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BIONOMICS AND MANAGEMENT OF RICE WHORL MAGGOT- *HYDRELLIA* SPP. (DIPTERA : EPHYDRIDAE) - A REVIEW

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ABSTRACT

The rice whorl maggot *Hydrellia* spp. is a pest of rice mainly in irrigated ecosystem. It causes 20-30% yield loss on the first crop during April-September but the infestation was less in the second crop. The taxonomic characters and host plants of *Hydrellia* spp. viz., *Hydrellia philippina*, *Hydrellia sasakii* and *Hydrellia griseola* were described. The adult insects prefer places with abundant calm water and less vegetation. Eggs to adult period is normally 25-28 days. The maggots of the fly feed on unopened leaves and nibbles the inner margins. Conspicuous linear feeding lesions are visible when the central leaf opens. *Hydrellia philippina* is a multivoltine species with overlapping generations under field conditons. The bionomics and management of rice whorl maggot have been reviewed.

Whorl maggot is an important insect pest causing serious damage to rice crop during vegetative phase, direct seeded rice have more risk than transplanted rice. The pest attack other crops also than the rice crop. In India, as well as in Philippines the occurrence recorded through out the year. The species of rice whorl maggot *Hydrellia philippina* Ferino, *Hydrellia sasakii* Yu. & Is. and *Hydrellia griseola* (Fallen) (Diptera : Ephydridae) were not recorded in the Asian countries until the early 1960's but now assumed pest status in many parts of Asia. All the species of genus *Hydrellia* damage rice leaves. They prefer mostly an aquatic habitat.

PEST STATUS : *Hydrellia* spp. is a pest of rice plants only in irrigated ecosystem. After 3 or 4 weeks of transplanting whorl maggot does more damage in continuous flooded fields as the gravid flies prefer flooded fields for oviposition (Viajante and Heinrichs, 1985a). Ferino (1968) reported an estimated yield loss of 1.4 t/ha due to the damage of this pest in the Philippines. In south India, Thomas *et al.* (1971) reported that the whorl maggot could cause 20-30 per cent yield loss on the first crop during April to September. But the infestation was less in the second crop. However, Nurullah (1979) reported that whorl maggots do not cause any adverse effect on tiller production rather its infestation can increase the number of productive tillers compensating the possible grain losses. Studies conducted by Viajayante and Heinrichs (1986) revealed that the whorl maggot did not adversely affect the yield but delayed the maturity with rice varieties of IR 36.

NOMENCLATURE (FAUNISTICS) : *Hydrellia* spp. belong to the order Diptera and family Ephydridae because it has developed membranous wings with venation and hind wings reduced to club like halters; pro and mesothorax greatly reduced. Deeming (1977) reported *Hydrellia* Robienace attacking rice in southern Nigeria. Ismail *et al.* (1979) described the leaf minor *Hydrellia prospernalis* Deeming from Arab. In Polland, four new names and 21 new synonyms of 13 names of *Hydrellia* spp. were proposed and later *Hydrellia chinensis* and *Hydrellia sinica* both of which are synomized with *Hydrellia griseola* (Zotwarnicki, 1988). In Colombia *Hydrellia wirthi* affected by plant density (Salazar *et al.*, 1993) The detail of common name and differences among the adults of Hydrellia spp.and their heads is given in Table 1. Barrion and Litsinger (1994) described the taxonomy characters of *Hydrellia philippina*, Ferino, *Hydrellia*

Table 1 : Common names used for *Hydrellia* spp. in different countries.

Common Name	Country	References
Smaller leaf miner	Japan	Fujimaki & Takanashi (1961)
Smaller rice miner	Japan	Funabasama (1966)
Rice leaf miner	Japan	Funabasama (1966)
	USA	Way *et al.* (1983)
	Egypt	El-Nahal *et al.* (1971)
	Guyana	Rambajan (1979)
Rice leaf whorl maggot	India	Mani & Jayraj (1976),
Whorl maggort	India	Ramamurthy *et al.* (1976)
Smaller rice leaf miner	Philippines	Barrion & Litsinger (1981)
	Korea	Choi *et al.* (1983)
Barley leaf mining fly	Germany	Kreiter (1927)
Barley mining fly	Germany	Kreiter (1927)
Barley fly	Germany	Kreiter (1927)

griseola (Fallen), *Hydrellia tomiokai* Miyagi and *Hydrellia sasakii* Yuasa et Ishitani. The taxonomical identification of *Hydrellia* spp. are as follows:

***Hydrellia philippina* Ferino** : In this sp. four dorsocentral setae are present. Face bordered with 6 facials; frons and cheeks silvery white. Mesonotum greyish with silvery white and brown tinge scutellum silvery white to grey. Antennae dark grey with light silvery tinge in the inner portion of second segment, 7-10 aristal hairs. Abdomen silvery white to grey with blackish brown medians in the basal three segments; legs yellow except femora I to III, inner portion of femur I with about 10-12 spines. The adult flies are grey in colour with transparent wings.

