Agriculture, Ecosystems and Environment 195 (2014) 120–126

Contents lists available at ScienceDirect

Agriculture, Ecosystems and Environment

journal homepage: www.elsevier.com/locate/agee

Effects of grass management intensity on ground beetle assemblages in rice field banks

Elisa Cardarelli*, Giuseppe Bogliani

Department of Earth and Environmental Science, University of Pavia, Via Ferrata 9, 27100 Pavia, Italy

ARTICLE INFO

Article history:
Received 24 October 2013
Received in revised form 9 May 2014
Accepted 11 May 2014
Available online 24 June 2014

Keywords:
Carabidae
Functional group
Cutting
Agroecosystem
Northern Italy

ABSTRACT

Within the framework of a general decline in farmland biodiversity, sustainable management of field boundaries and margins has been widely recognized as one of the key approaches for incorporating conservation strategies within agronomic practices. The creation and sympathetic management of edges could improve abundance, diversity, and functional composition of farmland communities. Moreover, many species of arthropods inhabiting these habitats are natural enemies of crop pests and could play a valuable role in biological control. The aim of this research was to investigate the response of ground beetle assemblages to different management regimes in the rice field banks of an intensive agricultural area of northern Italy. Between May and November 2010, we collected carabids in 13 paddy banks (5 uncut, 4 mown twice, 4 cut monthly during June–September) by means of pitfall traps. Frequent cutting operations favoured assemblages dominated by generalist, mobile species, while more specialized ground beetles, such as predatory and short-winged ones, were associated with an absence or low levels of human disturbance. Our results suggest that environmentally friendly managed banks could help to ameliorate the persistence of species with poor dispersal ability and predator populations. Management implications for ground beetle conservation in rice ecosystem are discussed.

1. Introduction

In agricultural landscapes, increasing habitat quality and landscape heterogeneity are considered to be of great importance to restore, sustain, and enhance biodiversity (Benton et al., 2003). Sympathetic management of field margins and boundaries has been recognized as one of the key approaches for combining benefits for biodiversity with the economic viability of agriculture (Marshall, 2002; Woodcock et al., 2008; Vickery et al., 2009). As a consequence, field margins are often one of the target elements of conservation measures.

The creation and sustainable management of edges could improve abundance, diversity, and functional composition of farmland communities (Thomas and Marshall, 1999; Griffiths et al., 2007; Woodcock et al., 2007), even if it might not be enough for the re-establishment of some group of specialized species (e.g. forest species, Fournier and Loreau, 2001). Field margins and boundaries provide foraging and breeding sites, overwintering habitats, and refuge from detrimental agronomic practices for wildlife (Marshall and Moonen, 2002). Moreover, many species of arthropods found in these habitats are natural enemies of crop pests and could play a valuable role in biological control and integrated pest management (Symondson et al., 2002). Field enlargement to increase agricultural production, however, has led to the progressive loss of these linear features (Stoate et al., 2001; Robinson and Sutherland, 2002), while mechanical removal and the use of chemicals to control weeds and pests has drastically reduced margin suitability for farmland wildlife (Vickery et al., 2009).

Rice fields are recognized worldwide as surrogate habitats for wetland species (Fasola and Ruìz, 1996; Czech and Parsons, 2002; Bambaradeniya et al., 2004; Leitao et al., 2007). The rice ecosystem is composed by three distinct habitats (Bambaradeniya et al., 2004): (1) the rectangular or similar shaped flooded fields; (2) the surrounding banks (also called bunds or levees), which are earthen-made strips about 1 m wide, that enclose water and separate adjacent fields; (3) irrigation canals and ditches. Paddy and ditch banks are part of the habitat complexes on which rice field fauna depend. Some birds nest in the strips of natural vegetation that develop along paddies and irrigation canals (Pierlussi, 2010),

* Corresponding author. Tel.: +39 0832986303.
E-mail addresses: elisa.cardarelli@unipv.it (E. Cardarelli), giuseppe.bogliani@unipv.it (G. Bogliani).

http://dx.doi.org/10.1016/j.agee.2014.05.004
0167-8809/

while others' field use is affected by the amount of spontaneous flora in the surrounding bunds (e.g. Great Bittern, Longoni et al., 2011). Paddy banks also support high activity densities of some arthropod species (e.g. spiders, Tahir and Butt, 2009), among which there could be important predators of rice pests (Way and Heong, 1994, 2009). Nevertheless, bunds are usually heavily managed by farmers, and vegetation is chemically or mechanically removed for different reasons: to allow an easy control of the inlet and outlet of paddy floodwaters, to contain weeds, and, sometimes, to make fodder for animals. In some cases, banks are periodically short-trimmed only to maintain them as "tidy" (Macdonald and Johnson, 2000). The result is often a strip dominated by resistant grasses (e.g. Poaceae, Cyperaceae, Asteraceae, *Convolvulus* sp., *Trifolium* sp.) or a belt of bare soil. For all we know, even if evidences exist on the essential role that vegetated bunds could have in the maintenance of a functioning rice ecosystem (Longoni et al., 2011; Naito et al., 2013), no studies were specifically focused on the effect of human disturbance, such as mowing, herbicide application, or chemicals drifting from adjacent fields, on bank's fauna.

