DOSSIER ON *SCIRPOPHAGA* SPP. AS PESTS OF SUGARCANE

Genus *Scirpophaga* Treitschke 1832

The genus *Scirpophaga* Treitschke belongs to the family Pyralidae, subfamily Schoenobiinae. Members of this genus are mainly stem borers of graminaceous crops. The genus is distributed in the Palaearctic, Ethiopian, Oriental and Australian regions. It is especially important in the Indian subregion, where species are pests of rice and sugarcane (Arora 2000).

Some species have a restricted host range, such as the rice borer *Scirpophaga incertulas* (Walker), whilst others have a wide host range, such as *S. nivella* (Fabricius) and *S. excerptalis* (Walker). Lewvanich (1981), who provided a thorough revision of this previously confused genus, lists 35 species of *Scirpophaga*, two of which are 'recorded' from sugarcane. These are *S. excerptalis* and *S. innotata* (Walker). The latter species is known to be strictly a pest of rice, and there are no documented references of this species attacking cane anywhere the pest exists; therefore, that record is highly doubtful. Another species, *S. magnella* de Joannis, which is morphologically very similar to *S. excerptalis*, is listed by Lewvanich (1981) as feeding on *Saccharum* sp. in Bangladesh, and on *Saccharum bengalense* in Pakistan.

One important finding of Lewvanich (1981) was that *Scirpophaga nivella* is not a pest of sugarcane, and all the references to this species in cane are referable to *S. excerptalis*, since *S. nivella* is mainly a pest of rice.

In the current document, information is provided on *S. excerptalis* and *S. magnella*. Information on *S. nivella* is also presented here, based on a large number of references which refer to this species as a pest of sugarcane. Many references from India and Indonesia still refer to the 'sugarcane top borer' as *S. nivella*. It is important, therefore, to confirm the identity of *Scirpophaga* borers in India and Indonesia before any control strategies are to be put in place.

The followings are the main characteristic features of the Schoenobiinae based on Lewvanich (1981) and Arora (2000):
Head with the frons rounded; ocelli present; labial palpi generally porrect, sometimes upturned or turned downwards distally, size variable; maxillary palpi present, generally porrect and not exceeding half the length of labial palpi; proboscis absent; antennae filiform, finely ciliated, or weakly serrate in male; ciliation confined to ventral surface, the dorsal surface smoothly scaled. Chaetosema present. Hindwings with frenulum spine single in male and held by a well-developed retinaculum process or bar from subcostal vein of forewing underside; in female, the spine is single or more but held by a cluster of bristles from cubital vein of forewing underside. Fore tibiae with a lamellate spur at middle of inner surface; mid and hind tibiae with unequal pair of spurs, the outer ones being the shorter. Abdomen slender; tympanal organs present and located near the base of abdomen; praecinctorium present, simple, with the tympanic bullae medially fused; a large flattened scale-tuft generally presenting male, extending from the posterior median of seventh sternite to the eighth sternite; this membranous area possesses another tuft of flattened and shorter scales; female devoid of any such tufts, but with anal tufts at the posterior tip mainly to cover eggs during oviposition. The tufts in female variously coloured, which help in identifying various species. Venation. Forewing: Vein R_1 free, or confluence with Sc; R_2, R_5 free, or stalked with R_{3+4}; Cu_2 (Cu_p) generally developed only near the margin. Hindwing: Vein Sc stalked with Rs for a short distance beyond angle, after latter's origin; Rs-M_1 shortly stalked, from angle of cell; Cu_2 only developed near margin.

The following is a key to Asian species of economic importance in the genus *Scirpophaga* based on Arora (2000):

1. Forewing with the vein R_1 anastomosed with Sc 2
- Forewing with the vein R_1 free from Sc 5

2. Forewings upperside ochreous in both sexes; hindwing with the frenulum spine single in male, double fused in female. Labial palpi twice the diameter of eye. Anal tufts in female ochreous white ..... *Scirpophaga whalleyi* Lewvanich

- Forewings upperside ochreous only in male, or white in both sexes; hindwings with the frenulum spines single in both sexes 3

3. Forewings upperside ochreous white to yellowish in male, white in female; underside fuscous in male, white in female. Labial palpi about 2.5 times the diameter of eye. Anal tufts in female yellowish ..... *Scirpophaga xanthogastrella* (Walker)

- Forewings upper and underside white in both sexes. Labial palpi 1.5 times the diameter of eye ... 4

4. Anal tufts orange red in female ..... *Scirpophaga excerptalis* (Walker)

- Anal tufts yellowish in female ..... *Scirpophaga magnella* de Joannis

5. Forewings upperside ochreous yellow in male, with, or without spots on submedian area and lower angle; with an oblique series of spots from apex in male, ochreous yellow or whitish in female, with or without spot at lower angle 6

- Forewing upperside pale ochreous or white in both sexes, without any markings 8

6. Labial palpi much longer, about 3-4 times the diameter of eye, and porrect. Forewings with the vein R_1 curved, running close to Sc, sometimes touching it; upperside ochreous in both sexes; hindwing with the frenulum spine double in female; anal tufts pale ochreous in female ..... *Scirpophaga incertulas* (Walker)

- Labial palpi shorter, not more that twice the diameter of eye. Forewings with the vein R_1 running close to Sc, without touching it; upperside whitish in female; hindwing with the frenulum spine single or double in female 7

7. Labial palpi 1.3 times the diameter of eye. Hindwings with the frenulum spine double in female. Anal tufts ochreous yellowish in female ..... *Scirpophaga nivella* (F.)

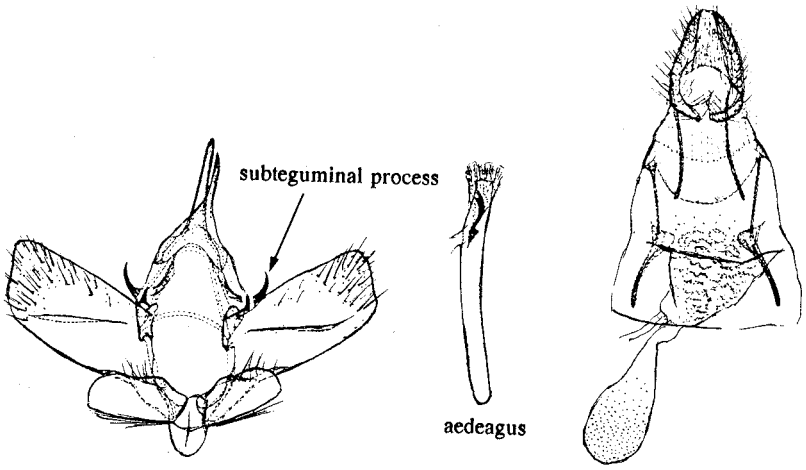
- Labial palpi 1.5 times the diameter of eye. Hindwings with the frenulum spine single in female. Anal tufts greyish in female ..... *Scirpophaga gilviberbis* Zeller

8. Labial palpi about twice the diameter of eye. Hindwings with the frenulum spine double in female. Anal tufts whitish in female ..... *Scirpophaga innotata* (Walker)

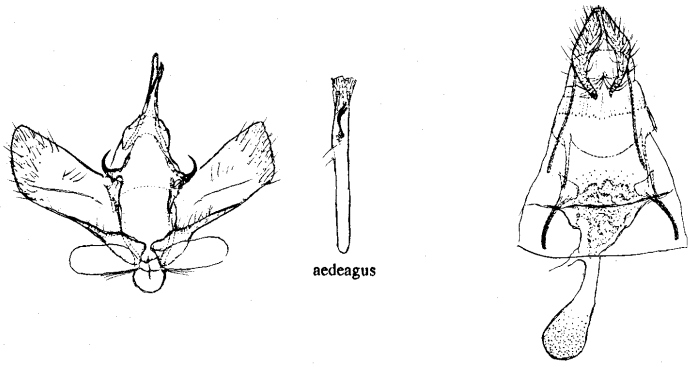
- Labial palpi equal to diameter of eye. Hindwings with the frenulum spine single in both sexes. Anal tufts whitish to pale ochreous in female 9

9. Specimens larger ..... *Scirpophaga fusciflua* Hampson

- Specimens smaller ..... *Scirpophaga virginia* Schultze



Genitalia of *S. incertulas*



Genitalia of *S. innotata*

Although some Asian members of the genus *Scirpophaga* are major pests of rice and, to a lesser degree, sugarcane, African species do not seem to be of any significance to gramineous crops and are not extensively studied (Maes 1998).