***Hydrellia griseola* (Fallen)** : In this sp. four dorsocentral setae are present. Face golden yellow covered with silvery tinge. Frons black with greyish tinge and cheeks greyish white. Mesonotum and scutellum brown, and antennae black with 5-6 aristal hairs; head index 5 :1. Abdomen greyish to dark brown, legs black with greyish tinge and yellow metatarsi, inner portion of femur I armed with more than 25 small teeth.

***Hydrellia sasakii* Yuasa and Isitani** : In this sp. two dorsocentral setae are present. Face golden yellow to yellowish brown with six hairs like facials. Frons blackish brown with velvety black laterals. Antennae black, 3rd segment with brownish pubescence; 7 aristal hairs. Abdomen brown, coxae yellow, femora black, tibiae yellow except mid tibiae brownish yellow, basal half of hind tibiae blackish brown.

***Hydrellia tomiokai* Miyagi** : In this sp. two dorso central setae are present; face and lunula silvery white with 5-6 moderate facials; frons and antennae black; mesonotum and scutellum black with dense brown tinge; third antennal segment with whitish pubescence, 8 aristal hairs present; abdomen half shining black but yellow apically; tibiae and tarsi are yellow.

GEOGRAPHICAL DISTRIBUTION : The Asian countries which affected by *Hydrellia* spp. are Pakistan, India, Bangladesh, Srilanka, Myanmar, China, Taiwan, Korea, Japan, Thailand, Laos, Vietnam, Kampuchea, Malaysia, Indonesia, Papua New Gunea besides Germany, north Africa and USA (Reissig *et al.*,1985). The geographical distribution of *Hydrellia philippina* is shown in detail in Table 2.

Table 2 : Geographical Distribution of *Hydrellia* sp.

Country/Region	References
ASIA	
BANGLADESH	Alam & Alam (1977)
CHINA	Reissig *et al.* (1985)
INDIA	Azam and Tejkumar (1971)
	Thomas *et al.* (1971)
INDONESIA	Reissig *et al.* (1985)
JAPAN	Okamota & Koshihara (1954)
	Funabasama (1966)
KAMPUCHEA	Reissig *et al.* (1985)
KOREA	Choi *et al.* (1983)
	Reissig *et al.* (1985)
LAOS	Reissig *et al.* (1985)
MALAYSIA	Reissig *et al.* (1985)
MYANMAR	Reissig *et al.* (1985)
PAKISTAN	Deonier (1978)
PAPUA NEW GUNEA	Reissig *et al.* (1985)
PHILIPPINES	Ferino (1968a)
SRILANKA	Fernando (1978)
TAIWAN	Cheng (1978)
THAILAND	Patanakamjorn (1964)
VIETNAM	Reissig *et al.* (1985)
AFRICA	
EGYPT	Elnahal *et al.*(1971)
NIGERIA	Deeming (1977)
NORTH AND CENTRAL AMERICA	
USA	Grigarick (1959)
	Way *et al.* (1983)
SOUTH AMERICA	
GUYANA	Rambajan (1979)
EUROPE	
FRANCE	Feron & Audemard (1956)
ITALY	Corbetta (1973)

HOSTS : The host plants of *Hydrellia* spp. other than rice were reviewed by Dale (1994). The host plants of *Hydrellia* spp. are as follows:

1. ***Hydrellia griseola* (Fallen)** : *Agropyron* sp, *agrostis tenuous* Sibth., *Alisma plantago-acquatica* L., *Allium cepa* L., *Avena sativa* L., *Bellis perennis* L., *Bromus inermis* Leyss., *Cynodom dactylon* (L.) Pers., *Cyperus rotundus* L., *Dactylis glomerata* L., *Digitaria sanguinalis* (L.) Scop., *Echinochloa colona* (L.) link, *Festuca parvigluma* steud., *Hordeum vulgare* L., *Hydrocharis morsus-ranae* L., *Lamium album* L., *Lemna minor* L., *Lolium perenne* L., *Lychnis*

dioica L., *Muhlenbergia mexicana* (L.) Trin., *Panicum repens* L., *Paspalum scrobiculatum* L., *Phalaris arundinacea* L., *Phleum paniculatum* Huds., *Phragmites australis* (Cav.) Trin. ex Steud., *Poa compressa* L., *Polygonum lapathifolium* L., *Polypogon fugax* Nees, *Sagittaria latifolia* Willd., *Scirpus grossus* L., *Secale cereale* L., *Setaria glauca* (L.) Beauv., *Stellaria media* (L.), Cyr., *Stratiotes aloides* L., *Trifolium pratense* L., *Triticum aestivum* L., *Typha latifolia* L., *Veronica officinalis* L., *Zea mays* L., *Zizania aquatica* L.

