in type confluent with *Sc*, but fused with *Sc* for a long distance in the other female studied; ground colour dull yellow; discal dot small; subterminal line as ill defined, yellow brown line; median line probably ill-defined or reduced (difficult to detect in poorly preserved specimens studied); terminal dots present; metallic scales absent; a brown oblique shade from near apex to about middle of the width of the wing; type almost uniformly brown. Hind wing silky white.

***Chilo louisiadalis* Hampson**
**Distribution:** Papua New Guinea (Louisiade Archipelago, Vulcan Island).
**Morphology:** Bleszynski (1970) gives the following description of *C. louisiadalis*: Ocellus small. Face broadly rounded, very slightly protruding forward beyond eye; corneous point and ventral ridge both absent. Labial palpus 3 (male) to 4 (female) times as long as diameter of eye. Fore wing: length 9.0-15.0 mm; $R_1$ confluent with *Sc*; ground-colour dull yellow brown, marking brown; a brown shade from apex, obliquely to discal dot, the latter in most instances very distinct; wing longitudinally indistinctly streaked with brown; subterminal line and median line present; subterminal line a row of brown specks, rather distant from termen; subdorsal tooth absent, median line a brown shade; discal dot present; terminal dots present; fringe slightly glossy. Hind wing varying cream to brown.

Bleszynski (1970) states that the ranges of *C. louisiadalis* and *C. terrenellus* overlap, and both species are externally very similar, and the female genitalia of the two species are almost indistinguishable from each other. However, the semi-circular sclerite near the ostium bursae in *C. louisiadalis* is better developed, broader than in *C. terrenellus*, and the ductus seminalis is narrower than in *C. terrenellus*.

***Chilo luniferalis* Hampson**
**Distribution:** Central African Republic, Congo, Ethiopia and Sudan.
**Morphology:** Bleszynski (1970) gives the following description of *C. luniferalis*: Ocellus small. Face rounded, slightly protruding forward beyond eye; corneous point and ventral ridge both absent. Labial palpus 3 (male) to 4 (female) times as long as diameter of eye. Fore wing: length 10.0-15.0 mm; $R_1$ free; ground-colour dull dirty cream dusted with brown scales; metallic scales absent; discal dot double; terminal dots very distinct; median line reduced; subterminal line a poorly traceable brown shade, in some specimens almost absent; fringes slightly glossy. Hind wing dirty cream, termen edged with greyish.

***Chilo luteellus* (Motschulsky)**
**Distribution:** Spain, south Italy, southern Romania, north Africa, Middle East, Central Asia, China, Japan, Philippines.
**Morphology:** Bleszynski (1970) gives the following description of *C. luteellus*: Head similar to *phragmitellus* except for labial palpus which is proportionately slightly shorter in *luteellus*: 4(male) to 5 (female) times as diameter of eye. Fore wing: length 13.0 - 18.0 mm; $R_1$ free; termen in female less oblique than in *phragmitellus*; ground-colour varying from brownish yellow to brown, with variable irroration of metallically lustrous scales arranged in longitudinal rows along veins; some specimens with a very slight trace of subterminal line. Hind wing silky white to creamy.

***Chilo mercatorius* Bleszynski**
**Distribution:** Congo.
**Morphology:** Bleszynski (1970) gives the following description of *C. mercatorius* based on only male specimens: Ocellus present. Face slightly protruding forward beyond eye, corneous point and ventral ridge both absent. Labial palpus 3.5 times as long as diameter of eye. Fore wing: length 7.5 mm; $R_1$ confluent with *Sc*; ground-colour dark grey; subterminal line whitish, bordered with brown exteriorly; dorsal-middle area whitish; discal dot double, very distinct; median line absent; terminal dots very distinct, black; fringes strongly shiny, almost metallic; otherwise no metallic scales in fore wing. Hind wing light grey.

***Chilo mesoplagalis* (Hampson)**
**Distribution:** Ghana, Nigeria, Sierra Leone, Sudan.
**Morphology:** Bleszynski (1970) gives the following description of *C. mesoplagalis*: Ocellus well developed. Face rounded; corneous point and ventral ridge both absent. Labial palpus 3.5 times as long as diameter of eye. Fore wing: length 9.5-11.5 mm; $R_1$ free; ground colour yellowish, sparsely dusted with dark scales; subterminal line close to termen, consisting of metallically shiny, silvery scales; broadly excurved without subdorsal tooth; median line also silvery, edged with brown at either side, reduced in dorsal half, forming a large contrasting spot; a semicircular dark spot apical of median line; terminal specks distinct; fringes slightly glossy, grey-brown. Hind wing silky white.

***Chilo perfusalis* (Hampson)**
**Distribution:** Ghana, Nigeria, Senegal, Sierra Leone.
**Morphology:** Bleszynski (1970) gives the following description of *C. luniferalis*: Similar to *luniferalis*. Fore wing considerably varying in size and colour, from brownish yellow to almost unicolorous brown.

***Chilo phragmitellus* (Hübner)**
**Distribution:** Central Asia, China, Japan, Middle East; North, Central and South Europe; Ukraine.
**Morphology:** Bleszynski (1970) gives the following description of *C. phragmitellus*: Ocellus well developed. Face strongly conical with distinct point and strong ventral ridge. Labial palpus 4.5 (male) to 5.5 (female) times as long as diameter of eye. Fore wing: length 12.0-22.0 mm, male generally smaller than female: $R_1$ free; ground colour dull, varying from straw-yellow to dark brown, in some instance with an ochreous hue; variably dusted with dark scales over basal and dorsal areas; transverse lines absent; metallic scales absent, discal dot in most specimens distinct. Hind wing grey or beige in male and silky white or white in female.