***Scirpophaga excerptalis* (Walker)**

Chilo excerptalis Walker 1863
Scirpophaga monostigma Zeller 1863
Scirpophaga butyrota Meyrick 1889
Scirpophaga intacta Snellen 1890
Scirpophaga excerptalis (Walker): Hampson 1895
Scirpophaga chrysorrhoa Zeller sensu Hampson 1895 (misidentification)
Scirpophaga auriflua Zeller: sensu Hampson 1895 (misidentification)
*Topeutis (*sic) *rhodoproctalis* Hampson 1919
Scirpophaga xanthogastrella (Walker): sensu Fletcher and Gosh 1920 (misidentification).
Scirpophaga nivella (F.): sensu Shibuya 1928 (misidentification).
Tryporyza butyrota (Meyrick): Common 1960
Tryporyza nivella (F.): sensu Butani 1979 (misidentification).

This species has also been referred to as *Tryporyza nivella intacta* Snellen in some references (Pu *et al*. 1988; Alba 1990; 1991), see also Samoedi (1988a).

IMPORTANT
This species has been incorrectly referred to as *Scirpophaga nivella* in several publications. It is now confirmed that *S. excerptalis* and *S. nivella* are two different species, with *S. nivella* being strictly a pest of rice and does not occur in cane (Lewvanich 1981). However, several recent publications still refer to *S. excerptalis* as *S. nivella*. Only references using the name *S. excerptalis* are cited in this chapter.

Common names
Top borer, sugar cane top borer, top shoot borer.

Distribution
Bangladesh, Bhutan, China, India, Indonesia, Japan, Malaysia, Nepal, Pakistan, Philippines, Papua New Guinea, Singapore, Sri Lanka, Taiwan, Thailand, Vietnam (Arora 2000).

Host plants
Scirpophaga excerptalis is mainly a pest of sugarcane. Other hosts include *Chloris barbata*, *Echinochloa colona*, *Erianthus arundinaceum*, *E. munja*, *E. ravennae*, *Naranga prophyrocoma*, *Panicum* sp., *Pennisetum purpureum*, *Saccharum spontaneum*, *Sclerostachya fusca*, *Sorghum bicolor* and *Sorghum halepense* (Arora 2000).

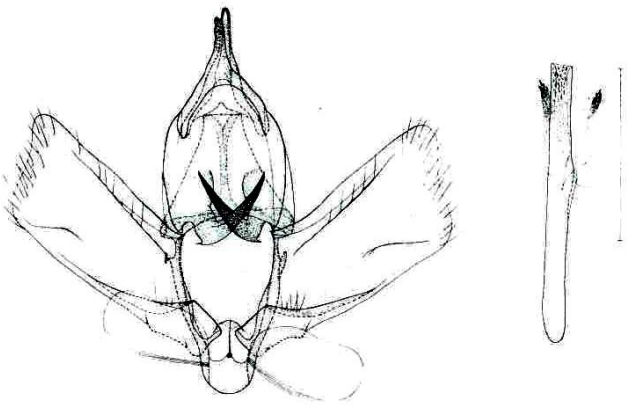
Symptoms
Common symptoms of infestation are the appearance of parallel rows of 'shot holes' on leaves, a red streak caused by mining inside the midrib, deadhearts and a bunchy top appearance of shoots (Arora 2000).

Economic impact
Scirpophaga excerptalis is considered to be a major pest of sugarcane in many parts of India. Reductions in yield and sugar contents of up to 51% and 2.0 units, respectively, were recorded in Indian cane fields (Pandey *et al.* 1997a; Madan *et al.* 1999). In a study in Karnal, India, during the 1997-98 and 1998-99 seasons, sugarcane infestation by *S. excerptalis* resulted in 30.08% weight loss and decreased cane length by 24.39% (Madan & Singh 2001). In Uttar Pradesh, India, a study by Singh & Singh (1997) recorded reductions in cane stalk length by up to 68.0%, the number of internodes by up to 67%, cane weight by up to 86%, and CCS by up to 25.90% due to borer infestation.

Morphology
Arora (2000) gives the following description of this species:
Head with the frons smooth; labial palpi porrect, about 1.5 times the diameter of compound eye, sometimes slightly longer but never more than twice the diameter of eye; ocelli present, small; antennae simple in both sexes, profusely ciliated in male, sparsely in female, about half the length of forewing-costa in male and two-fifths the length in female (shorter in female). Hindwing with frenulum single in both sexes.

Male

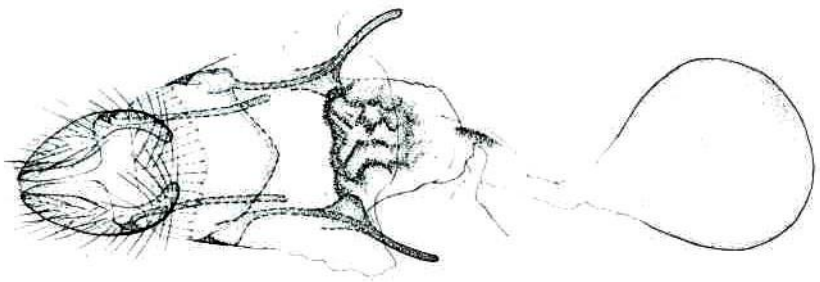
Head with the frons white; labial palpi white, sometimes suffused with fuscous; antennae generally dark. Thorax upperside white, underside pale ochreous, suffused with fuscous; legs generally white on innerside, fuscous on outerside generally throughout upto claws, particularly in forelegs, fuscous suffusion sometimes reduced in tibia of mid- and hind legs. Abdomen white on upperside, pale ochreous on underside. Wings slightly shining white on upperside, pale ochreous on underside, sometimes suffused with fuscous, without or with a dark prominent spot at lower angle of cell in forewing.



Male genitalia

Female

As in male except that legs are more shining white, with less of fuscous suffusion on underside. Anal tufts brilliant orange-red.



Female genitalia

Forewing

Vein R_1 anastomosed fully with Sc, arising almost in line with Cu_{1b} below; R_2 a little before upper angle of cell; R_3+R_4 stalked, the stalk generally shorter than R_4 which is longer than R_3; R_5 from below the upper angle of cell; M_1 below R_5; M_2-M_3 very close to each other but not connate; Cu_{1a} slightly before lower cell-angle, close to M_3 and in line with the origin of R_2 above; Cu_{1b} from before the cell angle and Cu_{1a}.

Hindwing

Sc free till about cell angle, beyond which it is anastomosed with Rs for halfway toward margin; M_1 from cell angle; M_2-M_3, Cu_{1a}, Cu_{1b} as in forewing.

It is very important to realize that this species has for a long time been erroneously referred to as *Scirpophaga nivella*. Lewvanich (1981) states clearly that *S. nivella* does not occur in cane, which pauses

a question mark regarding the status of *S. nivella* as a cane pest. In addition, Arora (2000) refers to this confusion of identity and states that a large number of specimens identified as *S. nivella* has been re-examined in India and found to be *S. excerptalis*. However, he states that about 35 male and female specimens present in the Indian Institute of Sugarcane Research (IISR), Lucknow, were found to be true *S. nivella* that were collected from sugarcane fields. It is also important to realise that no further records of *S. nivella* in cane have been made at the IISR in Lucknow since 1972. Hence, a survey of pyralids in cane fields of Lucknow (where the insects were collected) is envisaged by Indian taxonomists to establish whether *S. nivella* is associated with sugarcane. The confusion in the identity of *S. excerptalis* and *S. nivella* was resolved by Lewvanich (1981) who differentiated the two species based on the following set of characters:

Character	***S. excerptalis***	***S. nivella***
Labial palpi	1.5-2 times the diameter of eye	1.3 times the diameter of eye
Vein R_1	Anastomosed with Sc in forewing	Free
Frenulum spine in female	Single	Double
Anal tufts in female	Orange-red	Ochreous
Male forewing	White	Ochreous, with oblique band of spots from apex

Detection methods

Scirpophaga excerptalis adult moths are characterised by both wings being shining white in both sexes on both upper and underside. Females have characteristic orange-red anal tufts not found in any other *Scirpophaga* species. R_1 vein is anastomosed with Sc in forewings and frenulum spine is single in females (Arora 2000).

Trials in sugarcane plantations in Zhanjiang, Guangdong Province, China, showed that the greatest number of *S. excerptalis* males were attracted to traps baited with a 7:3 ratio of (E)-11-hexadecenal to (Z)-11-hexadecenal (Liu *et al.* 1992).