Ground beetles (Coleoptera, Carabidae) are one of the most common and species-rich families of surface-active arthropods in agricultural landscapes and constitute a key component of farmland communities: some species prey on crop pests (Ghahari et al., 2009; Symondson et al., 2002), others are food sources for birds and mammals (Holland et al., 2006; Jaskuła and Soszyńska-Maj, 2011), and some others are of conservation interest on their own. This taxon is often used as environmental indicator of human impact and habitat quality (Luff, 1996; Kromp, 1999; Brandmayr et al., 2005; Koivula, 2011), and extensive literature is available on the effect of agricultural practices on diversity, density, and assemblage structure of carabids (Burel et al., 1998; Holland and Luff, 2000; Cole et al., 2002; Maisonhaute et al., 2010). In particular, ground beetle species that compose a community exhibit life-history traits strictly linked to land management intensity (Ribera et al., 2001), and morpho-ecologically based analysis often allow a better understanding of environmental disturbance effects than species richness and composition alone (Cole et al., 2002; Gobbi and Fontaneto, 2008). Species richness could even be a misleading parameter for the evaluation of anthropic pressure: in Italian agroecosystems, Gobbi and Fontaneto (2008) found out that carabid richness is positively related to human impacts, due to the presence of an higher number of pioneer, opportunistic species in perturbed sites. On the contrary, studies on the relationship between life-history traits and intensity of farming consistently predicted that wingless, large and strictly predatory species are negatively related to human impact (Ribera et al., 2001; Gobbi and Fontaneto, 2008; Barbaro and van Halder, 2009). Conversely, mobile, omnivorous and small species are expected to better perform in disturbed and fragmented habitats thanks to their major dispersal ability, capability to use different food resources, and higher probability to complete their life cycle due to the shorter larval stage.

This paper describes the responses of ground beetle communities to different cutting regime of grass on rice field banks. Timing and intensity of mowing influence arthropod assemblages both in grassland (Morris, 1979; Morris and Plant, 1983; Morris and Rispin, 1987; Volkl et al., 1993) and along field margins of arable lands (Feber et al., 1996; Baines et al., 1998; Woodcock et al., 2007, 2008). In those studies, diversity and abundance of arthropods were usually lower in plots where vegetation was removed in respect to control plots, where no grass management occurred. Analogously, we hypothesized that ground beetles assemblages of rice field banks could be disrupted by mechanical control of vegetation. In particular, we aimed to test if bunds subjected to no cutting of herbaceous cover during the vegetative period can host more specialized carabids, i.e. wingless, large and predatory, than cut banks, by providing shelter from disturbance.

2. Materials and methods

2.1. Study area

The study was carried out in a 2.5 km^2 rice field area in the middle of the Po plain located in north-western Italy approximately 13 km north from the city of Pavia (45°17′21.77″ N, 09°09′26.19″ E).

During 2010, ground beetles were sampled in thirteen banks along the perimeter of separate rice fields. Banks were naturally vegetated and hosted on average 5.3 (±0.6) herbaceous species, belonging to 11 families. Poaceae (48.3%), Cyperaceae (16.6%), Asteraceae (12.9%) and Fabaceae (12.3) were the most abundant taxa; dominant species were *Setaria* sp. (39.3%), *Carex* sp. (16.6%), *Trifolium pratense* (10.3%) and *Taraxacum officinale* (6.3%).

Banks differed in the amount of human disturbance they underwent during the vegetative period:

(1) unmanaged banks ($n = 5$) were characterized by a permanent herbaceous cover. No control of spontaneous vegetation occurred;
(2) low-managed banks ($n = 4$), where grass were mown twice, once in early July and once in early September. Stems were cut in a single piece at a few centimetres above the ground level, left in situ to dry for some days, and then removed to use as animal food;
(3) high-managed edges ($n = 4$), where grass were cut once a month from June to September. Plants were cut at the ground level, reduced in small pieces, and left in situ.

No chemical control of wild plants occurred during the study period, but all bunds could have been affected by the drift of herbicides used in the adjacent rice fields. The banks have been managed under the selected practices for at least three years before the beginning of the study.

2.2. Data collection

Carabids were sampled using plastic pitfall traps (62 mm in diameter and 70 mm deep) buried in the soil and filled with 50 ml of wine vinegar and a drop of detergent. Traps were covered with a 10 cm × 10 cm wooden roof to prevent flooding. A row of four traps spaced at 10 m intervals was placed in the centre of each boundary. Ground beetle communities were sampled from early May until early November 2010, and pitfalls were emptied fortnightly.

Carabids were identified at the species level following the nomenclature of the Fauna Europaea web project (Vigna Taglianti, 2010), and the following morpho-ecological information was collected for each species: (1) wing development, (2) body size, (3) adult diet. Data on wing development and body size was derived from Hůrka (1996). Presence of functional wings (metathoracic alae) was checked for the dimorphic species: individuals with wings longer than the elitrae were considered macropterous, whereas individuals with wings shorter than the elitrae were considered brachypterous (Brandmayr et al., 2005). Species diet was established according to Brandmayr et al. (2005), Purtauf et al. (2005), Melis et al. (2009), Bettacchioli et al. (2012), Vanbergen et al. (2010) and the Carabids.org web project (Homburg et al., 2013).

Ground beetles were grouped on the basis of their morpho-ecological features. As for wing morphology, all species were classified as brachypterous and macropterous, and consequently have low and good dispersal ability respectively (Brandmayr et al., 2005). Although in *Calathus melanocephalus*, *Patrobus atrorufus* and