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Hydroglyphus pusillus (Fabricius) (Coleoptera Dytiscidae): Its Role as a Mosquito Larvae Predator in Rice Fields (*)

Introduction

Modern rice cultivation practices of the temperate regions still require the semi-permanent flood of rice paddies (Luppi and Finassi, 1992). The artificial aquatic habitat allowed the development of a rich entomofauna, including several mosquito species.

The relation between rice fields and mosquitoes has been known from long time ago when, in Italy, the higher incidence malaria reached in rice growing areas was described (Franchini, 1927; Celli, 1934). The main mosquito species able to exploit Northern Italy rice fields for larval development are: *Ochlerotatus caspius* (Pallas), *Anopheles atroparvus* (Van Thiel), *An. melanoon* (Hackett), *An. messae* (Falleroni), *Culex modestus* (Ficalbi), *Cx. pipiens* (L.) (Zanella, 1996). Locally some other species may be found like *Uranotaenia unguiculata* Edwards, *Cx. impudicus* Ficalbi and *Cx. territans* Walker.

In the rice agroecosystems mosquito larval populations pass through an high natural mortality with only 2-5% of the larvae reaching the adult stage (Mogi, 1984; Mogi *et al.*, 1986; Northup and Washino, 1983; Service, 1977). Mainly predators, both vertebrate and invertebrate, contribute to this drastic impact (Mogi and Miyagi, 1990).

Aquatic insects inhabiting rice fields were studied principally in Asian countries, where rice has enormous economic and social importance. A useful reference on this subject was provided by Yano *et al.* (1983a). Literature on aquatic insects inhabiting paddy fields often deals with water beetles, principally Dytiscidae and Hydrophilidae.

Among quantitatively dominant Dytiscidae it was recorded the genus *Laccophilus*: *Laccophilus minutus* (L.) and *L. variegatus* (Germar) are reported by Moretti (1932)

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from Italian rice fields. *L. parvulus* Aubé and *L. sharpi* Régimbart were reported as dominant species in Philippine paddy fields (Yano *et al.*, 1983b).

Even more frequently the dominant water beetles observed in paddy fields are Dytiscidae of the genus *Hydroglyphus* Motschulsky sensu Biström and Silfverberg (1981) (= *Guignotus* Houlbert, 1934) such as *H. japonicus* (Sharp) in Japan (Ban and Kiritani, 1980; Yano *et al.*, 1983b), *H. signatellus* (Klug) in Egypt (El-Sherif *et al.*, 1976), and *H. flammulatus* (Sharp) in Taiwan (Yano *et al.*, 1983b).

Some medium-size and large Dytiscidae are well known Culicid larvae predators. Adults and larvae of *Rhantus* sp. feed mostly on culicid larvae (Guignot, 1933), sometimes as monophagous predators. Also voracious *Cybister* feed willingly on culicids. In our paddy fields *Hydaticus* sp. larvae were seen attacking mosquito larvae.

Laboratory observations on the efficiency of various mosquito larvae predators showed that adult *Rhantus* sp. have the highest efficiency, followed by Odonata pre-imago stages and Rhynchota Heteroptera, while *Rhantus* larvae were less efficient than adults (Ouda *et al.*, 1986). In a laboratory experiment *Dytiscus marginalis* L. resulted very efficient in preying *Cx. quinquefasciatus* larvae (Nelson, 1977).

On the other hand, very scarce information are available on the predation activity of small Dytiscidae. In snowmelt pools in boreal forests it was shown by Nilsson and Svensson (1995) that small *Hydroporus* are predators of culicid larvae. We found no information in literature on the efficiency of *Laccophilus* and *Hydroglyphus* as mosquito larvae predators.

The aim of this study was to clarify the bio-ecology of *H. pusillus* (Fabricius) particularly in relation to its predatory action against mosquito larvae in rice agroecosystem.

Materials and Methods

The observations were conducted in the rice fields of the Ferrara province during the years 1996-1998, regarding four rice farms: "Pierina" (Torbiera di Codigoro-FE), "Agripadana" (Jolanda di Savoia-FE), "Le Contane" (Le Contane di Jolanda di Savoia-FE), "Società di Bonifica Terreni Ferraresi" (Cisi di Jolanda di Savoia-FE).

For each year of study samplings were performed be-weekly during the entire rice growing season, from May to September (dates vary according with agronomic practices).

During the first year of study sampling stations were planned in the number of 8 for singular rice paddy: 4 on the rice paddy perimeter (approximately at the middle of each paddy side), and 4 inside the rice paddy (on a transept going from one side to the opposite). In 1997-98 the number of sampling stations per rice paddy was doubled (8 on the perimeter plus 8 on internal transept).