Biology and Ecology

Adult females of *Scirpophaga excerptalis* lay their eggs in masses on the lower surface of the leaves. Singh *et al.* (1999) showed that the distribution of egg masses on sugarcane leaves followed a positive binomial distribution. On the other hand, a study conducted in a cane farm at Ishurdi, Bangladesh Sugarcane Research Institute, showed that the dispersion pattern of the egg masses follows a Poisson distribution, in contrast with that of the larvae, which showed an aggregated pattern (Kundu *et al.* 1996). Studies in India suggested that collecting of egg masses mechanically during the first and second broods is an economic method to reduce the damage caused by the third generation significantly (Madan *et al.* 1999).

Studies in India showed that *S. excerptalis* has five broods (generations) during the cane-growing season. Reports from the states of Punjab and Haryana reveal that the third brood in particular is the most damaging (Duhra & Sharma 1993; Chaudhary & Yadav 1995; Pandey *et al.* 1997a). Gangwar *et al.* (2003) stated that the third brood of *S. excerptalis* was responsible for the greatest losses in cane weight (74.36%) and juice (81.43%) in Lucknow, Uttar Pradesh, India.

In Haryana, India, Mukunthan (1985) recorded four larval instars in both the second and third generations as determined from head capsule widths. In the laboratory, first-instar larvae tended to enter the midrib of the first leaf of growing plants via the lower epidermis, which is the only part of the leaf exposed at this stage. Larvae tunnel in the same midrib for 24-48 h and emerge through the upper epidermis. Two or three first- or second-instar larvae, or more rarely third instars, can be found in the spindle of stems, and, due to competition for food, only one larva ultimately survives in the region near the growing point of the stem.

In a study in Haryana, India, Sardana & Das (2001) showed that high temperature coupled with intermittently high rainfall and humidity favoured *S. excerptalis* infestation. In Karnal, India, the highest incidences of the borer infestation (41.48 and 36.51%) were recorded in October, while the lowest (13.27

and 12.06%) were recorded in May (Madan & Singh 2001). Similarly in the Punjab, Shenhmar & Brar (1996) recorded *S. excerptalis* as being active from March to October, with most of the damage inflicted during July-August. The borer starts appearing in cane fields in the northern Indian states of Punjab and Haryana in mid March to mid May, and the population is generally very low (first brood). During the second brood (mid May to end June), temperature is usually high and this keeps the population under check. The third brood (July-August) coincides with the onset of monsoons, when climatic conditions favour the multiplication of the pest. Hence, this generation is the most destructive to shoots and causes reduced tilling. Populations start declining during the fourth generation (August-September) and reach a minimum during the overwintering fifth generation (October-March) (Madan *et al.* 1999). Larvae feed on the growing points of cane plants causing deadhearts and reducing tilling. In India, Saikia *et al.* (1994) recorded an increase in the incidence of *S. excerptalis* as levels of nitrogen fertilizers increased, with the lowest borer incidence (5.56%) recorded at 0 kg N/ha.

In a study on the key mortality factors of *S. excerptalis* in Haryana, India, results showed that parasitization of various stages and failure of neonate larvae to enter the midribs were the key mortality factors common on all the host plants, with *Telenomus* sp. causing the highest mortality of the egg stage. The first three larval instars were not attacked by parasitoids, but the final instar was attacked by *Rhaconotus scirpophagae* (Hymenoptera: Braconidae) and *Isotima javensis* (Hymenoptera: Ichneumonidae), and the pupae by the *Stenobracon deesae* (Hymenoptera: Braconidae) and *Xanthopimpla predator* (Hymenoptera: Ichneumonidae) (Mukunthan 1989).

Management

Chemical control

Phosphamidon, a systemic organophosphorus insecticide, reduced top borer incidence and increased cane yield over control by 53.25 and 34.12% at Saraiya sugar factory in Uttar Pradesh, India, respectively (Pandey and Solanki 2007).

In Assam, India, malathion 10% dust at 2.0 kg ai/ha reducing the infestation of *S. excerptalis* along with *Chilo tumidicostalis* from 57.59 and 66.42% in untreated controls to 15.71 and 16.25%, respectively (Deka *et al.* 1999b). While in Gujarat, three treatments of phorate 10 G at 1 kg a.i./ha reduced incidence of top borer to only 1.82%, and also minimized damage by other cane borers (Pandya 1997). In Orissa, Aldrin 30 EC was shown to reduce borer infestation by up to 78.63% (Jena *et al.* 1994), while in Haryana, two applications of carbofuran granules at 1.0 kg a.i./ha effectively reduced the borer's 3rd and 4th brood attack in ratoons, with application at the end of July being better than at the end of June (Mrig & Chaudhary 1992).

In the state of Bihar, India, nitrogen fertilizers mixed with gamma HCH (lindane), urea mixed with lindane, compost soaked urea with lindane, neem cake blended with urea and lindane, and a combination of the latter two treatments applied at planting reduced the incidence of the third and fourth borer generations. Compost soaked urea in combination with lindane gave the maximum increase in cane height and leaf area (Yazdani *et al.* 1993). While in Lucknow, Uttar Pradesh, basal application of Furadan at 1.0 Kg/ha in the last week of June proved effective (Tanwar *et al.* 2003), while the application of carbofuran at 1 kg a.i./ha combined with the collection and destruction of egg masses was recorded to be highly effective (Gangwar *et al.* 2003).

In Navsari, India, a “maximum protection” approach comprised of: sett treatment with 0.1% dimethoate; 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 the detrashing of lower leaves at 6, 7 and 8 months after planting (Pandya & Patel 2007).

In Padrauna, India, plant extracts of *Eucalyptus rostrata* reduced bore infestation to only 3% following application (Pandey & Singh 1998). Treatment with 2.0% Multineem (a neem oil based product) resulted in the lowest top borer incidence (3.93%) when applied against third brood in field trials in India (Tewari 2001). While treatment with Nimbicidine (a neem-based insecticide) at 2.5 litres/ha in March, April and August was effective in suppressing top borer populations in Bangladesh (Abdullah *et al.* 2006).

Biological control

The following is a list of natural enemies recorded to attack the different stages of *S. excerptalis*:

***Apanteles* (*Cotesia*) *flavipes* Cam. (Hymenoptera: Braconidae):** Larval parasitoid, recorded in the Philippines and Thailand (Alba 1990; Suasa-ard & Charernsom 1995).

***Elasmus zehntneri* Ferr. (Hymenoptera: Elasmidae):** Gregarious larval ectoparasitoid. Recorded to attack *S. excerptalis* in Uttar Pradesh and in North Bihar, India (Gupta *et al.* 1994; Pandey *et al.* 1997a; Tanwar & Varma 1997; Singh *et al.* 2002). Egg and larval periods combined were 7.12 ± 0.83 days, and the pupal period was 11.30 ± 2.12 days. Male and female adults lived for 13.75 ± 2.59 and 17.0 ± 2.13 days, respectively (Tanwar 1990).

***Glyptomorpha* (=*Stenobracon*) *nicevillei* Bingham (Hymenoptera: Braconidae):** Larval parasitoid, recorded in cane fields of Uttar Pradesh, India (Tanwar &Varma 1997).

***Heterorhabditis indicus* Poinar (Nematoda: Heterorhabditidae):** A species of nematodes described from populations recovered from *S. excerptalis* in Coimbatore, India (Poinar *et al.* 1992).

***Isotima javensis* Row. (Hymenoptera: Ichneumonidae):** A solitary larval ectoparasitoid that attacks late instar larvae and the prepupal stage of *S. excerptalis* in North Bihar and Uttar Pradesh, India (Easwaramoorthy *et al.* 1992; Tanwar & Varma 1997); also recorded from the pupal stage (Gupta *et al.* 1994; Pandey *et al.* 1997a). In the Punjab, India, Shenhmar & Brar (1996) conducted field releases of this parasitoid and recorded parasitism levels of up to 52%. Damage by *S. excerptalis* where the parasitoid was released was reduced to 10% compared to 22% in the control.

***Melcha ornatipennis* Cameron (*Goryphus ornatipennis*) (Hymenoptera: Ichneumonidae):** Pupal parasitoid. Low parasitism levels were recorded in Uttar Pradesh, India (Singh *et al.* 2002).

