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RICE FIELDS AS A HOT SPOT OF WATER BEETLES (COLEOPTERA ADEPHAGA AND POLYPHAGA)

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Lupi D., Jucker C., Rocco A. – Rice fields as a hot spot of water beetles (Coleoptera Adephaga and Polyphaga).

The study is representative of wetlands subjected to strong anthropogenic impact as rice fields are. The aquatic Coleoptera have been collected monthly from channels, rice fields and a natural spring for one year, resulting in 31 species belonging to 8 families (Brachyceridae, Dytiscidae, Dryopidae, Elmidae, Gyrinidae, Haliplidae, Helophoridae, Hydrophilidae) which have been identified, 19 of which in rice paddies. The comparison of paddies subjected to different anthropogenic impacts shows that the flooding period is only one of the factors influencing the community of water beetles. Important information on the occurrence of the species during the year is also provided and adds to the few knowledge present in the literature. All the data, as well as the detection of vulnerable and rare species, evidence that rice agro-ecosystems are essential for the exploitation of water beetle biodiversity in areas densely colonized, industrialized and cultivated, where wetlands has strongly reduced over the last centuries.

KEY WORDS: faunistic study, rice agro-ecosystem, wetland, biodiversity.

INTRODUCTION

The order Coleoptera comprises approximately 5,000 species which are adapted to an aquatic existence all over the world, and are able to colonize all environments from sea water to freshwater ponds (ELLIOT, 2008; JÄCH and BALKE, 2008; AUDISIO and VIGNA TAGLIANTI, 2010). It is known that they constitute an important part of the macrobenthos of freshwater habitats and chiefly include predators of aquatic invertebrates and small vertebrates, but also algivores and detritivores, consumers of filamentous algae and herbivores of vascular plants (FAIRCHILD *et al.*, 2000; MOTTA and UIEDA, 2004).

Among the three Coleoptera suborders comprising aquatic representatives [Myxophaga (nearly 90% aquatic), Adephaga (approximately 18% aquatic), and Polyphaga (approximately 1.25% aquatic)], only Adephaga and Polyphaga aquatic beetles are present in Italy. In detail these families are Dytiscidae, Gyrinidae, Haliplidae, Hygrobiidae, and Noteridae (among the Adephaga) and Dryopidae, Elmidae, Helophoridae, Hydraenidae, Hydrochidae, Hydrophilidae, Psephenidae, Scirtidae, Spercheidae (among the Polyphaga) which are regarded as mainly aquatic. In addition, there are species living in or in close association with freshwater habitats also in families with the majority of their members exclusively terrestrial (JÄCH and BALKE, 2008).

The ability of water beetles to reach a great diversity in lentic habitats such as wetlands and pond margins is favored by the aptitude of many adults to leave the habitat in which they live in search of mate or more adapt conditions (BOUCHARD, 2004). However, in densely colonized, industrialized and cultivated areas such as northern Italy, wetlands have been replaced by rice agro-ecosystems, the agricultural transformation of natural temporary ponds (FASOLA *et al.*, 2003; LUPI *et al.*, 2012). YANO *et al.* (1983) in their review on the biodiversity of Coleoptera in rice fields, examined the studies published on water beetle communities all over the world and recorded a total of 117 species, reporting data on the Italian literature that are much outdated (MORETTI, 1932; SUPINO, 1932; GOIDANICH, 1943; MORONI, 1961). Only a few articles in the Italian literature add information to this review (BELLINI *et al.*, 2000; CALDARA *et al.*, 2004). Actually, 32 taxa are found associated to rice paddies, but often the more detailed classification is lacking (Table 1).

The principal aim of this work was to update faunistic information on water beetle community of some rice agro-ecosystem considered representative of northern Italy rice habitats, emphasizing the biology and the relationships between water beetles living in channels and in rice fields subjected to different anthropogenic impacts.

METHODS

Water beetles were collected once a month (from March 2010 to February 2011) in 4 different stations in Pavia Province, in an area belonging to the Po river basin historically cultivated with rice. The area has an altitude of 100 m and is characterized by a temperate subcontinental climate (PINNA, 1978). The habitats considered were the rice fields, which are handled with different management strategies (Station 1-4), their adjacent channels (Station 1-4), and one natural spring (Station 3) making a total of 9 sites (Table 2).

In each station a sample of approximately 1,500 cc of sediment per habitat was collected in the presence of water. A pond net (30×30 cm, 300 µm mesh size) was used to allow the collection of the adults that normally

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Table 1 – Water beetles from paddy fields in Italian literature.

Species	Family	Moretti 1932	Supino 1932	Gôidanich 1943	Moroni 1961	Bellini *et al.* 2000	Caldara *et al.* 2004
Acilius sp.	Dytiscidae	-	-	-	-	X	-
Coelambus impressopunctatus (Schaller, 1783)	Dytiscidae	-	-	-	-	X	-
Cybister sp.	Dytiscidae	-	X	-	-	-	-
Cybister lateralimarginalis (De Geer, 1774)	Dytiscidae	X	-	X	-	-	-
Dytiscus sp.	Dytiscidae	-	X	-	-	-	-
Dytiscus marginalis Linnaeus, 1758	Dytiscidae	X	-	X	-	-	-
Hydaticus sp.	Dytiscidae	-	-	-	-	X	-
Hydroglyphus geminus (Fabricius, 1792)	Dytiscidae	-	-	-	X	X	-
Hydroporus planus (Fabricius, 1781)	Dytiscidae	-	-	-	-	X	-
Ilybius fuliginosus (Fabricius, 1792)	Dytiscidae	X	-	-	-	-	-
Laccophilus minutus (Linnaeus, 1758)	Dytiscidae	X	-	-	X	X	-
Laccophilus poecilus Klug, 1834	Dytiscidae	X	-	-	-	X	-
Rhantus suturalis (MacLeay, 1825)	Dytiscidae	-	-	-	-	X	-
Gyrinus sp.	Dytiscidae	-	X	-	-	-	-
Gyrinus natator (Linnaeus, 1758)	Gyrinidae	X	-	-	-	-	-
Gyrinus urinator Illiger, 1807	Gyrinidae	X	-	-	-	-	-
Haliplus sp.	Haliplidae	-	X	-	-	-	-
Haliplus lineatocollis (Marsham, 1802)	Haliplidae	X	-	-	-	-	-
Haliplus ruficollis (De Geer, 1774)	Haliplidae	-	-	-	-	X	-
Noterus sp.	Noteridae	-	X	-	-	-	-
Noterus clavicornis (De Geer, 1774)	Noteridae	X	-	-	-	X	-
Lissorhoptrus oryzophilus Kuschel, 1952	Brachyceridae	-	-	-	-	-	X
Limnebius furcatus Baudi, 1872	Hydraenidae	-	-	-	-	X	-
Berosus spinosus (Steven, 1808)	Hydrophilidae	-	-	-	-	X	-
Coelostoma sp.	Hydrophilidae	-	-	-	-	X	-
Enochrus melanocephalus (Olivier, 1792)	Hydrophilidae	-	-	-	-	X	-
Enochrus quadripunctatus (Herbst, 1797)	Hydrophilidae	-	-	-	-	X	-
Helochares lividus (Forster, 1771)	Hydrophilidae	-	-	-	-	X	-
Hydrochus elongatus (Schaller, 1783)	Hydrophilidae	X	-	-	-	-	-
Hydrophilus sp.	Hydrophilidae	-	X	-	-	-	-
Hydrophilus piceus (Linnaeus, 1758)	Hydrophilidae	X	-	X	-	X	-
Spercheus emarginatus (Schaller, 1783)	Hydrophilidae	-	-	-	-	X	-

hide among dense vegetation, stones and detritus. This operation was executed by netting and shaking the bottom at random along a transect through the habitat considered. Water temperature was measured with a multi-probe field meter (Geotech WTW 3400i Multi-Parameter Field Meter; Geotech Environmental Equipment Inc., Denver, CO, USA) in each locality at each sampling date. The samples were transported to DeFENS laboratory (University of Milan), where the sediment was rinsed using a 0.5 mm mesh sieve to isolate adult water beetles. The specimens were separated into different families, labeled, and conserved in ethyl alcohol 75% until identification to species level. Insects were then classified using a stereomicroscope (Leica MZ 12.5, Leica Microsystems GmbH, Wetzlar, Germany; and Wild Heerbrugg M5A, Leica Geosystems Gmbh, Heerbrugg, Switzerland) with the aid of different taxonomic keys (Kuschel, 1951; Balfour – Browne, 1953; Young, 1963; Everett and Newsom, 1964; Olmi, 1978; Franciscolo, 1979; Holmen, 1987; Friday, 1988; Nilsson and Holmen, 1995; Larson *et al.*, 2000; Incekara *et al.*, 2005; Przewozny and Buczynski, 2008; Topkara, 2008; Mart *et al.*, 2010; Malekpour and Shiva, 2011). The scientific nomenclature of De Jong (2011) was adopted for this study. As male genitalia provide very important diagnostic characteristic, males were identified and separated. The aedeagus was extracted through the basal foramen, through the opening between the last dorsal and ventral plates, or by removing the last segment or the abdomen at the base. It was then placed onto a piece of paper tissue and studied in dry conditions. Afterwards the genitalia were mounted with entomological glue onto the same card as the beetle. For Elmidae and Dryopidae a different procedure was adopted: the abdomen was dissected and placed into 10% hot potassium hydroxide for 10 minutes to soften the sclerites; the aedeagus was then rinsed in distilled water. It was then removed and fixed on a slide with Faure's fluid to allow microscopic observation (Leitz Wetzlar SM-LUX, Leica Microsystems GmbH, Wetzlar, Germany).

Table 2 – Station descriptions

Stations	Coordinates	Habitat*	Water presence	Details
1 Trovo	45° 14'86N; 9° 01' 34E	R1	2 months	Dry seeded and flooded after 40 days
		C1	12 months	Smooth flow
2 Bereguardo	45° 16'09N; 9° 02' 16E	R2	4 months	Water seeded
		C2	12 months	Smooth flow
3 Zeme Loja	45° 12'42N; 8° 38' 44E	R3	4 months	Water seeded
		C3	12 months	Smooth flow
		S3	12 months	Spring forming a channel; rippled flow
4 Zeme Zanaglia	45° 11'74N; 8° 38' 25E	R4	11 months	Water seeded
		C4	12 months	Smooth flow

*R1, rice field 1; C1, channel 1; R2, rice field 2; C2, channel 2; R3, rice field 3; C3, channel 3; S3, spring 3; R4, rice field 4; C4, channel 4.