During the entire investigation period 1996-1998 we sampled 12 paddy fields, collecting a total of 1,568 samples, as shown in Tab. 1.

Samples were collected by an aquatic net of 12 cm diameter made with gauze

of narrow mesh (1 mm), kept in the water close to the surface and rapidly moved for about 50 cm. Collected organisms were gently washed with clear water in a plastic pan, specimens were collected and placed in alcohol for further identification.

During field observations focused on aquatic animal behaviour we were able to notice the attack events by *H. pusillus* on *Oc. caspius* larvae. Several field observations were then conducted to collect more information on the predation activity of this species.

In August 1999 a laboratory experience was settled to collect quantitative data on the predation capability of the Dytiscid on *Cx. pipiens* larvae.

300 *H. pusillus* adults were collected in rice fields of "Pierina" farm, and transferred in aquarium (52.5 x 26 cm x 31 cm height) containing 35 litres rice-field water at laboratory temperature (22-28 °C).

After 48 h starvation, 50 *Cx. pipiens* field collected larvae (III-IV instars) were added in the aquarium. Starting the following day, and for 6 times at 1-2 days interval, mosquito larval presence was checked and 50 new collected larvae supplied.

Tab. 1 - Rice paddies sampled during the three-years period 1996-98

Years	N.paddies	Name	N.samples
1996	4	"Traversini", "Ballonara", "Ducale II Est", "Ducale II Ovest"	160
1997	3	«Traversini», «Ducale II Est», «Ducale II Ovest»	344
1998	5	«Ducale II Est», Ducale II Ovest», «Brusabò II», «Antanelle», «405»	1064
Total			1568

Results and Conclusions

The water beetles collected and their relative abundance are listed in a decreasing order in Table 2.

Considering only the adults, *H. pusillus* resulted the dominant water beetle in Ferrara rice fields, representing 75-90% of the collected specimens. *B. spinosus* and *L. minutus* showed also a good adaptation to rice fields environment. Other species seems much more rare or restricted to certain micro-environment.

Larval density showed a noticeable different species composition: larvae of *Hydroglyphus* resulted absent, while larvae of *Laccophilus* were dominant followed by *Coelambus* and *Coelostoma* larvae.

Such a discrepancy could be explained by the different behaviour between *Hydroglyphus* larvae and adults. While adults largely move in the water column and therefore may be easy to collected by dipper or aquatic net tools, larvae prefer to stay on the bottom resulting difficult to catch with these techniques (De Marzo, personal communication).

Water beetles seasonal population dynamic largely depends on paddies and years.

Tab. 2. - Beetle species collected during the investigations (total number individuals sampled and in parenthesis % on the total of the year).

Adults

Species	1996	1997	1998
Hydroglyphus pusillus (Fabricius)	322 (80.3)	2228 (90.2)	3410 (74.6)
Berosus spinosus (Steven)	12 (3.0)	52 (2.1)	482 (10.5)
Laccophilus minutus (L.)	51 (12.7)	128 (5.2)	270 (5.9)
Enochrus quadripunctatus (Thoms)	5 (1.2)	27 (1.1)	107 (2.3)
Helochares lividus (Forst)	1 (0.2)	16 (0.6)	81 (1.8)
Laccophilus variegatus (Germar)	0	0	82 (1.8)
Spercheus emarginatus (Schaller)	5 (1.2)	8 (0.3)	60 (1.3)
Haliplus ruficollis (De Geer)	0	10 (0.4)	34 (0.7)
Noterus clavicornis (De Geer)	0	0	40 (0.9)
Hydrous piceus (L.)	0	0	8 (0.2)
Enochrus melanocephalus (Oliv.)	3 (0.7)	0	0
Limnebius furcatus (Baudi)	2 (0.5)	0	1
Coelostoma sp. Brullé	0	0	1

Larvae

Species	1996	1997	1998
Laccophilus Leach sp.	123 (74.5)	204 (55.0)	949 (58.9)
Coelambus impressopunctatus (Schaller)	0	27 (7.3)	388 (24.1)
Coelostoma Brullé sp.	15 (9.1)	76 (20.5)	129 (8.0)
Spercheus emarginatus (Schaller)	13 (7.9)	40 (10.8)	96 (6.0)
Hydaticus Leach sp.	12 (7.3)	15 (4.0)	39 (2.4)
Berosus spinosus (Steven)	2 (1.2)	0	5 (0.3)
Acilius sp. Leach	0	7 (1.9)	0
Rhantus suturalis pulverosus (Stephens)	0	2 (0.5)	1 (0.1)
Haliplus ruficollis (De Geer)	0	0	2 (0.1)
Hydroporus planus (Fabricius)	0	0	2 (0.1)
Hydrous piceus (L.)	0	0	1 (0.1)

As a representative example in Fig.I we report the data related to a rice field which has been regularly sampled during the three years period.