***Pseudoshirakia* sp. (Hymenoptera: Braconidae):** Larval parasitoid, recorded in Eastern Uttar Pradesh cane fields, India, parasitizing *S. excerptalis* in low levels (Tanwar & Varma 1997).

***Rhaconotus* sp. (Hymenoptera: Braconidae):** Larval parasitoid, recorded in India (Pandey *et al.* 1997a).

***Rhaconotus scirpophagae* Wlk. (Hymenoptera: Braconidae):** Larval parasitoid, recorded attacking *S. excerptalis* in Indian cane fields. Maximum parasitization (33.42%) was recorded in August in the state of North Bihar (Gupta *et al.* 1994), also recorded to be abundant in Uttar Pradesh (Tanwar & Varma 1997; Singh *et al.* 2002).

***Rhoptromeris* sp. (Hymenoptera: Eucoilidae):** Larval parasitoid, recorded in Eastern Uttar Pradesh cane fields, India (Pandey *et al.* 1997a).

***Spathius* sp. (Hymenoptera: Braconidae):** Larval parasitoid. Recorded in Eastern Uttar Pradesh cane fields, India, parasitizing *S. excerptalis* in low levels (Tanwar & Varma 1997).

***Stenobracon deesae* Cam. (Hymenoptera: Braconidae):** Solitary larval ectoparasitoid, recorded by Gupta *et al.* (1994) to be the most prevalent parasitoid of *S. excerptalis* in all cane crops in North Bihar, India. Peak parasitization (54.80%) was recorded in June - August. Also recorded in Uttar Pradesh (Singh *et al.* 2002).

***Stenobracon* sp. (Hymenoptera: Braconidae):** Recorded in Papua New Guinea to be a key parasitoid of this species in *Saccharum spontaneum* (wild cane), but rarely found in commercial crops (Kuniata & Korowi 2005).

***Telenomus beneficiens* (Zehntner) (Ceraphron) (Hymenoptera: Scelionidae):** Egg parasitoid. Parasitism levels of up to 43.8% were recorded in Andhra Pradesh, India (Rajak & Varma 2001).

***Telenomus dignus* Gahan (Hymenoptera: Scelionidae):** Egg parasitoid. Recorded to cause parasitism of up to 47.1% of the egg masses in cane fields of Eastern Uttar Pradesh, India (Pandey *et al.* 1997a; Tanwar & Varma 1997). In Orissa, India, field records attribute 14.63% percentage parasitism to this species in sugarcane (Jena & Patnaik 1997).

***Temelucha* sp. (Hymenoptera: Ichneumonidae):** Solitary larval endoparasitoid. Recorded attacking *S. excerptalis* in cane fields of Uttar Pradesh, India (Tanwar & Varma 1997).

***Tetrastichus howardi* (Olliff) (Hymenoptera: Eulophidae):** A gregarious pupal endoparasitoid. Recorded to attack pupae of *S. excerptalis* in Uttar Pradesh, India (Baitha 2007). However, *T. howardi* is a polyphagous facultative hyperparasitoid which attacks a wide range of hosts including other parasitoids, hence, the option for its use in introduction biological control should be reconsidered.

***Trichogramma dignoides* (Hymenoptera: Trichogrammatidae):** Egg parasitoid. Recorded to result in almost 60% egg parasitism in cane fields in the Philippines (Alba 1990; 1991).

***Trichogramma chilonis* Ishii (Hymenoptera: Trichogrammatidae):** Egg parasitoid. Recorded to attack eggs of *S. excerptalis* in Uttar Pradesh cane fields, India (Tanwar & Varma 1997). This species was also used in inundative releases in cane fields of Eastern Uttar Pradesh at the rate of 20,000 wasps/acre/week, which resulted in percentage parasitism of only 10 - 15% (Pandey *et al.* 1997a). More recent results from Uttar Pradesh showed that 12 sequential releases of 50000 adults/ha at 10 days intervals proved effective in reducing top borer infestation (Singh 2006).

***Trichogramma japonicum* Ashmead (Hymenoptera: Trichogrammatidae):** Egg parasitoid. Used for inundative releases in India (Pandey *et al.* 1997a).
***Xanthopimpla pedator* (Hymenoptera: Ichneumonidae):** Pupal parasitoid. Recorded to attack *S. excerptalis* in sugar cane fields of Haryana, India (Mukunthan 1989).

Pheromone trapping
Trials in sugarcane plantations in Zhanjiang, Guangdong Province, China, showed that the greatest number of *S. excerptalis* males were attracted to traps baited with a 7:3 ratio of (E)-11-hexadecenal to (Z)-11-hexadecenal (Liu *et al.* 1992).

Host resistance
Resistance in sugarcane to *S. excerptalis* infestation has been investigated in India. Chaudhary & Yadav (1998a) examined 30 sugarcane genotypes of known susceptibility to *S. excerptalis* and showed a positive correlation between incidence of top borer and moisture present in leaf blades, mid ribs and growing points. On the other hand, there was a negative correlation between dry matter content of these plant parts and borer incidence. In another study, Chaudhary & Yadav (1998b) showed that the presence of lignin in midribs of genotypes had a significant negative correlation with borer incidence, but not in growing points or leaf blades. A negative correlation was found between total chlorophyll content in the mid ribs, growing points and leaf blades of different sugarcane genotypes and infestation by *S. excerptalis*, while the presence of nitrogen in the mid ribs, growing points and leaf blades showed a positive correlation with borer incidence (Chaudhary & Yadav 1995; 1996).

In a study in Haryana, India, Mukunthan & Mohanasundaram (1996) recorded that the larval period of borer, larval and pupal weight and borer fecundity did not differ in resistant and susceptible sugarcane hybrids. This suggested that no antibiosis mechanism operates in resistant varieties once the larvae are established in the spindle. In a tolerant host, the larval period was shortened and the larval and pupal weights were reduced. This was attributed to shortage of food supply due to the short spindle and thin stalk diameter. Mukunthan & Mohanasundaram (1998) observed two types of failures of attack by *S. excerptalis* in relation to sugarcane resistance to deadheart formation in Karnal (Haryana State) and Chakia (Bihar State) of India. Attacks were unsuccessful either because of failure of neonate larvae in the mid rib to reach the spindle or failure of older larvae in the spindle to reach the meristem (Type 2). Type 1 failure was frequent (19.2 to 26.7%) while Type 2 was rare (2.9 to 5.1%) among the genotypes they studied.

In the Indian Punjab, 14 varieties of sugarcane were screened for resistance to *S. excerptalis* and termites (*Odontotermes* spp. Varieties with longer leaf spindles suffered less damage from the pyralid, while fast germinating varieties were less damaged by termites (Singla *et al.* 1988).

Recent studies in Papua New Guinea showed that the following sugarcanr varieties were susceptible to *Scirpophaga excerptalis*: Q209, Q235, Q219, Q221, Q190, Q243 and KQ228. Varieties Q231, Q234, Q183 and Cadmus were found to be intermediate while Q136 and Q135 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.

Intercropping
In Sangrur, Indian Punjab, autumn planted cane intercropped with radishes and turnips had the lowest incidence of the first brood of *S. excerptalis*. Similar results were obtained in sugarcane intercropped with sunflower and gobhi sarson (*Brassica campestris* var. *sarson*) (Singla *et al.* 1994). Intercropping cane with coriander (*Coriandrum sativum*), ajowan (*Carum copticum*), onions, garlic, fenugreek, fennel and black cumin (*Nigella sativa*) reduced incidence of the top borer, with ajowan as an intercrop giving the lowest incidence (4.8%), compared with control (sugarcane only) where borer incidence reached 14.65% (Varun *et al.* 1990). In Shahjahanpur, Uttar Pradesh, intercropping sugarcane with spices such as coriander (*Coriandrum sativum*), onion, methi (*Trigonella foenum-graecum*), garlic, souff, ajavain and mangrail (*Nigella sativa*) reduced the incidence of *S. excerptalis* and increased sugarcane yield. Intercropping with "ajavain" recorded the lowest incidence of the first brood (2.12%), second brood (1.88%) and third brood (2.88%) *S. excerptalis* (Singh *et al.* 2003).

Farming practices

In the Indian Punjab, an irrigation interval of 12-14 days or above in the spring, a higher plant density (24000 three-budded setts), and irrigation at a rate equivalent to the soil water content during the monsoon season resulted in a lower incidence of *S. excerptalis* (Singla & Duhra 1990).