Species phenology

The occurrence of the different species during the year is summarized in a table and only the species captured more frequently (more than 50 specimens) were studied in detail. Differences among the months and the habitat have been evaluated. Considering the high number of specimens of *Hydroglyphus geminus* (Fabricius, 1792)collected, ANOVA was applied to compare different stations using the software package SPSS® Statistic (Version 19 for Windows, SPSS Inc. Chicago, Il, USA).

Biodiversity indices

Dominance index (Di) was applied to evaluate the species dominance in the habitats considered (Tischler, 1949; Heydemann, 1955). In each habitat the species were classified in relation to their percentage against the entire range as subrecedent (Di < 1.0%), rare recedent (1.0% < Di < 2.0%), fairly numerous subdominant (2.0% < Di < 5.0%), numerous dominant (5.0% < Di < 10.0%), very numerous eudominant (Di > 10.0%).The classic Sørensen similarity index, based on the presence/absence of species in paired samples, and the modified version of Chao *et al.* (2005) based on species abundance, were then applied to evaluate the same habitat in different stations and to compare channel and rice paddies in the same place.

Feeding habits

The species were listed considering adult and larval feeding habits according to the literature available. As different terminology was used by diverse authors, each species was assigned to a trophic group according to Merritt and Cummins (1996): predators, herbivores, omnivores and others (including algivores, detritivores and scavengers).

Ecological information

Ecological information on each family was summarized. For each species the following data were provided: identification keys adopted, dimensional variability (expressed as length), ecology and biology according to the literature available, the habitat (rice paddies/channels/spring), the date of capture and the number of individuals.

RESULTS

A total of 2,228 adult water beetles were collected during the period of study. Water beetles belonging to 31 species placed in 8 families were identified: Brachyceridae (1 species), Dytiscidae (12 species), Dryopidae (1 species), Elmidae (1 species), Gyrinidae (1 species), Haliplidae (6 species), Helophoridae (1 species), Hydrophilidae (8 species). Ten species were already recorded for Italian rice areas: Dytiscidae (4 species), Haliplidae (1 species), Brachyceridae (1 species) and Hydrophilidae (4 species) (Table 3). Among the species found, 28 were collected in channels, 19 in rice fields and 13 in the natural spring. The following species can be classified in relation to their ability to colonize different environments:

– species capable to adapt to all the habitats considered: *Berosus frontifoveatus* Kuwert, 1888, *Berosus signaticollis* Charpentier, 1825, *Enochrus quadripunctatus* (Herbst, 1797), *Hydroglyphus geminus* (Fabricius, 1792), *Haliplus heydeni* Wehncke, 1875, *Laccobius minutus* (Linnaeus, 1758), *Laccophilus hyalinus* De Geer, 1774, *Laccophilus poecilus* Klug, 1834, *Lissorhoptrus oryzophilus* Kuschel, 1952.
– species found only in two habitats: *Dryops luridus* (Erichson, 1847), *Helophorus brevipalpis* Bedel 1881, *Helochares lividus* (Forster, 1771), *Hydrophilus piceus* (Linnaeus, 1758), *Hygrotus impressopunctatus* (Schaller, 1783), *Laccophilus minutus* (Linnaeus, 1758), *Peltodytes caesus* (Duftschmid, 1805), *Rhantus suturalis* (MacLeay, 1825) (in channels and in rice paddies) and *Haliplus lineaticollis* (Marsham, 1802) (in channels and in natural spring).
– species found in one habitat only: *Agabus guttatus* (Paykull, 1798), *Haliplus flavicollis* Sturm, 1834, *Haliplus laminatus* (Schaller, 1783), *Hydaticus grammicus* (Germar, 1830), *Hydroporus marginatus* Duftschmid, 1805, *Hydrovatus cuspidatus* Kunze, 1818, *Hygrotus inaequalis* (Fabricius, 1776), *Ilybius chalconatus* (Panzer, 1796), *Limnius volkmari* (Panzer, 1793) (in channels); *Enochrus melanocephalus* (Olivier, 1792), *Haliplus fulvus* (Fabricius, 1801) (in rice paddies); *Aulonogyrus concinnus* (Klug, 1834), *Hydrochara caraboides* (Linnaeus, 1758) (in natural spring).

Vulnerable and rare species of Coleoptera were also

Table 3 – List of species collected, number of sites of detection, and species phenology (from March 2010 to February 2011).

	Species	Already known in literature	Number of sites	Number of adults	Months											
					III	IV	V	V	VII	VIII	IX	X	XI	XII	I	II
Dytiscidae	*Agabus guttatus* (Paykull, 1798)		1/9	1	0	0	0	0	1	0	0	0	0	0	0	0
	Hydaticus grammicus (Germar, 1830)		2/9	3	0	0	0	1	0	0	2	0	0	0	0	0
	Hydroglyphus geminus (Fabricius, 1792)	*	9/9	1,682	28	23	27	27	275	515	324	165	11	18	101	168
	Hydroporus marginatus (Duftschmid, 1805)		1/9	1	0	1	0	0	0	0	0	0	0	0	0	0
	Hydrovatus cuspidatus Kunze, 1818		1/9	1	0	0	0	1	0	0	0	0	0	0	0	0
	Hygrotus impressopunctatus (Schaller, 1783)		4/9	6	0	1	0	0	2	1	1	1	0	0	0	0
	Hygrotus inaequalis (Fabricius, 1776)		1/9	1	0	0	0	0	0	0	1	0	0	0	0	0
	Ilybius chalconatus (Panzer, 1796)		2/9	2	0	0	0	2	0	0	0	0	0	0	0	0
	Laccophilus hyalinus De Geer, 1774		6/9	9	0	0	0	3	4	2	0	0	0	0	0	0
	Laccophilus minutus (Linnaeus, 1758)	*	8/9	66	0	0	1	1	5	7	13	5	26	1	4	3
	Laccophilus poecilus Klug, 1834	*	5/9	27	0	0	0	10	0	3	9	3	0	0	0	2
	Rhantus suturalis (MacLeay, 1825)	*	5/9	7	0	0	3	0	0	0	1	2	0	0	0	1
Gyrinidae	*Aulonogyrus concinnus* (Klug, 1834)		1/9	10	0	0	10	0	0	0	0	0	0	0	0	0
Haliplidae	*Haliplus flavicollis* Sturm, 1834		1/9	1	0	0	0	0	0	0	1	0	0	0	0	0
	Haliplus fulvus (Fabricius, 1801)		7/9	24	0	0	7	6	6	4	1	0	0	0	0	0
	Haliplus heydeni Wehncke, 1875		6/9	52	0	0	4	11	16	6	2	6	2	0	1	4
	Haliplus laminatus (Schaller, 1783)		1/9	1	0	1	0	0	0	0	0	0	0	0	0	0
	Haliplus lineaticollis (Marsham, 1802)	*	3/9	5	0	2	2	0	0	0	0	0	0	0	0	1
	Peltodytes caesus (Duftschmid, 1805)		3/9	6	0	0	1	0	2	0	0	0	1	0	0	2
Brachyceridae	*Lissorhoptrus oryzophilus* Kuschel, 1952	*	9/9	78	0	0	8	21	16	11	19	0	0	0	0	3
Dryopidae	*Dryops luridus* (Erichson, 1847)		8/9	61	0	0	0	1	9	40	11	0	0	0	0	0
Elmidae	*Limnius volckmari* (Panzer, 1793)		1/9	2	0	0	0	0	0	1	1	0	0	0	0	0
Helophoridae	*Helophorus brevipalpis* Bedel 1881		4/9	13	0	0	11	1	0	0	0	0	0	0	0	1
Hydrophilidae	*Berosus frontifoveatus* Kuwert, 1888		8/9	37	1	2	4	0	2	3	2	22	0	0	0	1
	Berosus signaticollis Charpentier, 1825		8/9	36	0	3	6	3	0	5	4	12	1	0	0	2
	Enochrus melanocephalus (Olivier, 1792)	*	3/9	4	0	0	0	0	1	2	1	0	0	0	0	0
	Enochrus quadripunctatus (Herbst, 1797)	*	8/9	48	0	3	12	3	5	14	8	2	0	1	0	0
	Helochares lividus (Forster, 1771)	*	6/9	17	0	3	1	4	2	2	2	0	0	0	0	3
	Hydrochara caraboides (Linnaeus, 1758)		1/9	1	0	0	0	0	1	0	0	0	0	0	0	0
	Hydrophilus piceus (Linnaeus, 1758)	*	3/9	6	0	1	0	0	0	1	2	2	0	0	0	0
	Laccobius minutus (Linnaeus, 1758)		6/9	20	0	8	1	1	6	1	0	3	0	0	0	0
Total				2,228	4	11	15	16	16	17	19	11	5	3	3	10