Water beetles were able to colonise rice fields early in the season just following the initial flooding of mid April. In June populations densities increased showing fluctuations mainly related to agronomic droughts. In particular *H. pusillus* reached the highest densities in July-August showing a rapid recovery of the population density following the droughts.

As absolute values the observed densities have to be considered of main importance on the regulation of mosquito larval population which, as a rough comparison, rarely reaches similar densities.

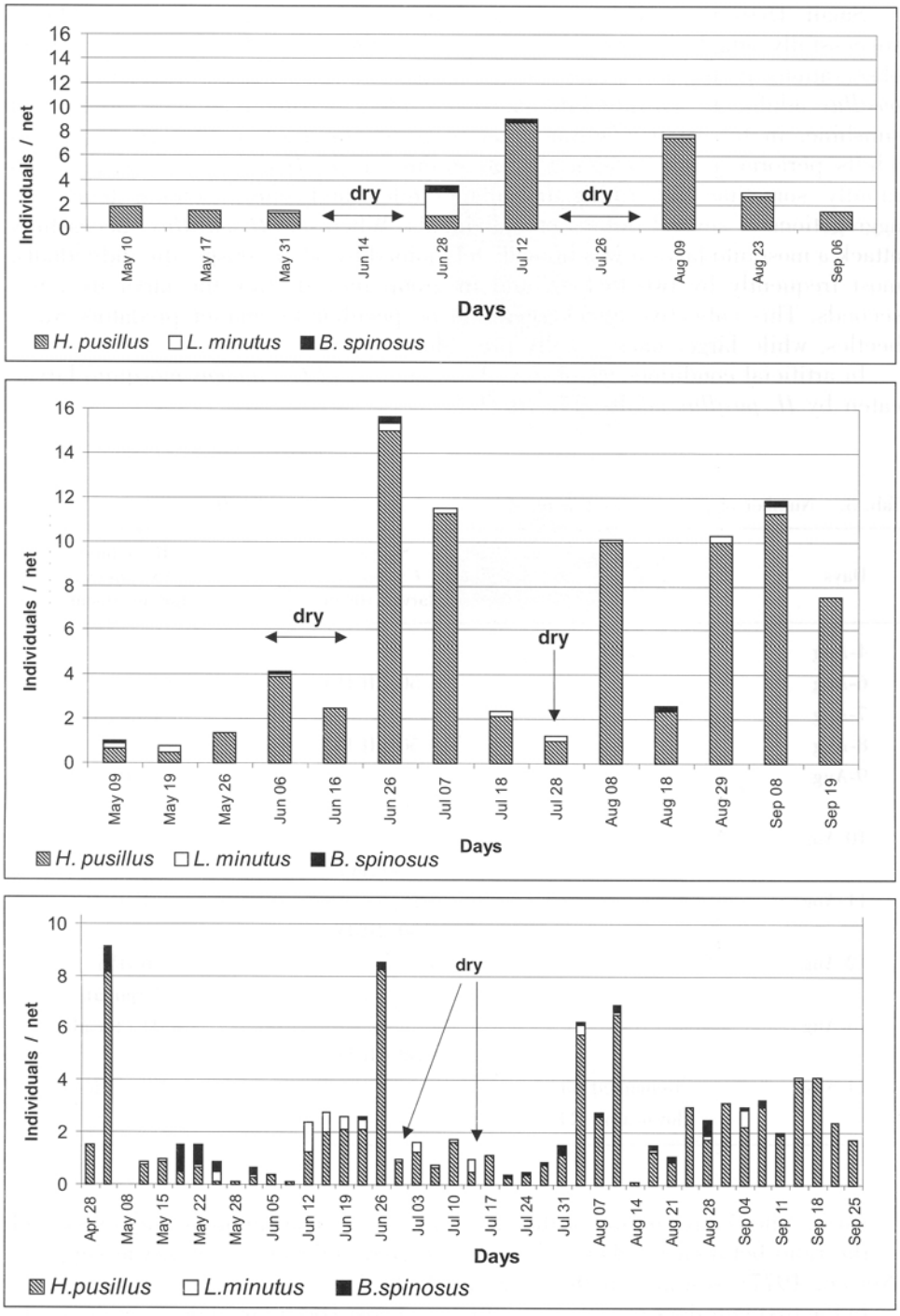

Fig. I. - Seasonal dynamic of the main beetle adult species in the rice paddy Ducale II Est (Codigoro - Ferrara) during 1966, 1997, 1998 from top to bottom. Dry means there was no water on the surface of the paddy, but some could be present in the hedge ditches.