In Uttar Pradesh, India, incidence of *S. excerptalis* and *Chilo auricilius* were markedly higher in the autumn and spring planted crops than the late spring-planted crop that had a negligible incidence. Early maturing cultivars were more susceptible to borer infestation than late-maturing cultivars (Singh *et al.* 1997).

In Sangrur, Indian Punjab, shoot damage by *S. excerptalis* was higher in east-west planted sugarcane, whereas this trend was reversed for *C. infuscatellus* (Singla & Duhra 1992).

Collection and destruction of pest egg masses, adults and infested shoots in April and May (first and second broods) was found to be a cheaper method of control than insecticide use (Madan & Singh 2000). Collecting egg masses is a common control method in India. In a big initiative in Bihar, over 11 million egg masses were collected in the 1987-88 cane season. Collected eggs were exposed in field cages so that *Trichogramma* egg parasitoids could be conserved (Singh *et al.* 1989). While in Haryana, the timely mechanical removal of top borer infested shoots or egg masses reduced the incidence of third brood by more than 50 % in all the cultivars studied (Jaipal 2000).

Integrated Pest Management

During 1993-95, an Integrated Pest Management approach for the control of *Scirpophaga excerptalis* was trailed on sugarcane at Seorahi, Uttar Pradesh, India. Control methods included egg-mass collection during oviposition by the first and second generations during March and May, treatment with carbofuran at 30 kg a.i./ha, and release of *Trichogramma chilonis* and *T. japonicum* at 50, 000 adults/ha per week during the third generation. This management approach was reported to increase cane yield by 18.07% (Pandey *et al.* 1997b).

Means of movement

The most likely means of entry of *Scirpophaga excerptalis* 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.

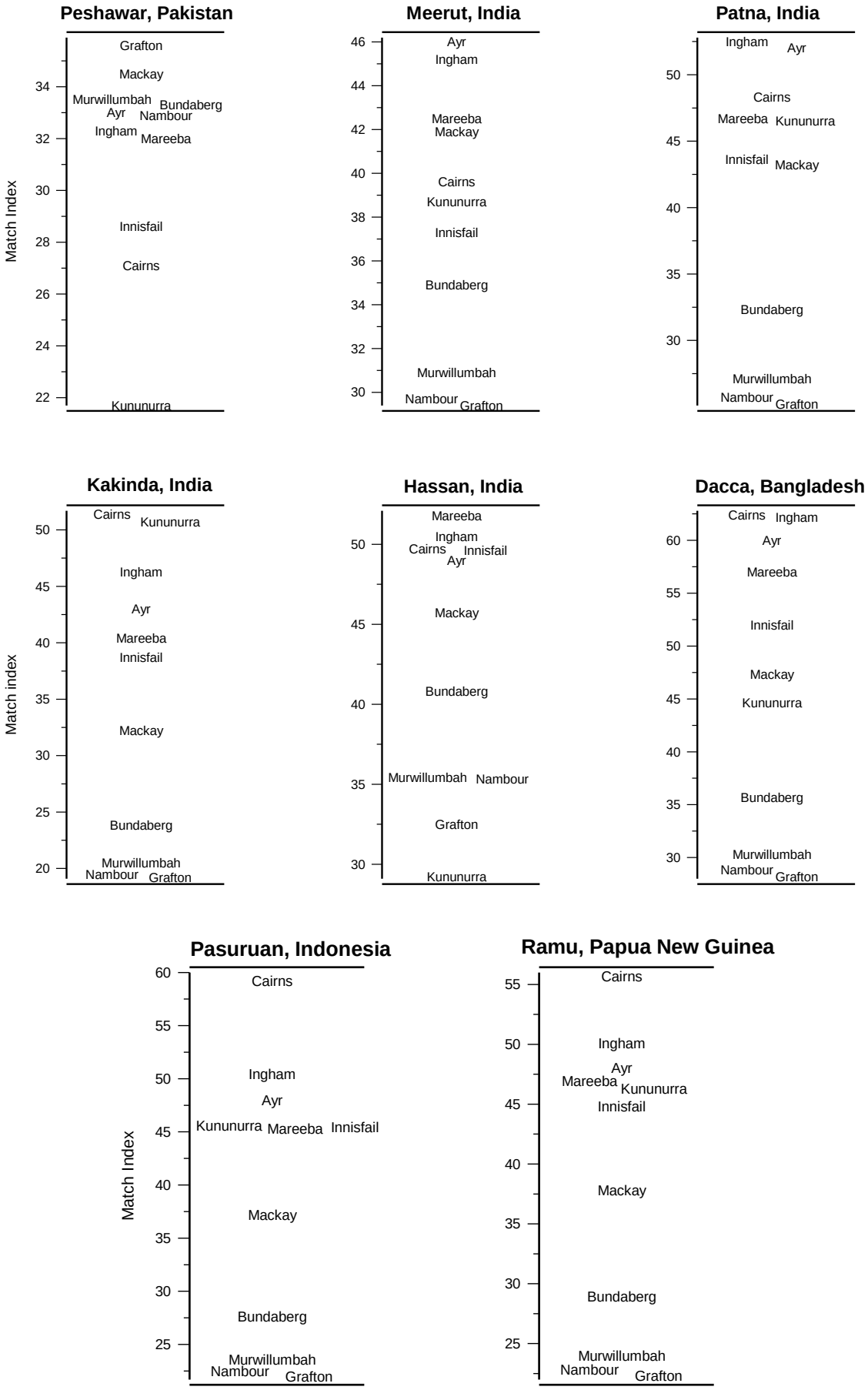
Phytosanitary Risk

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

Colonisation potential: High in 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).


Peshawar, Pakistan
Match Index
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Ingham
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Innisfail
Cairns
Kununurra
Meerut, India
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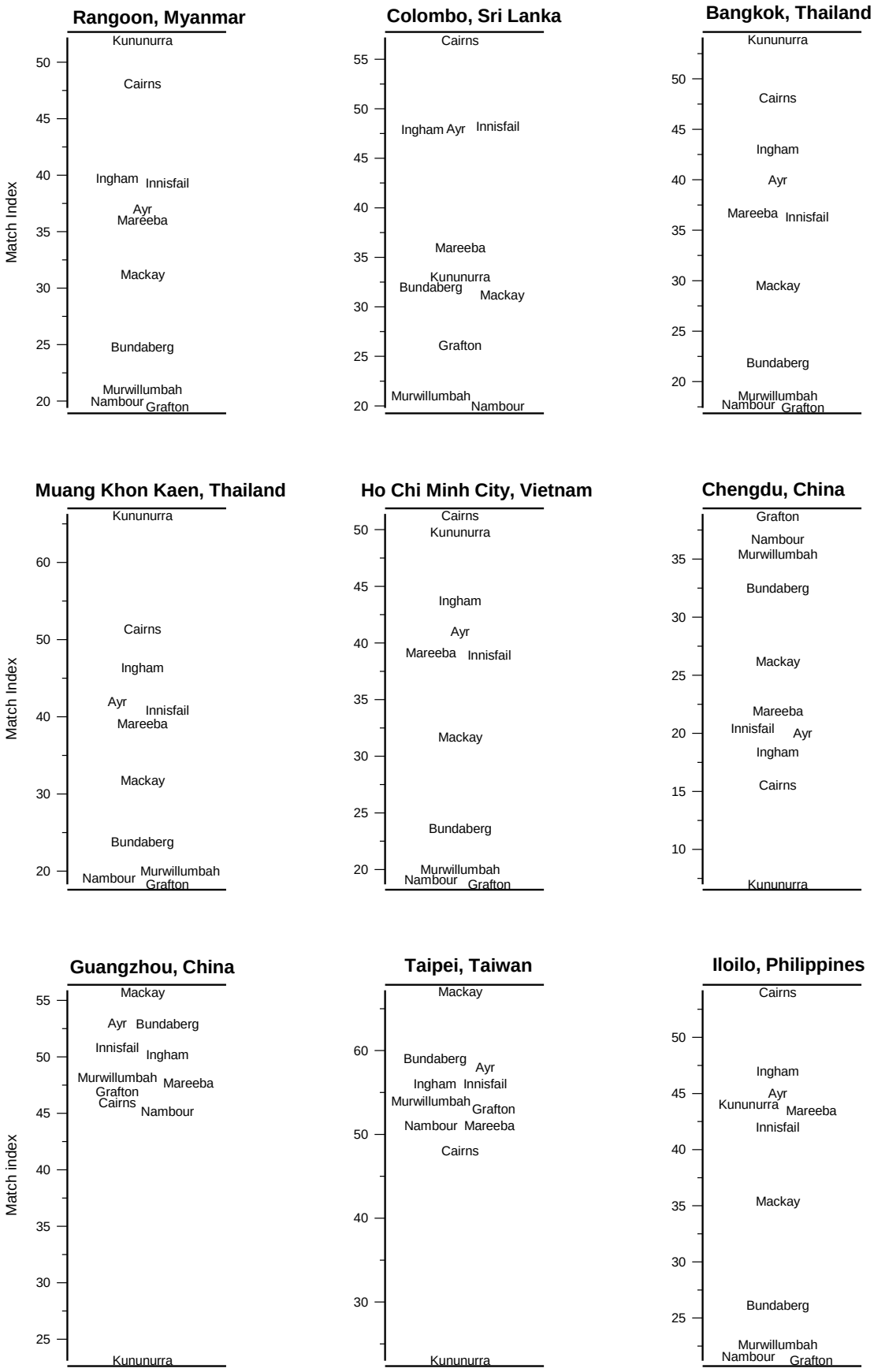
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Guangzhou, China
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Taipei, Taiwan
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Innisfail
Mackay
Bundaberg
Murwillumbah
Nambour
Grafton