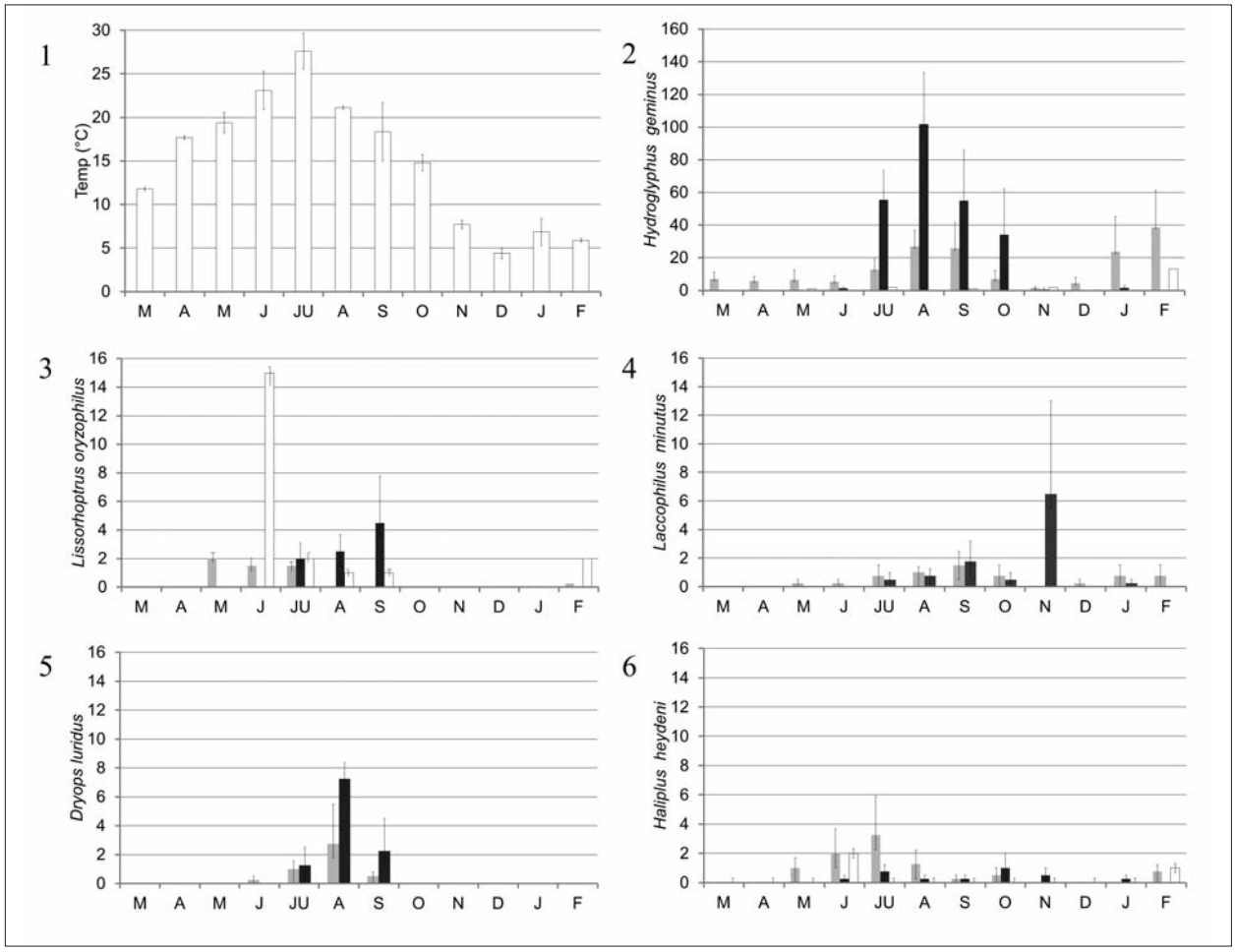

Fig. I – Measurements of water temperature (1) and phenology of the most abundant species collected in channels (grey bars), natural spring (white bars) and in rice fields (black bar) (2-6) from March 2010 until February 2011 (mean ± standard error).

found, the Hydrophilidae *B. frontifoveatus, H. piceus* and *H. caraboides* are classified as vulnerable species and in the Dytiscidae *H. grammicus* is a rare species (RUFFO and STOCH, 2005). All the rare and vulnerable species collected together with the following species are considered bio-indicators according to RUFFO and STOCH (2005): *D. luridus, E. melanocephalus, E. quadripunctatus, H. flavicollis*, *H. fulvus, H. cuspidatus*, *H. impressopunctatus*, *H. inaequalis, L. volkmari*. The presence of the majority of these species in rice paddies is remarkable.

SPECIES PHENOLOGY

There was a clear difference in specimen abundance between the stations, the sites and the months.

Twelve species were active also in colder months when water temperature stayed below 10°C (Table 3 and Fig. I.1). Figure I (2-6) illustrates the trend of the captures in channels and rice fields of the most abundant species: *H. geminus, L. oryzophilus*, *Laccophilus minutus*, *D. luridus*, *H. heydeni*. *Hydrogliphus geminus,* covering 75% of the beetles collected with 1,682 adults was also the most detected species in rice fields with 1,000 specimens sampled. The adults of the species were captured throughout the year and peaked in channels during winter (January and February) and in summer and autumn (from July to October) in the rice paddies. *Lissorhoptrus oryzophilus* captures reflect its strict preference for the rice plant as food: the insect was found active from April until September, in channels and in the natural spring before and after rice emergence. *Laccophilus minutus* captures were constant during the year, except for November when collection peaked in rice fields and March-April when no specimen was found. *Driops luridus* was active from June until September with a peak in August in the rice fields. *Haliplus heydeni* collections were constant during the whole year with the exceptions of December, March and April when no specimens were detected. Statistical analysis on *H. geminus* evidenced no differences between the stations (Levene's test F = 1.473; df = 3; P = 0.235; ANOVA F = 1.103; df = 3; P = 0.358).

BIODIVERSITY INDICES

Table 4 lists the classification of the species according to their Dominance index values (Di). Subrecedent and recedent species represented 82% of the ones collected in channels, 74% of the ones in rice fields and 61% of the ones in the spring. In the subrecedent group the following species were found in both channels and rice fields: *H. piceus* ($Di_{channels}$= 0.337, Di_{rice}= 0.241), *H. impressopunctatus* ($Di_{channels}$= 0.449, Di_{rice}= 0.160), *L. hyalinus* ($Di_{channels}$= 0.673, Di_{rice}= 0.160), *P. caesus* ($Di_{channels}$= 0.449, Di_{rice}= 0.160), and *R. suturalis* ($Di_{channels}$= 0.561,

Table 4 – Species dominance in the different habitats: channels, rice fields and natural spring

	Channels	Rice fields	Spring
Eudominant	*Hydroglyphus geminus*	*Hydroglyphus geminus*	*Aulonogyrus concinnus* *Hydroglyphus geminus* *Lissorhoptrus oryzophilus*
Dominant	–	–	–
Subdominant	*Enochrus quadripunctatus* *Haliplus heydeni* *Lissorhoptrus oryzophilus* *Laccophilus minutus*	*Berosus frontifoveatus* *Dryops luridus* *Laccophilus minutus* *Lissorhoptrus oryzophilus*	*Haliplus heydeni* *Laccobius minutus*
Recedent	*Dryops luridus* *Berosus frontifoveatus* *Berosus signaticollis* *Haliplus fulvus* *Helophorus brevipalpis* *Helochares lividus* *Laccobius minutus* *Laccophilus poecilus*	*Berosus signaticollis* *Enochrus quadripunctatus* *Haliplus heydeni*	*Berosus frontifoveatus* *Berosus signaticollis* *Haliplus fulvus* *Enochrus quadripunctatus* *Haliplus lineaticollis* *Hydrochara caraboides* *Laccophilus hyalinus* *Laccophilus poecilus*
Subrecedent	*Agabus guttatus* *Haliplus laminatus* *Haliplus lineaticollis* *Haliplus flavicollis* *Hydaticus grammicus* *Hydrophilus piceus* *Hydroporus marginatus* *Hydrovatus cuspidatus* *Hygrotus impressopunctatus* *Hygrotus inaequalis* *Ilybius chalconatus* *Laccophilus hyalinus* *Limnius volckmari* *Peltodytes caesus* *Rhantus suturalis*	*Enochrus melanocephalus* *Haliplus fulvus* *Helophorus brevipalpis* *Helochares lividus* *Hydrophilus piceus* *Hygrotus impressopunctatus* *Laccophilus hyalinus* *Laccobius minutus* *Laccophilus poecilus* *Peltodytes caesus* *Rhantus suturalis*	–

Eudominant (Di > 10.0%); dominant (5.0% < Di < 10.0%); subdominant (2.0% < Di < 5.0%); recedent (1.0% < Di < 2.0%); subrecedent (Di < 1.0%).

Di_{rice}= 0.160). Similarly *B. signaticollis* was a recedent species in all the habitats considered ($Di_{channels}$= 1.459, Di_{rice}= 1.764, Di_{spring}= 1.587). The following species were included in different groups according to the habitat: *B. frontifoveatus* ($Di_{channels}$= 1.010, Di_{rice}= 2.245, Di_{spring} =1.587), *D. luridus* ($Di_{channels}$= 2.020, Di_{rice}= 3.448), *E. quadripunctatus* ($Di_{channels}$= 2.694, Di_{rice}= 1.844, Di_{spring}= 1.587), *H. fulvus* ($Di_{channels}$= 1.908, Di_{rice}= 0.481), *H. heydeni* ($Di_{channels}$= 4.040, Di_{rice}= 1.043, Di_{spring}= 4.762), *H. lividus* ($Di_{channels}$= 1.571, Di_{rice}= 0.481), *H. brevipalpis* ($Di_{channels}$= 1.347, Di_{rice}= 0.241), *Laccobius minutus* ($Di_{channels}$= 1.459, Di_{rice}= 0.401), *L. poecilus* ($Di_{channels}$= 1.684, Di_{rice}= 0.882) and *L. oryzophilus* ($Di_{channels}$= 2.357, Di_{rice}= 2.887, Di_{spring}= 33.333). Eudominant species included *H. geminus* in all the habitat examined ($Di_{channels}$= 71.268, Di_{rice} = 80.219 and Di_{spring}= 30.159), and *A. concinnus* only in the spring (Di_{spring} =15.873).

In Table 5 the values of similarity indices are given. The comparison between pairwise stations applying Sørensen index shows values generally comprised between 0.526 and 0.645. The only exception was for the two stations which were located closer to each other geographically, where the similarity increases, reaching 0.903 in rice paddies and 0.800 in the channels. Hence differences in the species composition in rice paddies seems to be due more to the geographical position of the stations than to the period of flooding. The index provided in CHAO *et al.* (2005) considers the role of unseen shared species, and provides different values. In detail with pairwise stations, it deletes the effect due to geographic position with values approximating 1 in channels and between 0.486 and 0.500 in rice paddies, where lower values were due to the presence of few shared species generally represented by numerous specimens. In the same station CHAO *et al.* index gives values next to 1 comparing the channels and the rice paddies and emphasizing the similarity of the two habitats.

FEEDING HABITS

Table 6 describes the feeding habits of the species identified. It was difficult to insert 51.60% of the adults into a well-defined trophic group as information changes according to author [e.g. *H. piceus* that is considered a vegetarian for HANSEN (1987), a predator for GRAFIUS and ANDERSON (1973), a omnivore for BEEBEE (2007) and a detritivore for BOUKAL (2008)]. In some cases this should be due to the ability of some species to show dietary variation with relation to changes in climate [e.g. *Agabus* spp. are carnivores in wet periods and detritivores in dry periods (MOTTA and UIEDA, 2004)]. The situation was different for larvae as they were easily assigned to a defined trophic group: 64.52% carnivores, 6.45% herbivores and 29.03% other food items.

Table 5 – Similarity indices applied to pairwise stations/habitats (Sørensen index values in italics and Chao *et al.* index values in bold).

	C1	C2	C3	C4	R1	R2	R3	R4
C1		**0.936**	**0.942**	**0.914**	**0.987**	**-**	**-**	**-**
C2	*0.581*		**0.956**	**0.939**	-	**0.980**	**-**	**-**
C3	*0.645*	*0.632*		**1.000**	-	**-**	**0.980**	**-**
C4	*0.581*	*0.632*	*0.800*		-	**-**	**-**	**0.981**
R1	*0.737*	-	-	-		**0.486**	**0.494**	**0.495**
R2	-	*0.645*	-	-	*0.526*		**0.491**	**0.498**
R3	-	-	*0.765*	-	*0.636*	*0.593*		**0.500**
R4	-	-	-	*0.686*	*0.609*	*0.643*	*0.903*	

ECOLOGICAL INFORMATION

Dytiscidae

In the current study 12 species of Dytiscidae were collected: *A. guttatus*, *H. grammicus*, *H. geminus*, *H. marginatus*, *H. cuspidatus*, *H. impressopunctatus*, *H. inaequalis*, *I. chalconatus*, *L. hyalinus*, *Laccophilus minutus*, *L. poecilus*, and *R. suturalis*.