***Chilo plejadellus* Zincken**
**Distribution:** Canada, USA.
**Morphology:** Bleszynski (1970) gives the following description of *C. plejadellus*: Ocellus well developed. Face strongly protruding forward beyond eye, conical, with distinct point; ventral ridge absent. Labial palpus 4 times as long as diameter of eye. Fore wing: length 9.0-15.0 mm; $R_1$ free; ground-colour dull yellow, variably dusted with brown scales; median line with some lustrous golden brown scales;

subterminal line formed by series of lustrous metallic, golden scales; terminal dots distinct; fringes strongly shiny golden, in some specimens darker than ground-colour. Hind wing white.

***Chilo psammathis* (Hampson)**
**Distribution:** Ghana, Nigeria.
**Morphology:** Bleszynski (1970) gives the following description of *C. psammathis*: Ocellus rather small, but distinct. Face rounded, slightly protruding forward beyond eye; corneous point and ventral ridge absent. Labial palpus 2.5 (male) to 3 (female) times as long as diameter of eye. Fore wing: length 8.0-9.0 mm; $R_1$ confluent with *Sc*; apex narrowly rounded; ground colour dull, almost unicolorous brown without markings except for indistinct terminal dots; metallic scales absent; fringes strongly shiny brown. Hind wing silky whitish, in some specimens with termen greyish.

***Chilo pulveratus* (Wileman and South)**
**Distribution:** China, Indonesia, Japan, Philippines, Taiwan, Timor.
**Morphology:** Bleszynski (1970) gives the following description of *C. pulveratus*: Ocellus well developed, slightly variable in size. Face broadly rounded without point. Labial palpus 3 (male) to 4 (female) times as long as diameter of eye. Fore wing: length 8.0-10.5 mm; $R_1$ confluent with *Sc*; ground-colour light yellowish cream dusted with brown scales; pattern brown; subterminal line well marked; in specimens from the Philippines distinctly dentate and edged with silvery scales proximally; in Formosan specimen a dark line without metallic scales; discal dot indistinct; median line traceable, with metallic scales in Formosan specimens; terminal dots distinct; fringe glossy. Hind wing whitish.

***Chilo pulverosellus* (Ragonot)**
**Distribution:** Bulgaria, Israel, Russia, South France, Syria, Turkey.
**Morphology:** Bleszynski (1970) gives the following description of *C. pulverosellus*: Ocellus well developed. Face broadly rounded, moderately protruding forward beyond eye; corneous point and ventral ridge both absent. Labial palpus 2 (male) to 2.5 (female) times as long as diameter of eye. Fore wing: length 11.0-13.0 mm; $R_1$ free; white to cream, variably dusted with brown scales; some specimens with indistinct longitudinal brown lines along veins; some females almost unicolorous white; subterminal line ill defined or absent; median line absent or ill defined; discal dot absent or indistinct; metallic scales absent. Hind wing silky white to cream.

***Chilo quirimbellus* Bleszynski**
**Distribution**: Angola, Congo.
**Morphology:** Bleszynski (1970) gives the following description of *C. quirimbellus*: Externally very similar to *thyrsis*, but with fore wing more heavily irrorated with brown scales; length of fore wing 8.0-12.0 mm.

***Chilo tamsi* Kapur**
**Distribution:** South India.
**Morphology:** Bleszynski (1970) gives the following description of *C. tamsi*: Ocellus small. Labial palpus 3.5 times as long as diameter of eye (female). Face conical, pointed, without ventral ridge. Forewing length 19.0 mm; R1 free; ground-colour light straw-yellow with very sparse, irregular sprinkling of brown to dark brown scales and with a distinct discal dot; transverse lines absent. Hind wing white.

***Chilo thyrsis* Bleszynski**
**Distribution:** Congo, Kenya, Malawi, Tanzania, Uganda and Zimbabwe.
**Morphology:** Bleszynski (1970) gives the following description of *C. thyrsis*: Externally almost indistinguishable from *C. orichalcociliellus* and allies. Face variable in shape, broadly rounded; slightly or moderately produced, in most instances without corneous point, but vestigial in one female from Malawi.

***Chilo vergilius* Bleszynski**
**Distribution:** India.

**Morphology:** Bleszynski (1970) gives the following description of *C. vergilius*: Ocellus well developed. Face moderately produced forward with distinct point; ventral ridge absent. Labial palpus 3 times as long as diameter of eye. Fore wing: $R_1$ free; length 10.5 mm; ground colour very light dull white-grey; subterminal and median lines distinct, ochreous brown; suffusion of brown scarce scales; discal dot absent; terminal dots very distinct; fringe slightly glossy, concolorous with ground-colour of wing, with darker basal line. Hind wing light brown with whitish fringe.

***Chilo zoriandellus* Bleszynski**
**Distribution**: Kenya.
**Morphology:** Bleszynski (1970) gives the following description of *C. zoriandellus*: Externally practically indistinguishable from *thyrsis*; length of fore wing 9.5-12.0 mm.

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