2 *Hydrellia philippina* Ferino : *Cynodon dactylon* (L.) Pers., *Ecinochloa colona* (L.) Link, *Echinochloa crusgalli* (L.) Beauv., *Eleusine indica* (L.)., Gaertn., *Fimbristylis miliacea* (L.) Vahl., *Paspalum scrobiculatum* L.

3 *Hydrellia sasakii* Yausa et. Isistani : *Leersia japonica* Honda, *Leersia oryzoides* (L) Sw. var, *Japonica* Hack., *Leptochloa chinensis* (L.) Nees.

SYMPTOMS OF DAMAGE : The maggots of this pest feed on unopened leaves and nibbling the inner margins. Conspicuous linear feeding lesions are visible when the central leaf opens. Damaged leaves become distorted and may broken off by the wind (Ferino, 1968). Infested plants shows reduction in plant height, tiller number, delayed panicle initiation, maturity of grain and reduction in leaf length and diameter. Of late this pest also found at ripening phase of the crop and damaging the boot leaf and developing panicles (Sain *et al.*, 1983) which can lead to only partial filling of grains (Varadarajan *et al.*, 1977). Small puncture appear in the middle of the flag leaf and its margin get discoloured (Basu, 1979). The chlorotic effect coupled with disrupted sugar metabolism and poor nutrients uptake are probably the reasons for the manifestation of damage symptoms of the infested plants (Ramamurthy *et al.*, 1977).

BIOLOGY AND ECOLOGY

ADULTS : The biology of *Hydrellia philippina* was studied by Ferino, (1968b) in detail in Philippines (Ferino, 1968b). The adults of whorl maggot are dull grey in colour, the size of the female flies vary from 1.5 to 3.0 mm but the males are slightly smaller. The peak time of adult emergence is from 7 to 10 a.m. The flies have a definite preference for places with abundant calm water and prostrate vegetation near slow flowing drainage and irrigation canals (Karim, 1969). They moved by a combination of walking and hopping in a zig-zag pattern. Adults are saprophagous on dead aquatic insects. Mating occurs mostly during morning and evening hours from the second day after emergence. Adults locate rice fields reflected sunlight from the water surface. Once the canopy closes they can no longer find rice crop, thus direct seeded fields or seedbeds are not highly attractive to the adults (Farino, 1968b).

EGGS : Females lay about 100 eggs during the life time of 3-7 days and flies preferred the basal portion of the upper half of the leaf. The eggs are laid singly on either sides of the leaf blades. The eggs are white, elongate and cigar in shape.The eggs are 0.65-0.85 mm long and 0.15-0.20 mm wide. The incubation period is 2-6 days.

MAGGOTS : The maggot move down the leaf into the whorl on a film of dew and feed within developing leaf whorls. The maggot is transparent to very light cream during the first instar but later becomes yellow. Larvae mostly remain inside the leaves and feed on the mesophyll tissues of the foliage. The maggot undergo 3 instars and range from 8-17 days. The full grown maggot are cylindrical with the posterior end tapering to a pair of pointed spiracles. It is about 4.4-6.4 mm long and 0.4-0.7 mm wide. Under low magnification the heavily sclerotized mouth hook and cephalopharyngeal skeleton can be easily identified (Farino, 1968b).

PUPATION : Pupation takes place between the leaf sheaths where the pupa is loosely attached to the stem. The puparium is light to dark brown, ovoid and subcylindrical in shape. The pupal period is 5-10 days. The eggs to adults period is normally 25-28 days (Farino, 1968b).

SEASONAL OCCURRENCE : In Philippine lowest fly population was observed during the first six months of the year coinciding with period of high temperature and low rainfall (Farino, 1968b). From July onwards its population continue to increase till November, there after it declines. But, in India, the autumn rice (April to mid-July) is reported to be most affected by whorl maggots, with a peak infestation in the first week of June

(Sasidharan *et al.*, 1979).

The optimum temperature for normal development of this insect was reported to range from 29 and 33°C. Under natural conditions, environments such as ponds, streams, lakes and irrigated rice fields provide a favourable ecological niche for the breeding of the flies (Karim, 1969).

CONTROL MEASURES

Cultural control : As the adult flies are attracted to standing water, draining the water at intervals of 3-4 days during the first 30 days after transplanting was reported to reduces egg laying (Salazar *et al.*, 1993). Drained fields however allow more weeds to grow.