Agabus guttatus (Paykull, 1798)

IDENTIFICATION - According to the description provided by NILSSON and HOLMEN (1995).
LENGTH - 7.8-9.2 mm.
BIOLOGY - The genus *Agabus* inhabits springs, fast flowing streams and rivers (USINGER, 1974). The oviposition of *A. guttatus* begins in June or July and continues into late summer and early autumn (GALEWSKI, 1971). This flexible reproductive period allows the species to overwinter either as larvae or as adults in water on the bottom or at the margin of dried up water bodies (NILSSON, 1986). Overwintering larvae do not pupate until the late spring or summer next year depending on the altitude and the atmospheric conditions (GALEWSKI, 1971). The flight muscles are poorly developed and adults fly only occasionally (JACKSON, 1973; NILSSON and HOLMEN, 1995). SOLDÁN *et al.* (2012) defines the life cycles of this taxon as semivoltine or flexible, but specific information is not available for Italy.
RECORDS - 1 specimen collected in a channel [Station 2 (1 on 05.VII.2010)].

Hydaticus grammicus (Germar, 1830)

IDENTIFICATION - According to the description provided by FRANCISCOLO (1979).
LENGTH - 9-11 mm.
BIOLOGY - *H. grammicus* is known to inhabit pools, puddles, margins of lakes, riverine forest and intermittent stream pools, and also paddy fields. OHBA and TAKAGI (2010) described the efficiency of the species in the predation of mosquito larvae. Further ecological information can be obtained from the literature on this genus. Ecology varies greatly from species to species (BALKE *et al.*, 2004): adults generally prefer temporary pools in early spring to take advantage of available food whereas in the summer they live in more permanent waters. The females prefer the aquatic vascular plants as oviposition sites (ROUGHLEY and PENGELLY, 1981). The larvae are good swimmers because of the dense fringe of swimming hairs on all legs and on the last two abdominal segments. They float to the surface when they do not swim due to the presence of large tracheae filled with air. Larvae prey on the juvenile stages of Odonata, Ephemeroptera, Trichoptera and Diptera (GALEWSKI, 1971). Pupation occurs on land near the larval habitat. The adults of the genus generally overwinter under leaf litter and moss on land, often quite far from the nearest body of water (GALEWSKI, 1971). This species is considered rare in Italy (RUFFO and STOCH, 2005) hence little is known about its biology and phenology. NARDI (2004) defines *H. grammicus* among the species of intermittent occurrence throughout the year, a result of either a seasonally determined colonization or a short-term adult activity. TOLEDO (2006) comments that the biology of *H. grammicus* in Italy has to be investigated as adults overwinter, and the larvae are generally collected in August and September, but the presence of temporary ponds can allow the development of larvae also in May.
RECORDS - 3 specimens found in channels [Station 2 (2 on 01.IX.2010); Station 4 (1 on 03.VI.2010)].

Hydroglyphus geminus (Fabricius, 1792)

IDENTIFICATION - According to the description provided by NILSSON and HOLMEN (1995).
LENGTH - 1.9-2.2 mm.
BIOLOGY - *H. geminus* is a ubiquitous species. It inhabits all types of standing and slowly flowing water, most frequently puddles and shallow water bodies with a sandy or loamy bottoms without vegetation (ROCCHI, 1986; BOUKAL *et al.*, 2008). It is a pioneering species that colonises man-made habitats such as rice fields, and is tolerant to water pollution (PICAZO *et al.*, 2010; BELLINI *et al.*, 2000; BURGHELEA *et al.*, 2011). *H. geminus* feeds mainly on planktonic crustaceans (especially Copepoda) and small insects. Information on insect predation is diverse as BELLINI *et al.* (2000) estimates

Table 6 – Feeding habits of the species collected.

Species		Alimentary habits in literature	Trophic groups (Merritt and Cummins 1996)
Agabus guttatus	Adult	Predator (Usinger, 1974); detritivore (Motta and Uieda, 2004)	Carnivores/Others
	Larva	Predator (Usinger, 1974)	Carnivores
Hydaticus grammicus	Adult	Predator (Usinger, 1974)	Carnivores
	Larva	Predator (Galewski, 1971; Usinger, 1974)	Carnivores
Hydroglyphus geminus	Adult	Predator (Usinger, 1974; Bellini *et al.,* 2000)	Carnivores
	Larva	Predator (Usinger, 1974)	Carnivores
Hydroporus marginatus	Adult	Predator (Grafius and Anderson, 1973; Usinger, 1974)	Carnivores
	Larva	Predator (Grafiusand Anderson, 1973; Usinger, 1974)	Carnivores
Hydrovatus cuspidatus	Adult	Predator (Usinger, 1974); detritivore (Boukal *et al.,* 2008)	Carnivores/Others
	Larva	Predator (Usinger, 1974)	Carnivores
Hygrotus impressopunctatus	Adult	Predator (Usinger, 1974)	Carnivores
	Larva	Predator (Usinger, 1974)	Carnivores
Hygrotus inaequalis	Adult	Predator (Usinger, 1974)	Carnivores
	Larva	Predator (Usinger, 1974)	Carnivores
Ilybius chalconatus	Adult	Predator (Grafius and Anderson, 1973; Usinger, 1974)	Carnivores
	Larva	Predator (Usinger, 1974)	Carnivores
Laccophilus hyalinus	Adult	Predator (Usinger, 1974)	Carnivores
	Larva	Predator (Usinger, 1974)	Carnivores
Laccophilus minutus	Adult	Predator (Burghelea *et al.,* 2011)	Carnivores
	Larva	Predator (Usinger, 1974)	Carnivores
Laccophilus poecilus	Adult	Predator (Usinger, 1974)	Carnivores
	Larva	Predator (Usinger, 1974)	Carnivores
Rhantus suturalis	Adult	Predator (Usinger, 1974)	Carnivores
	Larva	Predator (Usinger, 1974)	Carnivores
Aulonogyrus concinnus	Adult	Predator (Usinger, 1974; Holmen, 1987)	Carnivores
	Larva	Predator (Usinger, 1974; Holmen, 1987)	Carnivores
Haliplus flavicollis	Adult	Eggs of Chironomidae (Holmen, 1987); omnivore (Roughley, 2000)	Carnivores/Omnivores
	Larva	Characeans (Holmen, 1987)	Others
Haliplus fulvus	Adult	Omnivore (Roughley, 2000); Phytophagous (Ruffo and Stoch, 2005)	Herbivores/Omnivores
	Larva	Characeans (Holmen, 1987)	Others
Haliplus heydeni	Adult	Filamentous algae (Seeger, 1971b); omnivore (Roughley, 2000)	Others/Omnivores
	Larva	Filamentous algae (Seeger, 1971b)	Others
Haliplus laminatus	Adult	Filamentous algae and invertebrates such as oligochaetes and chironomid larvae (Seeger, 1971b); omnivore (Roughley, 2000)	Omnivores
	Larva	Filamentous algae (Holmen, 1987)	Others
Haliplus lineaticollis	Adult	Filamentous algae (Holmen, 1987); omnivore (Roughley, 2000)	Others/Omnivores
	Larva	Filamentous algae (Holmen, 1987)	Others
Peltodytes caesus	Adult	Filamentous algae (Seeger, 1971b); omnivore (Roughley, 2000)	Others/Omnivores
	Larva	Filamentous algae (Seeger, 1971b)	Others
Lissorhoptrus oryzophilus	Adult	Phytophagous (Lupi *et al.,* 2009)	Herbivores
	Larva	Rhizophagous (Lupi *et al.,* 2009)	Herbivores
Dryops luridus	Adult	Vegetarian (Usinger, 1974; Olmi, 1978)	Herbivores
	Larva	Rhizophagous (Usinger, 1974; Olmi, 1978)	Herbivores
Limnius volckmari	Adult	Bryophagous (Usinger, 1974; Olmi, 1978)	Others
	Larva	Microphagous (Usinger, 1974; Olmi, 1978)	Others
Helophorus brevipalpis	Adult	Phytophagous (Ruffo and Stoch, 2005)	Herbivores
	Larva	Predator (Pirisinu, 1981)	Carnivores
Berosus frontifoveatus	Adult	Vegetarian (Grafius and Anderson, 1973); detritivore (Boukal *et al.,* 2008)	Herbivores/Others
	Larva	Green algae (Usinger, 1974)	Others
Berosus signaticollis	Adult	Vegetarian (Grafius and Anderson, 1973); detritivore (Boukal *et al.,* 2008)	Herbivores/Others
	Larva	Green algae (Usinger, 1974)	Others
Enochrus melanocephalus	Adult	Vegetarian (Grafius and Anderson, 1973); detritivore (Boukal *et al.,* 2008)	Herbivores/Others
	Larva	Predator (Grafius and Anderson, 1973)	Carnivores
Enochrus quadripunctatus	Adult	Vegetarian (Grafius and Anderson, 1973); detritivorous (Boukal *et al.,* 2008)	Herbivores/Others
	Larva	Predator (Grafius and Anderson, 1973)	Carnivores
Helochares lividus	Adult	Phytophagous (Ruffo and Stoch, 2005); detritivore (Boukal *et al.*, 2008)	Herbivores/Others
	Larva	Predator (Ruffo and Stoch, 2005)	Carnivores
Hydrochara caraboides	Adult	Vegetarian (Boyce, 2004); detritivore (Boukal *et al.,* 2008)	Herbivores/ Others
	Larva	Predator (Boyce, 2004)	Carnivores
Hydrophilus piceus	Adult	Vegetarian (Hansen, 1987); predator (Grafius and Anderson, 1973); omnivore (Beebee, 2007); detritivore (Boukal *et al.,* 2008)	Carnivores/Herbivores/ Others/Omnivores
	Larva	Predator (Grafius and Anderson, 1973)	Carnivores
Laccobius minutus	Adult	Vegetarian (Grafius and Anderson, 1973); detritivorous (Boukal *et al.,* 2008)	Herbivores/Others
	Larva	Predator (Grafius and Anderson, 1973)	Carnivores