***Scirpophaga magnella* (de Joannis)**

Scirpophaga magnella de Joannis, 1929
Scirpophaga monostigma Zeller: sensu Hampson, 1895 (misidentification)
Scirpophaga auriflua Zeller: sensu Leech, 1901 (misidentification)

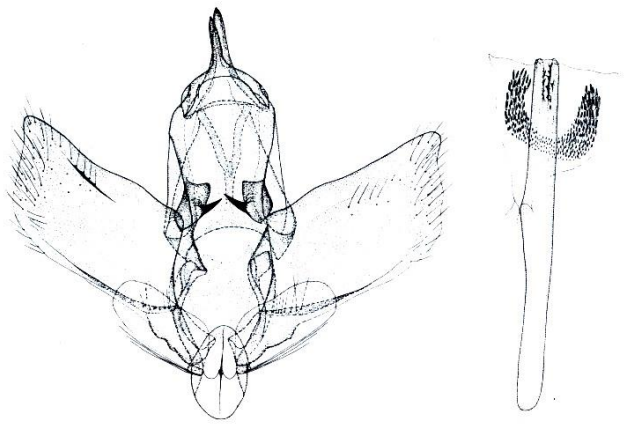
This species is morphologically almost identical to *S. excerptalis*; they can be separated using the following characters (Lewvanich 1981):

Character	***S. excerptalis***	***S. magnella***
Subteguminal process of the male genitalia	Takes the shape of a slender, long spine	Takes the shape of a stout, short spine
Colour of the anal tuft in female	Orange-red	Ochreous-yellow
Ostium bursae	Strongly wrinkled	Less wrinkled

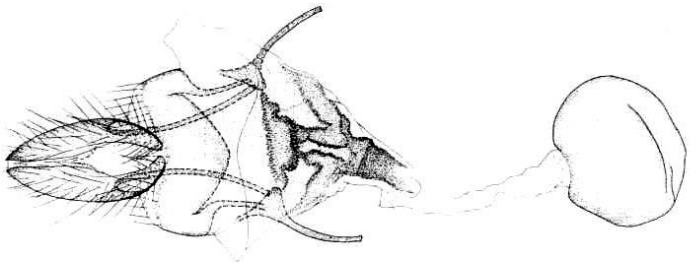
Distribution
Afghanistan, Bangladesh, Burma, China, Hong Kong, India, Iran, Nepal, Pakistan, Thailand, Vietnam.

Host plants
Scirpophaga magnella is reported to feed on *Saccharum* sp. in India, Pakistan, Taiwan and the Philippines; *Saccharum bengalense* in Pakistan; *Erianthus munja* in India and found at rest on *Oryza sativa* in India (Lewvanich 1981).

Morphology



Male genitalia



Female genitalia

No further information is available on this species; it has probably been confused with *S. excerptalis* and studied under the name *S. nivella* (Lewvanich 1981).

***Scirpophaga nivella* (F.)**

Tinea nivella Fabricius 1794
Crambus niveus (Fabricius) Fabricius 1798
Scirpophaga chrysorrhoa Zeller 1863
Scirpophaga auriflua Zeller 1863
Scirpophaga brunnescens Moore 1888
Scirpophaga butyrota Meyrick: sensu Meyrick 1889 (misidentification)
Schoenobius celidias Meyrick 1894
Schoenobius brunnescens (Moore): Hampson 1895
Crambus nivella (Fabricius) 1898
Apurima nivella (Fabricius): Aurivillius 1898
Scirpophaga euclastalis Strand 1918
Scirpophaga nivella (Fabricius): Shibuya 1928

Common names
Rice stem borer, white top moth borer.

Distribution
Bangladesh, Borneo, Hong Kong, India, Indonesia, Malaysia, Pakistan, Philippines, Singapore, Sri Lanka, Taiwan, Thailand, Vietnam (Cheng 1999; Arora 2000).

Status in Australia
The Checklist of the Lepidoptera of Australia (Nielsen *et al.* 1996) uses the name *chrysorrhoa* as an alternative species name for *Scirpophaga nivella.* Under that name, Common (1960) indicates that it is found in Northern Australia, extending southwards along the eastern coast to northern NSW. Specimens examined by Common (1960) from Australia were collected from the following regions: Queensland: Ayr, Bowen, Brisbane, Cairns, Cape York, Dunk Island, Halifax, Mackay, Stewart River, Silver Plains (Cape York Peninsula), Townsville; New South Wales: Brunswick Heads, Burringbar; Western Australia: Ivanhoe; Northern Territory: Bathurst Island, Darwin, Groote Eylandt, Humpty Doo, Marraki, Mary River, Melville Island, Stapleton.

Host plants

IMPORTANT
This species is mainly a pest of rice. Its status in sugarcane as a pest is now doubtful, since Lewvanich (1981) stated that *S. nivella* does not occur on sugarcane, and most records of this species in cane are referrable to *Scirpophaga excerptalis* (see section on *S. excerptalis*). However, several recent references are available on this species as a pest of cane. What is presented here is based on these references, but it is important to realize that the status of the species in cane has to be revised. In addition, the fact that *Scirpophaga chrysorrhoa* in Australia is the same species as *S. nivella* in Asia requires further examination.

Symptoms
Dead shoots appear as a result of tunnelling in the growing points. Early infestation results in thinning and stunting of cane, while later infestation leads to side shooting from the top buds (Samoedi 1995).

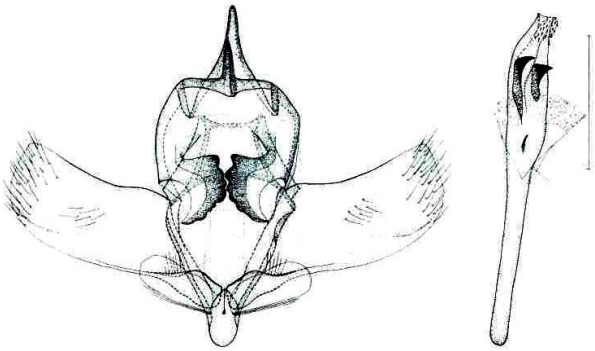
Economic impact
Few references are available on the economic impact of *S. nivella* in cane. In a variety trial in West Java, Indonesia, yield losses caused in sugarcane due to top borer ranged between 8.51% and 9.28%, with early infestation of young canes contributing most to yield losses (Samoedi 1988b). Similarly, Samoedi (1995) recorded a reduction of sugar yield due to borer infestation in Java by an average of 9%.

Morphology
Arora (2000) gives the following description of adult *Scirpophaga nivella*:
Head with the frons smooth; labial palpi porrect, short and about 1.3 times the diameter of eye; antennae minutely serrate and profusely ciliated in male and simple and sparsely ciliated in female, about half the

length of forewing costa in male and one third in female. Outer tibial spurs half the length of inner ones. Frenulum spine single in male and held by a retinaculum bar; spines two in female, held by a cluster of bristles.