Small Dytiscidae such as *Hydroglyphus* may be regarded as unable to successfully attack mosquito larvae, owing to their size. On the contrary, field observations in flooded paddy fields showed an extraordinary efficiency of *H. pusillus* adults as mosquito predators. At their maximum activity, under full sunshine, in the shallow warm water of paddy fields, hundreds *Hydroglyphus* adults perform a real slaughter of mosquito larvae. *Hydroglyphus* adults swim rapidly sometime describing irregular circles and often forming temporary aggregations of several dozens of individuals. When one *H. pusillus* successfully attack a mosquito larva it was immediately joined by other conspecific individuals, most frequently by two to four, and in group they destroy the larva in a few seconds. This collective attack seems to be peculiar to smaller predators water beetles, while larger ones usually prey alone.

In artificial conditions we observed the number of *Cx. pipiens* mosquito larvae eaten by *H. pusillus* adults (Fig. II, Tab. 3).

Tab. 3. - Number of prey provided at regular intervals and consumed by *H. pusillus*.

Days	*H. pusillus* Individuals	Supplied *Cx. pipiens* larvae (instar)	Remained *Cx. pipiens* larvae (instar)
4-Aug	300		
6-Aug		50 (III-IV)	
7-Aug			1 (pupa)
8-Aug		50 (III-IV)	
9-Aug			0
		50 (III-IV)	
10-Aug			0
		50 (IV)	
11-Aug			1 (IV)
		50 (III-IV)	
12-Aug			6 (IV)
			1 (pupa)
13-Aug			5 (IV) (dead)
		50 (III-IV)	
14-Aug	Remained 55		5 (IV) (4 dead)
	Flown away 245		

During the 8 days period of the observations, the consumption rate, expressed by the ratio between number of larvae destroyed and number of larvae supplied (Nelson, 1977), resulted in the range 86-100%.

In the first four days predation resulted in almost 100% larval destruction, while in the second part of the experiment mosquito mortality slightly decreased. This was probably due to the strong dispersal tendency of *H. pusillus* which escaped in

Fig. II. - *Hydroglyphus pusillus* adults preying on *Culex pipiens* fourth instar larva.

large number from the aquarium. No dead beetles were found during the experiment.

In the last days we were able to observe several dead larvae, apparently killed by the beetles, but not eaten.

From our observations it seems that *H. pusillus* play an important role as a mosquito larvae predator in North-East Italy rice fields. It results well adapted to rice field ecological conditions, it has a strong tendency to disperse thus rapidly colonising just-flooding rice paddies and moving from rice paddies during agronomic drought, it also has a good capability to prey on mosquito larvae.

It is, therefore, important to investigate the biological traits of this species to understand its ecological needs considering the possibility to introduce agronomic practices aimed at the conservation and increase of its populations.

SUMMARY

Northern Italy rice fields are important breeding sites for several noxious mosquito species: *Ochlerotatus caspius* (Pallas), *Anopheles atroparvus* (Van Thiel), *An. melanoon* (Hackett), *An. messae* (Falleroni), *Culex modestus* (Ficalbi), *Cx. pipiens* (L.).

Mosquito larvae in rice fields support high natural mortality largely due to predatory action. Among predators, several species of Dytiscidae resulted well adapted to rice field habitat of North-eastern Po valley. *Hydroglyphus pusillus* (Fabricius) is the most abundant species during the whole season and it was observed actively preying on *Oc. caspius* larvae. In aquarium experiments we confirmed the predatory ability of this species against third and fourth instar *Cx. pipiens* larvae.

KEY WORDS: *Hydroglyphus pusillus*, Dytiscidae, predator, Culicidae, rice, Italy.

Hydroglyphus pusillus (Fabricius) (Coleoptera Dytiscidae): importanza quale predatore di larve di zanzare in risaia

RIASSUNTO

Le risaie del Nord Italia sono sede di sviluppo per diverse specie di zanzare nocive: *Ochlerotatus caspius* (Pallas), *Anopheles atroparvus* (Van Thiel), *An. melanoon* (Hackett), *An. messae* (Falleroni), *Culex modestus* (Ficalbi), *Cx. pipiens* (L.).

Le larve di zanzara sono soggette in risaia a mortalità molto elevate dovute perlopiù all'azione dei predatori. Tra questi i Coleotteri Ditiscidi risultano particolarmente ben adattati all'ambiente di risaia nel Ferrarese. Tra le diverse specie rinvenute in risaia *Hydroglyphus pusillus* (Fabricius) oltre ad essere la specie largamente più abbondante per l'intera stagione è stata osservata attaccare larve di *Oc. caspius*. Prove condotte in acquario hanno confermato la buona capacità predatrice di questa specie nei confronti delle larve di terza e quarta età di *Cx. pipiens*.

PAROLE CHIAVE: *Hydroglyphus pusillus*, Dytiscidae, predatore, Culicidae, riso.

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