the important role of the species in controlling mosquito larvae, while OHBA and TAKAGI (2010) state that the species do not feed on mosquito larvae. The species is characterized by rapid larval development and a active dispersal (VERBERK *et al.*, 2008). In southern Europe adults can be observed throughout the year with a bivoltine life cycle; the first generations emerges in March and the second in September (RIBERA *et al.*, 1995; BELLINI *et al.*, 2000; BURGHELEA *et al.*, 2008).
RECORDS - 1,682 specimens collected in rice fields (1,000) [Station 1 (21 on 05.VII.2010; 102 on 04.VIII.2010); Station 2 (1 on 03.VI.2010; 84 on 05.VII.2010; 182 on 04.VIII.2010; 10 on 01.IX.2010); Station 3 (89 on 05.VII.2010; 96 on 04.VIII.2010; 77 on 01.IX.2010; 20 on 11.X.2010); Station 4 (4 on 03.VI.2010; 28 on 05.VII.2010; 27 on 04.VIII.2010; 133 on 01.IX.2010; 117 on 11.X.10; 3 on 25.XI.2010; 6 on 25.I.2011)], in channels (635) [Station 1 (2 on 07.IV.2010; 24 on 03.V.2010; 3 on 03.VI.2010; 6 on 05.VII.2010; 53 on 04.VIII.2010; 72 on 01.IX.2010; 22 on 11.X.2010; 2 on 25.XI.2010; 1 on 25.I.2011); Station 2 (11 on 09.III.2010; 6 on 07.IV.2010; 1 on 03.V.2010; 31 on 05.VII.2010; 22 on 04.VIII.2010; 11 on 01.IX.2010; 5 on 11.X.2010; 15 on 16.XII.2010; 88 on 25.I.2011; 9 on 28.II.2011); Station 3 (1 on 07.IV.2010; 4 on 03.VI.2010; 13 on 05.VII.2010; 27 on 04.VIII.2010; 1 on 01.IX.2010; 3 on 16.XII.2010; 2 on 25.I.2011; 99 on 28.II.2011); Station 4 (17 on 09.III.2010; 14 on 07.IV.2010; 1 on 03.V.2010; 15 on 03.VI.2010; 1 on 05.VII.2010; 6 on 04.VIII.2010; 19 on 01.IX.2010; 1 on 11.X.2010; 4 on 25.XI.2010; 4 on 25.I.2011; 47 on 28.II.2011] and in the spring (19) [Station 3 (1 on 03.V.2010; 2 on 05.VII.2010; 1 on 01.IX.2010; 2 on 25.XI.2010; 13 on 28.II.2011)].

Hydroporus marginatus (Duftschmid, 1805)

IDENTIFICATION - According to the description provided by FRANCISCOLO (1979).
LENGTH - 4.3 mm.
BIOLOGY - *H. marginatus* prefers shallow, warm water bodies with sandy or gravelly bottom (BOUKAL *et al.*, 2008). According to MILLÁN *et al.* (2006) *H. marginatus* is typical of clean, fresh and well oxygenated waters, with a coarse substratum and well-developed riparian vegetation. Like all the members of the subfamily Hydroporinae, *H. marginatus* adults are poor swimmers and often hide on the bottom of the freshwater habitat in which they live; the larvae creep among loose sediment on the bottom or in dense masses of vegetation, mainly preying small Crustacea. The females have a sclerotized ovipositor and they oviposit inside plant tissues. The larvae have a cutaneous respiration: they breathe oxygen dissolved in water, until they have completed their development. Many species of the genus *Hydroporus* are excellent flyers and leave water bodies when these dry up, or survive by burying themselves in the gravels in drying winterbournes (GALEWSKI, 1971). *H. marginatus* in northern Europe is a univoltine spring breeder with summer larval development, terrestrial pupation and overwintering adults (NILSSON, 1989; NILSSON and HOLMEN, 1995). No more information is available on the phenology of the species in Italy.
RECORDS - 1 specimen collected in a channel [Station 1 (1 on 07.IV.2010)].

Hydrovatus cuspidatus Kunze, 1818

IDENTIFICATION - According to the description provided by YOUNG (1963).
LENGTH - 2.5-2.9 mm.
BIOLOGY - *H. cuspidatus* can adapt to very different environments. It can be found in stagnant water, such as pools, irrigation ditches with very slow-flowing water, puddles and paddy fields, but also decaying wood, rivers, and lakes (BALKE *et al.*, 2004; BORDONI *et al.*, 2006). It is often associated with water bodies rich in vegetation or with eutrophic lakes (NILSSON and HOLMEN, 1995; BOUKAL *et al.*, 2008; IVERSEN *et al.*, 2011). Both larvae and adults often creep and hide among the vegetation on the bottom of water bodies (GALEWSKI, 1971). The adults are poor swimmers, but good flyers. *H. cuspidatus* is known from most central and southern European countries, but is mainly distributed in southern Europe. The species is actually spreading to the north probably due to its flight activity and has recently been recorded in the United Kingdom, in Sweden and in Denmark (IVERSEN *et al.*, 2011). In Italy it is considered a bio-indicator of water quality (RUFFO and STOCH, 2005). Even if it is a very common species (ROCCHI, 1986; BORDONI *et al.*, 2006), little is known about its biology. In Italy the adults of this species have been captured from May until December (Nardi, 2004) while in northern Europe adults can be found most frequently in April-May and again from mid September (NILSSON and HOLMEN, 1995; IVERSEN *et al.*, 2011).
RECORDS - 1 specimen collected in a channel [Station 3 (1 on 03.VI.2010)].

Hygrotus impressopunctatus (Schaller, 1783)

IDENTIFICATION - According to the description provided by LARSON *et al.* (2000).
LENGTH - 4.1-5.5 mm.
BIOLOGY - *H. impressopunctatus* is a euryecious species (BOUKAL *et al.*, 2008) that colonizes ponds and other shallow water bodies rich in vegetation, and it is absent or at least not common in oligotrophic habitats such as marshes (LARSON *et al.*, 2000). Larvae often creep and hide among vegetation in deeper, mostly stagnant bodies of water (GALEWSKI, 1971). In Italy this is a very common species, collected from plains to mountains and is considered a bio-indicator species of water quality (RUFFO and STOCH, 2005; BORDONI *et al.*, 2006). The species is considered univoltine in northern Europe (NILSSON and HOLMEN, 1995), but appears to be bi-multivoltine in Italy with oviposition period from spring to early autumn (TOLEDO, 2006).
RECORDS: 6 specimens collected in rice paddies (2) [Station 3 (1 on 11.X.2010; Station 4 (1 on 01.IX.2010)], and in channels (4) [Station 3 (2 on 05.VII.2010; 1 on 04.VIII.2010); Station 4 (1 on 07.IV.2010)].

Hygrotus inaequalis (Fabricius, 1776)

IDENTIFICATION - According to the description provided by BALFOUR-BROWNE (1953).
LENGTH - 3.0-3.5 mm.
BIOLOGY - *H. inaequalis* is a euryecious species inhabiting a wide range of habitats with preference for permanent stagnant water bodies, usually rich in vegetation and with

slow-flowing waters (USINGER, 1974; BOUKAL *et al*., 2008). Not-witstanding its broad distribution it is not known as a good flyer (CUPPEN, 1983). The species is considered univoltine in northern Europe (NILSSON and HOLMEN, 1995; CAYROU and CÉRÉGHINO, 2005), but appears to be bi-multivoltine in Italy with oviposition period from spring to early autumn (TOLEDO, 2006). It is considered a bio-indicator species in Italy (RUFFO and STOCH, 2005).
RECORDS - 1 specimen collected in a channel [Station 4 (1 on 01.IX.2010)].

Ilybius chalconatus (Panzer, 1796)

IDENTIFICATION - According to the description provided by NILSSON and HOLMEN (1995).
LENGTH - 7.5-8.7 mm.
BIOLOGY - *I. chalconatus* occurs mainly in open, more or less temporary pools with at least some vegetation and slow-flowing waters (USINGER, 1974; NILSSON and HOLMEN, 1995). Adults have well-developed flight muscles (JACKSON, 1973) and this can allow the colonization of new habitats. There is little information on the species biology: in Italy *I. chalconatus* is probably a semivoltine species (TOLEDO, 2006). Oviposition generally occurs in summer and autumn in a hole to a depth of 6 cm, but as the eggs have a long incubation period of a few months, they can overwinter and hatching takes place in spring or in early summer the next year (FRANCISCOLO, 1979).
RECORDS - 2 specimens collected in channels [Station 3 (1 on 03.VI.2010); Station 4 (1 on 03.VI.2010)].

Laccophilus hyalinus De Geer, 177

IDENTIFICATION - According to the description provided by MALEKPOUR and SHIVA (2011).
LENGTH - 4.6-5.1 mm.
BIOLOGY - *L. hyalinus* is often found in large bodies of running water, with a slow current and some vegetation, and less frequently in ponds and lakes (NILSSON and HOLMEN, 1995). The adults of the genus *Laccophilus* are excellent swimmers but poor creepers. In Italy adults can be caught all the year round, and occurrence of teneral adults during two specific periods has led to the hypothesis of two generations per year (NARDI, 2004). Oviposition occurs in late spring or in early summer inside plant tissues (GALEWSKI, 1971).
RECORDS - 9 specimens collected respectively in rice paddies (2) [Station 3 (1 on 04.VIII.2010); Station 4 (1 on 03.VI.2010)], in channels (6) [Station 2 (2 on 05.VII.2010; 1 on 04.VIII.2010); Station 3 (1 on 05.VII.2010); Station 4 (2 on 03.VI.2010) and in the spring (1) [Station 3 (1 on 05.VII.2010)].

Laccophilus minutus (Linnaeus, 1758)

IDENTIFICATION - According to the description provided by MALEKPOUR and SHIVA (2011).
LENGTH - 4-4.5 mm.
BIOLOGY - *L. minutus* is a common and widespread species occuring in permanent bodies of stagnant water with a slow currents, such as lakes and ponds, often with little or no vegetation (ROCCHI, 1986; NILSSON and HOLMEN, 1995). It appears to be tolerant to water pollution (BURGHELEA *et al*., 2011). In middle Europe the species overwinters as adults in water, oviposition occurs in late spring or early summer and larval development takes place during summer (GALEWSKI, 1978). In Italy adults are present throughout the year and the life cycle is comparable to *L. hyalinus* (NARDI, 2004; TOLEDO, 2006).
RECORDS - 66 specimens collected respectively in rice paddies (41) [Station1 (1 on 04.VIII.2010); Station 2 (2 on 05.VII.2010); Station 3 (2 on 04.VIII.2010; 1 on 01.IX.2010); Station 4 (6 on 01.IX.2010; 2 on 11.X.2010; 26 on 25.XI.2010; 1 on 25.I.2011)] and on channels (25) [Station 1 (1 on 03.V.2010; 3 on 05.VII.2010; 2 on 04.VIII.2010; 2 on 01.IX.2010; 3 on 11.X.2010); Station 2 (1 on 04.VIII.2010; 4 on 01.IX.2010; 3 on 25.I.2011); Station 3 (1 on 04.VIII.2010; 1 on 16.XII.2010; 3 on 28.II.2011); Station 4 (1 on 03.VI.2010)].