Male

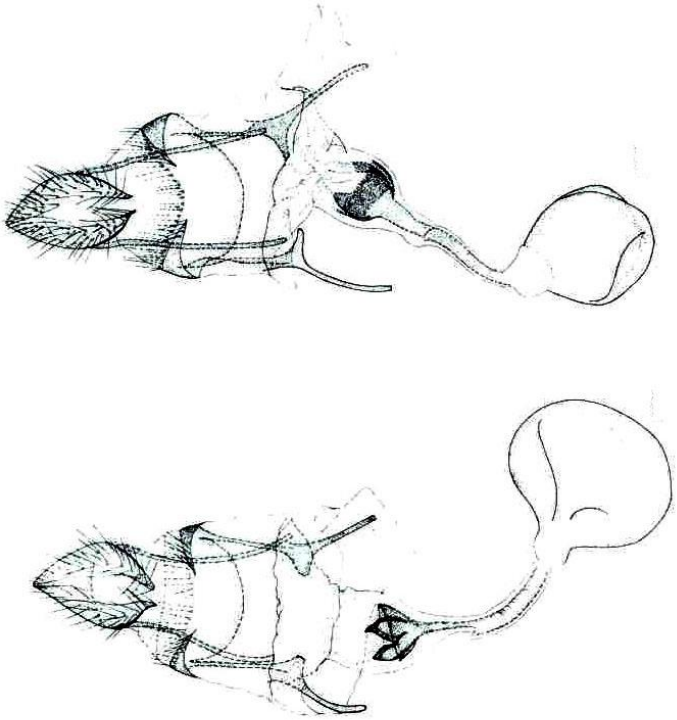
Head, thorax and abdomen pale ochreous. Forewing ochreous to dark-greyish ochreous; with three fuscous spots on submedian fold, the fourth spot at lower angle of cell; an oblique series of fuscous spots from costa, near apex, to near third spot; a series of very small fuscous neural dots along termen, sometimes quite reduced. Underside: labial palpi dark. Legs dark, particularly the basal joints; forewings fuscous; hind wing semi-hyaline white, paler in basal half.



Male genitalia

Female

Head, thorax, abdomen, wings and legs whitish on upper as well as underside. Wings unmarked on both sides. Anal tufts ochreous yellow.



Female genitalia

Forewing
Vein R_1 free, running straight to costa; R_2 free, from a little before the upper angle of cell; R_{3+4} on a long stalk; R_5, M_1 from below the upper angle of cell, nearly equidistanced to R_{3+4}; M_2, M_3 close to each other from lower angle; Cu_{1a} from before the angle, about twice as far from M_3 as the latter from M_2; Cu_{1b} also about twice as far from Cu_{1a} as the latter from M_3, and arising in line with R_1 above.

Hindwing
Vein Sc anastomosing with Rs, after the latter's origin from cell angle, for about basal one third; M1 from cell angle and connate with Rs; M_2, M_3 close to each other at lower angle and, along with Cu_{1a}, placed as in forewing. Other features as given for the genus.

Detection methods
Check growing points for damage or presence of larvae. Pheromone can be used to attract adult moths.

Biology and Ecology
Kamani & Vyas (1985) studied the biology of *Scirpophaga nivella* in Gujarat, India, in the laboratory. Results showed that the average incubation period was 7.97 days, and durations of the first, second, third, fourth and fifth larval instars were 2.13, 4.63, 5.23, 5.85 and 6.42 days, respectively. The prepupal and pupal periods lasted 1.45 and 11.80 days, respectively. The lifespan of male adults averaged 3.63 days and that of the female 3.44 days. The mean number of egg masses deposited by each female was 4.22, and fecundity averaged 94.15 eggs/female. Recorded sex ratio (males to females) was 1:1.109.

Samoedi *et al.* (1995) conducted field studies in Ngadirejo, Indonesia, and showed that the borer distribution was contagious both in irrigated and unirrigated fields, and the economic threshold was determined at the infestation level of 4%.

In a survey carried out in sugarcane fields in Taiwan in 1974-84, *S. nivella* represented only 11.3% of the pest population complex, whilst *Argyroploce schistaceana* (*Tetramoera schistaceana*) and *Proceras venosatus* (*Chilo sacchariphagus sacchariphagus*) represented 67.9% and 9.9% of the total pest population, respectively (Cheng *et al.* 1987).

In sugarcane fields of the Punjab, India, Goel *et al.* (1983) studied mortality factors influencing population levels of the top borer, which included relative humidities below 40% in the second and third weeks of May, temperatures above 40°C in May-June, egg, larval and pupal parasites, failure of first-instar larvae to enter the mid ribs and leaf whorls and quick growth of the cane plants. Parasitism by *Telenomus* sp. was higher in the second generation studied than the first. Parasitism of late-instar larvae by *Isotima javensis* (Rohw.), *Rhaconotus scirpophagae* Wlkn. and *Stenobracon nicevillei* (Bingham) was important in the third generation.

In rice fields, nightly light trap catches of *S. nivella* in West Bengal, India, showed two discrete peaks of abundance in each trap corresponding to conducive weather conditions and abundance of rice plants. Summer catches were significantly correlated with maximum temperature and minimum relative humidity during the day, and minimum temperature and wind speed at night, whereas autumn catches were significantly associated with maximum temperature and minimum relative humidity at night. Autumn crops had higher infestations, and sustained greater larval density than summer ones. Catches of immature and mature females were greatest at full moon and new moon, respectively (Banerjee *et al.* 1986).

Management
In India, soaking cane setts in monocrotophos 36 EC and phosphamidon 85 EC at 1.0% gave effective results against top borer as well as plassey borer (*Chilo tumidicostalis*). Insecticide soaking gave protection up to August, after which pest numbers increased, though crop yield did increase compared to untreated plots (Deka *et al.* 1999a).

In Pakistan, application of Furadan 3G (carbofuran) at germination and at earthing up gave the best control of *S. nivella*, *Chilo infuscatellus* and *Emmalocera depressella* (*Polyocha depressella*) (Halimie *et al.* 1989).

Other methods used in Pakistan include trash mulching at the time of sowing, removal of dead hearts, hand collection of egg masses and cutting of infested shoots at 15 days interval (Khaliq *et al.* 2005) .

Resistant varieties

In Pakistan, work by Khaliq *et al.* (2005) showed that infestation was positively correlated with nitrogen, potassium, calcium, magnesium and ferrous plant contents. While Phosphorous, carbohydrates, fats and zinc were correlated with lower infestation levels at tillering stage, with variety BF-162 and SPSG-26 being the most resistant.

Pheromone trapping

In Indonesia, studies showed that gland extracts of females contain the complex pheromones of hexadecenal (3%), (E)-11-hexadecenal (77%) and (Z)-11-hexadecenal (20%) (Permana *et al.* 1995).

Biological control

A large number of natural enemies are recorded on this pest, however, and according to Lewvanich (1981), they should be referred to *S. excerptalis*, since mostly all were recorded in cane. The followings are only the main parasitoids recorded on this species; many other ambiguous records were discarded.

***Anostectus* sp. (Hymenoptera: Eulophidae):** Larval parasitoid, recorded from India (Butani 1958).

***Apanteles flavipes* Cameron (Hymenoptera: Braconidae):** Larval parasitoid, recorded from India (Butani 1958; Butani 1972).

***Apanteles scirpophagae* Ashmead (Hymenoptera: Braconidae):** Larval parasitoid, recorded from India (Box 1953; Butani 1972).

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

***Bracon chinensis* Szepligetti (Hymenoptera: Braconidae):** Larval parasitoid, recorded from India (Butani 1972).

***Bracon famulus* Bingham (Hymenoptera: Braconidae):** Larval parasitoid, recorded from India (Butani 1972).

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

***Elasmus* sp. (Hymenoptera: Elasmidae):** Larval ectoparasitoid. Reported to attack mature *S. nivella* larvae in Indonesia (Samoedi 1993).

***Elasmus zehntneri* Ferriere (Hymenoptera: Elasmidae):** Larval ectoparasitoid. Reported to attack fully grown larvae and prepupae of *S. nivella* in Indonesia. Parasitism rates were increased due to inundative releases from only 0.8% to almost 30%. One host larvae produced up to 60 adult parasitoids both in the field and laboratory (Ubandi *et al.* 1988).

***Goniozus indicus* Ashmead (Hymenoptera: Bethylidae):** Larval ectoparasitoid, recorded from India (Box 1953; Butani 1958, 1972).