Close planting decreases oviposition and subsequent damage by whorl maggot (Viajante and Heinrichs, 1985b). Therefore, crop establishment method which enable the plants to cover the water surface most rapidly results insignificant damage from whorl maggot. Covering the water surface with azolla and *Salvinia molesta* in Indonesia (Bangun, 1988) helped to prevent infestation. Direct seeded rice fields or seed beds are not highly attractive to adults as compared to transplanted crop. In India, during autumn rice by increasing the plant density and nitrogen level decreasing the *Hydrellia philippina* damage (Yein and Das, 1988). Similarly, in Colombia, Salzar *et al.* (1993) observed that *Hyderellia* sp. Infestation was more in the field with lowest plant density.

Varietal resistance : The rice cultivar IR 40 and the wild rices viz., *Oryzae branchyantha* and *O. ridleuyi* identified as resistant to whorl maggot. In India attempts were made to screeen lines having resistance to *H.philippina* and few culture such as RP 2418-5, RP 2418-10 and RP 2419-3 with 3-5% damaged leaves (Sain and Hakim, 1988), and IR 9209-48-3-2 and UPR 82-1-7, have been identified to be least susceptible to *H.Philippina* in Punjab (Jaswant Singh *et al.*, 1990).

Biological control : Reissig *et al.* (1985), Pathak and Khan (1994) reported that the eggs of the *Hydrellia philippina* are paratized by *Trichogramma* egg parasites and preyed upon by *Dolichopus* sp flies and *Metioche vittaticollis* stal. Eulophid viz., *Tetrastichus* sp. and braconid viz., *Ademon decrescans* (Vayssiere, 1933), *Gyrocampa* spp. (Manjunath, 1978), *Chaenusa* sp. (Natarajan and Mathur, 1980), *Opius* sp. parasitize the whorl maggot larvae. In Latin America, *Opius* could parasitize upto 30 per cent of pupae of *Hydrellia* sp. (Webber *et al.*, 1988). Adult whorl maggot are preyed upon by ephydrid fly *Ochthera brevitibialis* de Meijere and spiders viz., *Oxyopes javanus* (Thorell), *Lycosa pseudoannulata*, Neoscona theisi (Walckenaer). List of natural enemies is given in Table 3.

Table 3 : List of natural enemies which attacked on various stages of *Hydrellia* spp.
(E = eggs, M = maggot, A = adult)

Natural Enemies		References
PARASITES:		
Trichogramma sp.	(E)	Reissig *et al.* (1985)
Dolichopus sp.	(E)	-do-
Tetrastichus sp.	(M)	-do-
Opius sp.	(M)	Webber *et al.* 1988
Gyrocampa spp.	(M)	Manjunath (1978)
Chaenusa sp.	(M)	Natrajan & Mathur (1980)
Ademon decrescens Nees	(M)	Vayssiere (1993)
PREDATORS:		
Metioche vittaticollis Stal	(E)	Reissig *et al.* (1985)
Ochthera brevitabialis (demeejeri)	(A)	-do-
Oxyopes javanus (Thorell)	(A)	-do-
Lycosa pseudoannulata (Boesenberg & strand)	(A)	-do-
Neoscona theisi (walckenaer)	(A)	-do-

Chemical control : Broadcasting of nonsystemic granules on standing water in the fields or soil incorporation of systemic granules before transplanting is usually more effective than foliar insecticides spraying. Foliar insecticides spray can, however, be applied 1 or 2 week after transplanting. However the threshold limit cross 20 per cent damaged plants by whorl maggot within 30 days after transplanting the application of Carbofuran or fenthion granules at the rate of 0.75 kg a.i./ha were found as less effective (Sain, 1991). Single root zone placement coated Carbofuran WP on urea supergranules with either coal tar or neem oil gave an effective control similar to that with 3 broadcast application of carbofuran granules against *Hydrellia philippina* as well as increased the grain yield and found economical its use in pest management (Krishnaiah *et al.*, 1988). Uthamaswamy and Jayaraj (1985) reported that Methomidophos,

fenvelrate and BPMC were most effective against whorl maggot *Hydrellia philippina* when applied foliar spraying above insecticide @ 500 litres per hectare at 20, 40 and 60 DAT. Deltamethrin at 0.012 kg a.i./ha trizophos and azinophos ethyl @ 0.4 kg a.i./ha exhibited ovicidal effect causing 98, 90 and 94 per cent mortality respectively in Philippines (Pantua and Litsinger, 1987). Macatula and Mochida (1987) found that Monocrotophos, MIPC and fenobucarb tested @ 0.3, 0.4 and 0.5 kg a.i./ha could not reduce the incidence of *Hydrellia philippina* below 50 per cent. Neem cake coated urea and coal tar coated urea significantly reduced the incidence of the rice whorl maggot during rice season (David, 1986).

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