Laccophilus poecilus Klug, 1834

IDENTIFICATION - According to the description provided by NILSSON and HOLMEN (1995).
LENGTH - 3.4-4 mm.
BIOLOGY - *L. poecilus* lives mainly in pools, bogs, ponds with slow currents (BORDONI *et al*., 2006). It can be also found in brackish water and in sheltered bays on silty bottoms with dense vegetation (NILSSON and HOLMEN, 1995). This predator prefers water with a large amount of decaying organic debris such as tree leaves and sedges (BOUKAL *et al*., 2008). The species, considered univoltine in northern Europe (NILSSON and HOLMEN, 1995), appears to be bivoltine in Italy (NARDI, 2004).
RECORDS - 27 specimens collected in rice paddies (11) [Station 3 (1 on 04.VIII.2010; 1 on 01.IX.2010); Station 4 (6 on 01.IX.2010; 3 on 11.X.2010)] and in channels (15) [Station3 (2 on 04.VIII.2010; 1 on 01.IX.2010; 2 on 28.II.2011); Station 4 (10 on 03.VI.2010)] and in the spring (1) [Station 3 (1 on 01.IX.2010)].

Rhantus suturalis (MacLeay, 1825)

IDENTIFICATION - According to the description provided by NILSSON and HOLMEN (1995).
LENGTH - 10.5-11.9 mm.
BIOLOGY - *R. suturalis* is present in small clay pools on coastal meadows, in brackish water, in shallow ponds, mainly with little or no vegetation and with slow-flowing waters (USINGER, 1974; NILSSON and HOLMEN, 1995). This species can be used as bioindicator of metal pollution (BURGHELEA *et al*., 2011). The adults are excellent flyers as they leave water bodies when these dry up or for hibernation. Like other species of the same genus the larvae live in water, creeping and swimming among the vegetation (GALEWSKI, 1971). Copulation and oviposition also occur in the water and only the pupal stage is found outside the aquatic environment (WESENBERG-LUND, 1943). HERBST *et al*. (2011) demostrated that *R. suturalis* females release sex pheromones to attract mating partners, and this is the first experimental demonstration of pheromones in the Dytiscidae. Adults in Italy are present throughout the year but little is known about the number of generations per year (NARDI, 2004). VALLADARES *et al*. (1994) reports that in Spain larvae can be found from September in ephemeral ponds where they quickly complete their cycle as the adult overwinters.

RECORDS - 7 specimens collected in rice paddies (2) [Station 3 (1 on 01.IX.2010); Station 4 (1 on 11.X.2010)] and in channels (5) [Station 1 (1 on 11.X.2010); Station 2 (1 on 03.V.2010); Station 3 (2 on 03.V.2010; 1 on 28.II.2011)].

Gyrinidae

Thirteen species and four genera of Gyrinidae are present in RUFFO and STOCH'S (2005) Italian check list, but only the species *A. concinnus* was collected in this study.

Aulonogyrus concinnus (Klug, 1834)

IDENTIFICATION - According to the description provided by HOLMEN (1987).
LENGTH - 5.1-7.0 mm.
BIOLOGY - *A. concinnus* lives in quiet areas of streams, but also in various stagnant habitats (HOLMEN, 1987). NARDI (2004) reports adult presence in northern Italy from February to April and also in July. No more information is available about the species' phenology.
RECORD - 10 specimens collected in the spring [Station 3 (10 on 03.V.2010)].

Haliplidae

Twenty one species and three genera Haliplidae are present in RUFFO and STOCH'S (2005) Italian check list and six species were collected in the present study: *H. flavicollis*, *H. fulvus*, *H. heydeni*, *H. laminatus*, *H. lineaticollis*, *P. caesus*.

Haliplus flavicollis Sturm, 1834

IDENTIFICATION - According to the description provided by FRIDAY (1988).
LENGTH - 3.5-4.0 mm.
BIOLOGY - *H. flavicollis* lives in bodies of stagnant or very slowly running water, especially in oligoproductive lakes with growth of characeans and in brackish water (SEEGER, 1971c). The species is known to fly (HOLMEN, 1987). The adult feeds on eggs of Chironomidae, the larvae on characeans. Eggs are laid in the spring or early in summer and the larva hatches after few weeks. In southern Europe the life cycle may be completed within one year (SEEGER, 1971a, b, c). *H. flavicollis* is considered a bio-indicator species of water quality in Italy (RUFFO and STOCH, 2005) but little is known about its phenology.
RECORD - 1 specimen collected in channel (1) [Station 2 on 01.IX.2010].

Haliplus fulvus (Fabricius, 1801)

IDENTIFICATION - According to the description provided by FRIDAY (1988).
LENGTH - 3.5-4.2 mm.
BIOLOGY - *H. fulvus* lives in oligoproductive, slightly acid lakes and also brackish waters with growth of characeans (SEEGER, 1971c). PAKULNICKA (2008) describes it as a species typical of clay-pit ponds, particularly large, deep, characterized by low trophy and dominated by species typical of small water bodies accompanied by species found in clean oligotrophic waters. The larva feeds on characeans and the adult is considered herbivorous or omnivourous. Similarly to *H. flavicollis* the species is able to fly and its life cycle can be completed within one year (SEEGER, 1971a, b, c; HOLMEN, 1987). It is also considered a bio-indicator species of water quality in Italy (RUFFO and STOCH, 2005) but little is known about its phenology.
RECORDS - 24 specimens collected in rice paddies (6) [Station 1 (1 on 04.VIII.2010); Station 3 (1 on 04.VIII.2010); Station 4 (1 on 03.VI.2010; 1 on 05.VII.2010; 1 on 04.VIII.2010; 1 on 01.IX.2010]; in channels (17) [Station 1 (1 on 03.V.2010); Station 3 (2 on 03.V.2010; 5 on 05.VII.2010; 1 on 04.VIII.2010); Station 4 (3 on 03.V.2010; 5 on 03.VI.2010)] and in the spring (1) [Station 3 (1 on 03.V.2010)].

Haliplus heydeni Wehncke, 1875

IDENTIFICATION - According to the description provided by FRIDAY (1988).
LENGTH - 2.2-2.8 mm.
BIOLOGY - *H. heydeni* is associated principally to small water bodies with rich vegetation. SEEGER (1971c) describes it as a characteristic species of poly-productive stagnant waters. Like *H. fulvus*, *H. heydeni* is adapted to live in very acid water as well as in brackish water. The larvae and probably the adults feed on filamentous algae. The species appears to be semivoltine in northern Europe (HOLMEN, 1987). The adults emerge in spring but they probably reproduce in the subsequent year. Eggs may be deposited through most of the summer (SEEGER, 1971b), inside emptied cells of submerged plants. The larvae hatch after a few weeks and can pupate in the late summer, but also overwinter to pupate the following spring. Hibernation of larvae and adults normally takes place out of the water (HOLMEN, 1987). In Italy little is known about the life cycle but adults can be found throughout the year (NARDI, 2004).
RECORDS - 52 specimens collected in rice paddies (13) [Station 2 (1 on 05.VII.2010); Station 4 (1 on 03.VI.2010; 2 on 05.VII.2010; 1 on 04.VIII.2010; 1 on 01.IX.2010; 4 on 11.X.2010; 2 on 25.XI.2010; 1 on 25.I.2011)], in channels (36) [Station 1 (1 on 01.IX.2010); Station 2 (3 on 03.V.2010; 2 on 05.VII.2010; 1 on 04.VIII.2010); Station 3 (1 on 03.V.2010; 1 on 03.VI.2010; 11 on 05.VII.2010; 1 on 28.II.2011); Station 4 (7 on 03.VI.2010; 4 on 04.VIII.2010; 2 on 11.X.2010; 2 on 28.II.2011)], and in the spring (3) [Station 3 (2 on 03.VI.2010; 1 on 28.II.2011)].

Haliplus laminatus (Schaller, 1783)

IDENTIFICATION - According to the description provided by FRIDAY (1988).
LENGTH - 2.5-3.0 mm.
BIOLOGY - *H. laminatus* prefers water with little vegetation, particularly slow flowing streams, drains and ponds in clay and gravel pits. The adults feed on both filamentous algae and invertebrates such as oligochaetes and chironomid larvae (SEEGER, 1971b). The larva feeds on filamentous algae (HOLMEN, 1981). Little information

is available about its life cycle. NARDI (2004) reports that adults can be captured all year round with a peak of activity in September.
RECORD - 1 specimen collected in a channel [Station 4 (1 on 07.IV.2010)].

Haliplus lineaticollis (Marsham, 1802)

IDENTIFICATION - According to the description provided by FRIDAY (1988).
LENGTH - 2.6-3.5 mm.
BIOLOGY - *H. lineaticollis* is a pioneering species of slowly flowing waters (CONTARINI, 1992). Due to its flying activity it can colonize new habitats (HOLMEN, 1987). It is also known as the commonest Haliplidae in Lombardy and Italy (FRANCISCOLO, 1979; ANGELINI, 1984). The larva and also the adults feed on filamentous algae. Eggs are deposited in spring or in summer and after a short period the larvae hatches. In southern Europe the life cycle may be completed the same year of oviposition (HOLMEN, 1987), but more specific information is lacking.
RECORDS - 5 specimens collected in channels (4) [Station 2 (1 on 07.IV.2010; 2 on 03.V.2010) Station 4 (1 on 07.IV.2010)] and in the spring (1) [Station 3 (1 on 28.II.2011)].

Peltodytes caesus (Duftschmid, 1805)

IDENTIFICATION - According to the description provided by FRIDAY (1988).
LENGTH - 3.5-4.0 mm.
BIOLOGY - *P. caesus* is typical of stagnant, eutrophic water bodies with rich vegetation. The larvae and probably the adults feed on filamentous algae. In northern Europe eggs are laid in the spring on the surface of submerged vegetation. Full-grown larvae occur later in the summer, as well as the adults that overwinter (HOLMEN, 1987). In Italy adults are present all over the year (NARDI, 2004), but more information on the biology is lacking.
RECORDS - 6 specimens collected in rice paddies (2) [Station 2 (2 on 05.VII.2010)] and in channels (4) [Station 2 (1 on 03.V.2010); Station 3 (1 on 25.XI.2010; 2 on 28.II.2011)].

Brachyceridae

Among the Brachyceridae only the species *L. oryzophilus* (the rice water weevil) was collected in the present study.