***Harmoniae* sp. (Hymenoptera: Chalcididae):** Larval parasitoid, recorded from India (Butani 1972).

***Iphiaulax famulus* Bingham (Hymenoptera: Braconidae):** Larval parasitoid, recorded from India (Butani 1972).

***Iphiaulax sikkimenis* Cameron (Hymenoptera: Braconidae):** Larval parasitoid, recorded from India (Butani 1972).

***Ischnojoppa luteator* F. (Hymenoptera: Ichneumonidae):** Pupal parasitoid, recorded from India (Butani 1972).

***Isotima dammermani* Rohwer (Hymenoptera: Ichneumonidae):** Pupal parasitoid, recorded from India (Butani 1972).

***Isotima javensis* (Rohw.) (Hymenoptera: Ichneumonidae):** A solitary ectoparasitoid. Reported to attack mature larvae and prepupae of *S. nivella* in Indonesia (Samoedi 1993). In India, a native strain is responsible for good control of the top borer, especially in the south (Goel *et al.* 1983; Pawar 1987). Also recorded from Indonesia (Kalshoven 1981).

***Listrognathus* (*Mesostenoideus*) *calvinervis* Cameron (Hymenoptera: Ichneumonidae):** Larval parasitoid, recorded from India (Butani 1958).

***Macrocentrus jacobsoni* Szépl. (Hymenoptera: Braconidae):** Larval parasitoid, recorded from Taiwan (Box 1953).

***Melcha ornatipennis* Cameron (Hymenoptera: Ichneumonidae):** Pupal parasitoid, recorded from India (Box 1953; Butani 1958) and Burma (Box 1953).

***Pharanus* sp. (*Telenomus* sp.) (Hymenoptera: Scelionidae):** Egg parasitoid. Reported to attack mature *S. nivella* larvae in Indonesia (Samoedi 1993).

Pimpla predator **Fabricius (Hymenoptera: Ichneumonidae):** Pupal parasitoid, recorded from India (Box 1953).
Rhaconotus roslinensis **Lal (Hymenoptera: Braconidae):** Larval parasitoid, recorded from India (Butani 1972).
Rhaconotus scirpophagae **Wilkinson** (**Hymenoptera: Braconidae):** Larval parasitoid, recorded from Pakistan (Carl 1962) and India (Butani 1972; Box 1953).
Rhaconotus signipennis **Walker (Hymenoptera: Braconidae):** Larval parasitoid, recorded from India (Butani 1972).
Shirakia yokohamensis **Cam. (Hymenoptera: Braconidae):** Larval parasitoid, recorded from Taiwan (Box 1953).
Stenobracon deesae Cameron **(Hymenoptera: Braconidae):** Larval parasitoid, recorded from India (Box 1953; Butani 1958) and Pakistan (Carl 1962).
Stenobracon karnalensis **Lal (Hymenoptera: Braconidae):** Larval parasitoid, recorded from India (Butani 1972).
Stenobracon maculata **(*S. trifasciatus*) (Hymenoptera: Braconidae):** Larval parasitoid. Recorded attacking *S. nivella* in Indonesia (Samoedi 1993).
Stenobracon nicevillei Bingham **(Hymenoptera: Braconidae):** Larval parasitoid, recorded from India (Butani 1958; Goel *et al.* 1983).
Stenobracon trifasciatus Szépl. **(Hymenoptera: Braconidae):** Larval parasitoid, recorded from Taiwan, Indonesia and the Philippines (Box 1953; Kalshoven 1981).
Sturmiopsis inferens **Townsend** (**Hymenoptera: Tachinidae):** Larval parasitoid, recorded from India (Butani 1972).
Syzeuctus **sp. (Hymenoptera: Ichneumonidae):** Larval parasitoid, recorded from India (Butani 1972).
Telenomus beneficiens **(Zehntner) (Ceraphron)** (**Hymenoptera: Scelionidae):** Egg parasitoid, recorded from India, Indonesia and the Philippines (Box 1953; Kalshoven 1981).
Telenomus beneficiens **var. *elongatus* (Hymenoptera: Scelionidae):** Egg parasitoid. Seasonal occurrence of this parasitoid was studied in Taiwan and parasitism rates as high as 68.4% were reached in the field. The parasitoid began emerging in March and reached a peak of 54.5 adults/312 m^2 in May then numbers declined gradually and none were found later than December (Cheng & Chen 1999).
Telenomus dignus **Gahan** (**Hymenoptera: Scelionidae):** Egg parasitoid, recorded from India (Butani 1958).
Telenomus dignoides **Nixon** (**Hymenoptera: Scelionidae):** Egg parasitoid, recorded from Indonesia (Mohyuddin 1987), Pakistan (Carl 1962) and India (Butani 1972).
Telenomus rowani **Gahan** (**Hymenoptera: Scelionidae):** Egg parasitoid, recorded from India (Butani 1972).
Telenomus saccharicola **Mani** (**Hymenoptera: Scelionidae):** Egg parasitoid, recorded from India (Butani 1972).
Temelucha **sp. (Hymenoptera: Ichneumonidae):** Larval parasitoid, recorded from India (Butani 1972).
Tetrastichus ayyari **Rohwer (Hymenoptera: Eulophidae):** Pupal parasitoid, recorded from India (Butani 1972).
Tetrastichus schoenobii **(Hymenoptera: Eulophidae):** Egg parasitoid, recorded from Indonesia (Mohyuddin 1987).
Tetrastichus scirpophaga **Mani (Hymenoptera: Eulophidae):** Egg parasitoid, recorded from India (Butani 1972).
Trichogramma australicum **Girault** (**Hymenoptera: Trichogrammatidae):** Egg parasitoid, recorded from India (Butani 1972).
Trichogramma chilonis **(Ishii)** (**Hymenoptera: Trichogrammatidae):** Egg parasitoid, recorded from China (Liu *et al.* 1996), Taiwan (Cheng *et al.* 1987) Inundative releases of this parasitoid in Al Noor Sugar Mills area of Pakistan reduced borer infestation significantly (Ashraf & Fatima 1996).
Trichogramma evanescens minutum **Riley** (**Hymenoptera: Trichogrammatidae):** Egg parasitoid, recorded from India (Butani 1958).
Trichogramma japonicum Ashmead **(Hymenoptera: Trichogrammatidae):** Egg parasitoid, recorded from Taiwan (Cheng and Chen 1999).
Trichogramma nanum **Zhnt.** (**Hymenoptera: Trichogrammatidae):** Egg parasitoid, recorded from Indonesia (Box 1953).
Vipio deesae **(Cameron) (Hymenoptera: Braconidae):** Larval parasitoid, recorded from India (Butani 1972).

***Xanthopimpla stemmator* Thunberg (Hymenoptera: Ichneumonidae):** Pupal parasitoid, recorded from Taiwan (Box 1953) and India (Butani 1972).

Predators

***Brumus suturalis* F. (Coleoptera: Coccinellidae):** Recorded feeding on eggs of *Scirpophaga nivella* (Fabr.) in India (Butani 1958).

***Brumus* (*Coccinella*) *suturalis* Fabricius (Coleoptera: Coccinellidae):** Recorded feeding on eggs of *Scirpophaga nivella* (F.) in India (Butani 1972).

Other species of *Scirpophaga*

The followings are the remaining *Scirpophaga* spp as listed by Lewvanich (1981), they are not recorded from sugarcane thus unlikely to be of any pest status in this crop.

Scirpophaga praelata (Scopoli)
Scirpophaga xanthopygata (Schawerda)
Scirpophaga parvalis (Wileman)
Scirpophaga phaedima Common
Scirpophaga gilviberbis Zeller
Scirpophaga percna Common
Scirpophaga imparella (Meyrick)
Scirpophaga xantharrenes Common
Scirpophaga melanoclista Meyrick
Scirpophaga xanthogastrella (Walker)
Scirpophaga brunnealis (Hampson)
Scirpophaga ochritinctalis (Hampson)
Scirpophaga bradleyi Lewvanich
Scirpophaga khasis Lewvanich
Scirpophaga flaviodorsalis (Hampson)
Scirpophaga melanostigma (Turner)
Scirpophaga tongyaii Lewvanich
Scirpophaga occidentella (Walker)
Scirpophaga fusciflua Hampson
Scirpophaga ochroleuca Meyrick
Scirpophaga virginia Schultze
Scirpophaga subumbrosa Meyrick
Scirpophaga marginepunctella (de Joannis)
Scirpophaga serena (Meyrick)
Scirpophaga goliath Marion & Viette
Scirpophaga lineata (Butler)
Scirpophaga aurivena (Hampson)
Scirpophaga auristrigella (Hampson)
Scirpophaga gotoi Lewvanich
Scirpophaga whalleyi Lewvanich

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