Lissorhoptrus oryzophilus Kuschel, 1952

IDENTIFICATION - According to the description provided by KUSCHEL (1951) and EVERETT and NEWSOM (1964).
LENGTH - 3.3-3.7 mm.
BIOLOGY - *L. oryzophilus* is a semi-aquatic beetle typical of stagnant and running water feeding on rice and many weeds coexisting with rice in the agro-ecosystem. It is considered one of the most important pests of rice in the world as its larvae can cause significant damage to the rice crops during feeding. The newly hatched larvae initially feed within the rice sheath, and then migrate to the roots where they complete their development, feeding until pupation. The swimming behavior of adults is peculiar and differs from other aquatic Coleoptera as the insect propels itself moving the mesothoracic legs in synchrony during extension and retraction (HIX *et al.*, 2000). The species was first detected in Italy in 2004 (CALDARA *et al.*, 2004) and is currently established in the major rice area in Italy (LUPI *et al.*, 2010). Overwintering adults can be observed on vegetation from April until the end of June. Oviposition generally begins in May, and larvae are found from the end of May until July. Adults generally emerge in late June-July and overwinter in the litter or in the first few centimetres of the soil (LUPI *et al.*, 2013).
RECORDS - 78 specimens were collected in rice paddies (36) [Station 1 (5 on 05.VII.2010; 1 on 04.VIII.2010); Station 2 (6 on 04.VIII.2010; 14 on 01.IX.2010); Station 3 (2 on 05.VII.2010; 1 on 04.VIII.2010); Station 4 (1 on 05.VII.2010; 2 on 04.VIII.2010; 4 on 01.IX.2010)], in channels (21) [Station 1 (3 on 03.VI.2010); Station 2 (8 on 03.V.2010; 1 on 03.VI.2010; 5 on 05.VII.2010); Station 3 (2 on 03.VI.2010; 1 05.VII.2010; 1 on 28.II.2011); and in the spring (21) [Station 3 (15 on 03.VI.2010; 2 on 05.VII.2010; 1 on 04.VIII.2010; 1 on 01.IX.2010; 2 on 28.II.2011)].

Dryopidae

Among Dryopidae, only the species *D. luridus* was collected in the present study.

Dryops luridus (Erichson, 1847)

IDENTIFICATION - According to the description provided by OLMI (1978).
LENGTH - 3.5-4.5 mm.
BIOLOGY - *D. luridus* is a microphagous species typical of stagnant and running waters in lowlands, hills and mountains (HANSSEN, 1987; MASCAGNI and MELONI, 2011). *D. luridus* is considered a bioindicator species of water quality according to RUFFO and STOCH (2005). In Italy it is recorded from almost all regions (OLMI, 1976; ROCCHI and TERZANI, 2010) but little is known about its biology. Adults have been collected from April to November (CORNACCHIA and FACCOLI, 2004) and a protracted summer mating and egg oviposition period has been reported (WHITE, 1978). Oviposition occurs in the rotten submerged wood, the larvae are xylophagous and they pupate in wood (OLMI, 1978).
RECORDS - 61 specimens collected in rice paddies (43) [Station 1 (8 on 04.VIII.2010); Station 2 (5 on 05.VII.2010; 9 on 04.VIII.2010; 9 on 01.IX.2010); Station 3 (4 on 04.VIII.2010); Station 4 (8 on 04.VIII.2010)] and in channels (18) [Station 1 (1 on 01.IX.2010); Station 2 (2 on 05.VII.2010; 11 on 04.VIII.2010); Station 3 (1 on 03.VI.2010; 2 on 05.VII.2010); Station 4 (1 on 01.IX.2010)].

Elmidae

Twenty eight species of Elmidae (MASCAGNI and MELONI, 2011) in nine genera are recorded in Italian Check list (RUFFO and STOCH, 2005). Among Elmidae, the species *L. volckmari* was collected in the present study.

Limnius volckmari (Panzer, 1793)

IDENTIFICATION - According to the description provided by OLMI (1978).
LENGTH - 2.9-3.2 mm.
BIOLOGY - The presence of *L. volckmari* is strictly related with the existence of filamentous algae in moderately flowing waters (USINGER, 1974). It is considered an excellent indicator of water quality (RUFFO and STOCH, 2005; ELLIOT, 2008). Larvae and adults live clinging on stones and on aquatic mosses or on the gravelly bottom of streams, and pupation occurs in the shore (OLMI, 1978). According to BERTHELEMY and OLMI (1978) the species is semivoltine. ELLIOT (2008) reports that in Great Britain it takes one year from the egg hatching to pupation in a stream bank and a further one year before adults' maturation and oviposition. Both adults and larvae are present during the year in northern and also in southern Europe (ELLIOT, 2006; PÉREZ-BILBAO *et al.*, 2010).
RECORD - 2 specimens collected in channels [Station 2 (1 on 04.VIII.10; 1 on 01.IX.2010)].

Helophoridae

Twenty five species and one genera of Helophoridae are present in the Italian check list by RUFFO and STOCH (2005). Only one species *H. brevipalpis* was collected in the habitats considered in the period of study.

Helophorus brevipalpis Bedel, 1881

IDENTIFICATION - According to the description provided by FRIDAY (1988).
LENGTH - 2.4-3.2 mm.
BIOLOGY - *H. brevipalpis* is an ubiquitous species generally present in stagnant fresh water, preferring shallow, often temporary, pools with grassy bottoms; it can be found also in slower reaches of running waters (CULIOLI *et al.*, 2006). It is a great colonizer of ephemeral waters due to its great dispersal capacity and to the fact that the habitat of juveniles differs from that of adults. In northern Europe the species is univoltine with adults present throughout the year. In spring they oviposit in mud at the edge of the water in cocoons of approximately 12 eggs each. The larvae do not emerge until the following spring or early summer (LANDIN, 1980; HANSEN, 1987). No information is available about the biology of the species in Italy.
RECORDS - 13 specimens collected in rice paddies (1) [Station 2 (1 on 03.VI.2010)] and in channels (12) [Station 1 (10 on 03.V.2010); Station 3 (1 on 03.V.2010); Station 4 (1 on 09.III.2010)].

Hydrophilidae

Forty nine species and thirteen genera are present in RUFFO and STOCH'S (2005) Italian check list; eight species in six genera were collected in the this study: *B. frontifoveatus*, *B. signaticollis*, *E. melanocephalus*, *E. quadripunctatus*, *H. lividus*, *H. caraboides*, *H. piceus*, *Laccobius minutus*.

Berosus frontifoveatus Kuwert, 1888

IDENTIFICATION - According to the description provided by PRZEWOZNY and BUCZYNSKI (2008).
LENGTH - 7 mm.
BIOLOGY - *B. frontifoveatus* is a detritophilous species, prefering shallow water with a large amounts of decaying organic debris such as tree leaves and sedges (BOUKAL *et al.*, 2008). Like all species of the genus the larvae have tracheal gills to breathe. The adults oviposit egg cases in small groups on the substrate, and cover these with a thin silk-like layer (BALKE *et al.*, 2004). *Berosus* spp. is one of the most commonly collected genera of water scavenger beetles in the world as well as one of the most recognizable due to their typical hunchbacked appearance (OLIVA and SHORT, 2012). Despite the species being regarded as one of the most common in Europe, its biology is still not clear. In Italy *B. frontifoveatus* is considered a vulnerable and a bioindicator species (RUFFO and STOCH, 2005).
RECORDS - 37 specimens collected in rice paddies (27) [Station 1 (3 on 04.VIII.2010); Station 3 (1 on 05.VII.2010; 3 on 11.X.2010); Station 4 (1 on 05.VII.2010; 1 on 01.IX.2010; 18 on 11.X.2010)], in channels (9) [Station 1 (1 on 03.V.2010; 1 on 01.IX.2010); Station 2 (2 on 07.IV.2010); Station 3 (1 on 03.V.2010; 1 on 11.X.2010); Station 4 (1 on 09.III.2010, 2 on 03.IV.2010)] and in the spring (1) [Station 3 (1 on 28.II.2011)].

Berosus signaticollis Charpentier, 1825

IDENTIFICATION - According to the description provided by PRZEWOZNY and BUCZYNSKI (2008).
LENGTH - 4.8-6.0 mm.
BIOLOGY - *B. signaticollis* is a detritophilus species and lives in stagnant fresh water or ephemeral ponds with a large amount of decaying organic debris (HANSEN, 1987; VALLADARES *et al.*, 2002; BORDONI *et al.*, 2006; BOUKAL *et al.*, 2008). The species appears capable to colonize temporary or recently formed environments, even small pools filled with rainwater, and is able to survive dry periods in muddy soils as adults (CUPPEN and VAN MANNEN, 1998; PORST *et al.*, 2012). Little is known about the biology of the species.
RECORDS: 36 specimens collected in rice paddies (22) [Station 2 (1 on 03.VI.2010); Station 3 (1 on 04.VIII.2010); Station 4 (1 on 03.VI.2010; 3 on 04.VIII.2010; 3 on 01.IX.2010; 12 on 11.X.2010; 1 on 25.XI.2010)], in channels (13) [Station 1 (4 on 03.V.2010); Station 2 (1 on 07.IV.2010); Station 3 (1 on 03.V.2010; 1 on 01.IX.2010; 2 on 28.II. 2011); Station 4 (2 on 07.IV.2010; 1 on 03.VI.2010; 1 on 04.VIII.2010)] and in the spring (1) [Station 3 (1 on 03.V.2010)].

Enochrus melanocephalus (Olivier, 1792)

IDENTIFICATION - According to the description provided by INCEKARA *et al.* (2005).
LENGTH - 4.2-5.0 mm.
BIOLOGY - *E. melanocephalus* is a euryecious species (BOUKAL *et al.*, 2008). It lives in shaded areas of stagnant, predominantly fresh and shallow, well vegetated waters with clay bottom (HANSEN, 1987; FOSTER and EYRE, 1992). Adults feed on decaying organic debris such as tree leaves and sedges, while larvae are carnivorous and prey on the Crustacea, tiny warms and fly larvae (WILLIAMS, 1936; BOUKAL *et al.*, 2008). Like other species of the same genus eggs are oviposited in groups attached to underside of leaves and to beneath floating debris (WILLIAMS, 1936). *E. melanocephalus* is considered a bio-indicator species of water quality, according

to RUFFO and STOCH (2005). Otherwise, little is known about its biology.
RECORDS - 4 specimens collected in rice paddies [Station 2 (1 on 04.VIII.2010); Station 3 (1 on 04.VIII.2010); Station 4 (1 on 05.VII.2010; 1 on 01.IX.2010)].

Enochrus quadripunctatus (Herbst, 1797)

IDENTIFICATION - According to the description provided by TOPKARA (2008).
LENGTH - 4.7-5.8 mm.
BIOLOGY - *E. quadripunctatus* is a euryecious species (BOUKAL *et al*., 2008), living in stagnant water, especially open, shallow pools with rich vegetation, but it can also colonize fresh waters. It is a very active flyer, often found in strandlines on the seashore (HANSEN, 1987, BORDONI *et al*., 2006). *E. quadripunctatus* is detritophilous (BOUKAL *et al*., 2008) and is considered a bio-indicator species of water quality according to RUFFO and STOCH (2005). Little is known about its biology.
RECORDS - 48 specimens collected in rice paddies (23) [Station 1 (2 on 05.VII.2010; 6 on 04.VIII.2010); Station 2 (3 on 04.VIII.2010); Station 3 (1 on 05.VII.2010; 3 on 04.VIII.2010); Station 4 (2 on 05.VII.2010; 4 on 01.IX.2010; 2 on 11.X.2010), in channels (24) [Station 1 (9 on 03.V.2010; 1 on 04.VIII.2010; 1 on 01.IX.2010); Station 2 (3 on 07.IV.2010; 3 on 03.V.2010; 2 on 01.IX.2010; 1 on 16.XII.2010); Station 4 (2 on 03.VI.2010; 1 on 04.VIII.2010; 1 on 01.IX.2010)] and in the spring (1) [Station 3 (1 on 03.VI.2010)].

Helochares lividus (Forster, 1771)

IDENTIFICATION - According to the description provided by MART *et al*. (2010).
LENGTH - 4.5-6.5 mm.
BIOLOGY - *H. lividus* is detritophilous species occurring predominantly in stagnant, often abundantly vegetated fresh water and very occasionally, on moors (BOUKAL *et al*., 2008). Like in other species in the genus, eggs are carried by the female ventrally on the abdomen (BALKE *et al*., 2004). In northern Europe adults can be found from March to October; egg-carrying females mainly in May, small larvae at the end of May, and pupae in July (HANSEN, 1987). In southern Europe the breeding season can begin in April (VALLADARES *et al*., 1994).
RECORDS - 17 specimens collected in rice paddies (3) [Station 2 (1 on 04.VIII.2010); Station 3 (1 on 04.VIII.2010; 1 on 01.IX.2010)] and in channels (14) [Station 1 (1 on 03.V.2010; 1 on 01.IX.2010); Station 2 (3 on 07.IV.2010; 1 on 05.VII.2010); Station 3 (1 on 05.VII.2010); Station 4 (4 on 03.VI.2010; 3 on 28.II.2011)].

Hydrochara caraboides (Linnaeus, 1758)

IDENTIFICATION - According to the description provided by FRIDAY (1988).
LENGTH - 15.0-18.0 mm.
BIOLOGY - *H. caraboides* is a euryecious species (BOUKAL *et al*., 2008), it lives in stagnant waters or very slow flowing water; usually occurring on very shallow water among leafy or detritus rich substrates (HANSEN, 1987; BOYCE, 2004). The information of adult diet is contradictory as BOYCE (2004) considers it a vegetarian species with a predilection for floating sweet grasses, while BOUKAL *et al.* (2008) consider it a detritophilous one. The beetle uses a film of air stored on the abdomen, coated with a dense pubescence to survive underwater. This air store gives the silvery appearance that has resulted in its common name of silver water beetle. The egg cocoon, made of white silk and tent-shaped, is extremely cryptic: when wrapped with a leaf it looks like a floating leaf. Even if adults are good swimmers, swimming seems to take place only as an escape mechanism, when the beetle is disturbed, and certainly in captivity. The species usually moves about by clambering through submerged detritus and on floating sweet grass (BOYCE, 2004). HANSEN (1987) reported the life cycle of *H. caraboides* in Scandinavia: the eggs are laid in spring or early summer; larvae are found from May to July. In northern Europe and also in Italy the adults normally hatch in summer, although they can occasionally emerge already in May (ROCCHI, 2011). In Italy *H. caraboides* is considered a vulnerable and a bio-indicator species of water quality (DELLA BELLA *et al*., 2005; RUFFO and STOCH, 2005).
RECORDS - 1 specimens collected in the spring [Station 3 (1 on 05.VII.2010)].

Hydrophilus piceus (Linnaeus, 1758)

IDENTIFICATION - According to the description provided by FRIDAY (1988).
LENGTH - 34-48 mm.
BIOLOGY - *H. piceus* lives in stagnant, rather eutrophic, and well vegetated, clear fresh water with muddy bottom, mainly in rather sunny ponds (HANSEN, 1987). According to GRAFIUS and ANDERSON (1973) the adult is predator while for BOUKAL *et al*. (2008) it is a detritophilous species. HANSEN (1987) reported the life cycle of *H. piceus* in Scandinavia: the eggs are laid in May-June in floating cocoons, normally containing up to 50-70 eggs each. The larvae feed predominantly on snails and are full grown in approximately 4 weeks; pupation occurs in soft humid soil near the edge of the water. The adults emerge in July-August and can live up to three years (VERBERK *et al*., 2008). In Italy, where it is considered a vulnerable as well as a bio-indicator species, little is known about its phenology (DELLA BELLA *et al*., 2005; RUFFO and STOCH, 2005).
RECORDS - 6 specimens collected in rice paddies (3) [Station 3 (2 on 01.IX.2010); Station 4 (1 on 07.IV.2010)] and in channels (3) [Station 3 (1 on 04.VIII.2010; 2 on 11.X.2010)].

Laccobius minutus (Linnaeus, 1758)

IDENTIFICATION - According to the description provided by FRIDAY (1988).
LENGTH - 2.6-3.2 mm.
BIOLOGY - *L. minutus* is a euryecious species (BOUKAL *et al*., 2008) present in almost all types of fresh waters and also in brackish ones (HANSEN, 1987). It is a detritophilous species, living in shallow well-vegetated water (FOSTER and EYRE, 1992; BOUKAL *et al*., 2008). HANSEN (1987) reported the life cycle of *Laccobius minutus* in Scandinavia with adults present in January and from March to October, larvae at the end of June,

and pupae and newly emerged adults in July. Little is known about the cycle in Italy.
RECORDS - 20 specimens collected in rice paddies (5) [Station 2 (4 on 05.VII.2010); Station 4 (1 on 11.X.2010)], in channels (13) [Station 2 (8 on 07.IV.2010; 1 on 04.VIII.2010); Station3 (1 on 03.V.2010; 2 on 05.VII.2010); Station 4 (1 on 03.VI.2010)] and in the spring (2) [Station 3 (2 on 11.X.2010)].

DISCUSSION

The current study highlighted that rice agro-ecosystem can encourage the settlement of many water beetles belonging to different ecological niches. Many species find in channels and in rice fields the perfect conditions to survive for at least a period of their life, migrating to more suitable habitat when conditions become unfavourable. Among these there are Dytiscidae, Hydrophilidae, Haliplidae and Dryopidae, having adults characterized by a strong flying ability that allows the recolonization of aquatic habitats after periods of drought (LAYTON and VOSHELL, 1991; ROSSI *et al*., 2003; OERTLI *et al*., 2005; RIGHI-CAVALLARO *et al*., 2010) and Elmidae, resistant to dry periods in the larval instar (ROSSI *et al*., 2003). The Dytiscidae *H. geminus* and *Laccophilus minutus,* behaved as pioneers rapidly colonizing the newly flooded paddies. On the contrary, *H. lineaticollis*, referred to as a pioneer species and also as one of the most common Haliplidae in Lombardy (ANGELINI, 1984) was rarely collected and never in rice fields. Few species were abundant in the habitats considered in this study, while the majority were detected occasionally and with few specimens. However it is known that in an ecosystem the number of the recedent and subrecedent species can contribute to an increase in diversity, despite the small number of individuals. The detection of infrequent species, with no apparent contributions to community stability or ecosystem functioning, draws attention to the role that these environments play in biodiversity. Infrequent species can have been underestimated in the environments considered, hence the index application by CHAO *et al*. (2005) led to the conclusion that rice paddies and channels contribute to water beetle biodiversity in the same way. Major differences are evidenced in rice paddies independently from management strategies. However the period of flooding is only one of the factors influencing the community of water beetles as human activities can influence other variables such as chemical and physical characteristics of the water and food availability, but it is hard to separate the different sources of stress as they are strongly related. Considering the alimentary regimes of the adults collected it should be noted that the species found have different food specializations according to the habitat: the rice paddies and the natural spring are colonized predominantly by herbivores, while channels contain carnivorous species.

Seasonal dynamics of water beetles in Italian rice paddies therefore depends on the species, on the seasonal climatic trends, and on the habitat. The eudominant species *H. geminus* occurred throughout the year, in agreement with the phenology of the species. *Laccophilus minutus*, *H. heydeni*, *B. frontifoveatus*, *B. signaticollis*, *E. quadripunctatus*, and *H. lividus* were captured frequently throughout the year (7-10 months). These captures add information to the few present in the Italian literature: *Berosus* specimens were collected in all the habitats all over the year with the exception of June, November, December and January for *B. frontifoveatus*, and March, July, December and January for *B. signaticollis;* similarly *E. quadripunctatus* was found during all the year in all the habitats with the exception of January, February, March and November. The detection of *H. lividus* from February to October confirms the information related to the phenology in southern Europe where the breeding season begins in April (VALLADARES *et al*., 2002). It remains to verify if the lack of captures in some months is due to the life cycle of the species considered or to a natural decrease in the population resulting in a failure in the capture. This should be the case of *L. hyalinus*; *Laccophilus minutus*, *L. poecilus*, *R. suturalis*, *H. heydeni*, *H. laminatus*, *P. caseus*, *L. volkmari*, and *H. brevipalpis*, which were recorded as present throughout the year in literature (HANSEN, 1987; NARDI, 2004; TOLEDO, 2006; PEREZ-BILBAO *et al*., 2010).

The occurrence of *H. fulvus* for five consecutive months (May to September) and of *Laccobius minutus* from April to October, seems to confirm that these two species are monovoltine also in southern Europe (HANSEN, 1987; HOLMEN, 1987). Similarly the capture of *D. luridus* from June to September confirms the assumption by CORNACCHIA and FACCOLI (2004).

Some species, poorly studied, were only sporadically collected making it difficult to perform assessment on their phenology, on their autoecology and on their capability to adapt to environments subjected to strong anthropogenic impacts, such as rice paddies. Probably some of these were not constant members of this taxocoenosis and were only accidentally found. In addition the different distributions of some species in the habitat considered can be influenced by their aptitude to adapt to different water flow. The majority of the species collected are considered in literature as lentic or facultative species; only *A. guttatus* and *L. hyalinus* belong to the lotic habitats. Therefore it is unusual to find *L. hyalinus* in a lentic habitat such as the rice fields, and also the discovery of *L. poecilus* in a lotic habitat of the natural spring.

This research suggests that rice agro-ecosystem can host a complex community of water beetles, which find in both the flooded paddies and the surrounding environment suitable conditions to live and reproduce. Hence this system should be protected in relation to the presence of rare and vulnerable species.

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