Estuarine, Coastal and Shelf Science 157 (2015) 99–108

Contents lists available at ScienceDirect

Estuarine, Coastal and Shelf Science

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

Two faces of agricultural intensification hanging over aquatic biodiversity: The case of chironomid diversity from farm ponds vs. natural wetlands in a coastal region

Encarnación Fenoy [a], J. Jesús Casas [a, b, *]

[a] Department of Biology and Geology, ceiA3 & ceiMar, University of Almería, 04120 Almería, Spain
[b] Andalusian Centre for the Evaluation and Monitoring of Global Change, CAESCG, 04120 Almería, Spain

A R T I C L E I N F O

Article history:
Received 27 May 2014
Accepted 3 March 2015
Available online 11 March 2015

Keywords:
Chironomidae
diversity
transitional waters
shoreline heterogeneity
Spain
Andalusia
Almería coast

A B S T R A C T

Increasing agricultural land use and intensification have given rise to the loss and eutrophication of coastal wetlands worldwide. In Mediterranean coastal regions, irrigated agriculture, in turn, has prompted the proliferation of farm ponds which might compensate for wetland loss and degradation if their management regimen results are compatible with biodiversity conservation. Here, we studied regional (γ-), local (α-) and interlocal (β-) diversities of chironomids in coastal wetlands and irrigation ponds from a Mediterranean region, to determine the contribution of each habitat type to regional diversity, and to disentangle which environmental factors, anthropogenic or natural, contributed most to explain diversity patterns. Regional diversity was slightly, but still significantly, higher in natural wetlands than in farm ponds, which can be attributed to the significantly higher β-diversity in natural wetlands, since, despite the much larger surface area of wetlands, both habitat types did not differ in local diversity (α-diversity). In both habitats, however, the contribution of β-diversity to regional diversity was higher compared to that of α-diversity, and the component 'spatial species turnover' exceeded that of the component 'nestedness' of β-diversity. This, together with an outstanding assemblage complementarity (approx. 50%) between habitat types, emphasizes the vital contribution of farm ponds, together with natural wetlands, to regional diversity. Despite the higher salinity and eutrophication of natural wetlands that tended to reduce diversity in chironomid assemblages, their more heterogeneous shore line likely compensated somewhat for such negative effects. Unlike wetlands, the homogeneous and unvegetated shore of farm ponds, in conjunction with their intensive management, probably induced adverse effects on local and interlocal diversity. Specific recommendations are given in this regards to mitigate impacts and improve the value of both habitats for biodiversity conservation.

© 2015 Elsevier Ltd. All rights reserved.

1. Introduction

Coastal wetlands are suffering biodiversity losses as a consequence of critical eutrophication processes caused by diffuse pollution from agricultural run-off and/or point-source inputs of inadequately treated urban wastewaters that have proliferated over recent decades (e.g. Boix et al., 2008; Casas et al., 2012; Deegan et al., 2012). Given the increasing agricultural land use and intensification in many regions, achieving optimal compatibility between agricultural production and biodiversity conservation has become a paramount global challenge (e.g. Tscharntke et al., 2012). Concerns on these issues have been reflected in the recent European Union resolution aimed at halting the loss of biodiversity and the degradation of ecosystem services by 2020, which particularly emphasise the need for intervening forthcoming reforms of the common agricultural policies (EU, 2011). The current debate on how to reconcile (reconciliation ecology sensu Rosenzweig, 2003) agricultural production and biodiversity conservation is polarized by two seemingly alternative options, 'land sparing' vs. 'land sharing'. The first advocated for maximizing yields in homogeneous intensive farmland areas but maintaining separate nature reserves, while the second targets integrating in heterogeneous landscapes both biodiversity conservation and farming founded upon environmentally-friendly practices (Fischer et al., 2008).

* Corresponding author. Department of Biology and Geology, ceiA3 & ceiMar, University of Almería, 04120 Almería, Spain.
E-mail address: jjcasas@ual.es (J.J. Casas).

http://dx.doi.org/10.1016/j.ecss.2015.03.003
0272-7714/© 2015 Elsevier Ltd. All rights reserved.

The recent land use strategies in Mediterranean countries have been apparently closest to the land sparing model in which a poor integration of environmental conservation and agricultural policies leads to natural preserves, sometimes 'highly' protected under diverse legal status, while EU funds promoting the expansion and intensification of agriculture often in, or encroaching, areas of high conservation value. This failure is particularly severe in Mediterranean coastal wetlands of Spain, where the expansion and intensification of agriculture and the proliferation of urbanizations for tourism have caused a large scale loss and degradation of these ecosystems, despite many of them being protected legally, although not in practice, for decades (Amezaga and Santamaría, 2000; Serrano and Zunzunegui, 2008; Casas et al., 2011a).

In these coastal areas, intensive agriculture has in turn created thousands of small in-farm ponds offering an opportunity for aquatic biodiversity conservation, if they act as refuges from disturbances in natural wetlands (see review by Chester and Robson, 2013). These ponds store irrigation water often free of eutrophication, but of lower salinity than natural coastal wetlands, thus hypothetically acting as complementary rather than alternative habitats to the coastal wetlands for the regional species pool (Casas et al., 2012). However, the management regime to which these farm ponds are subjected in intensive farming areas, characterized by frequent water-level fluctuations, periodic biocide (i.e. copper sulfate) applications and dredging, besides their construction characteristics (Juan et al., 2012), are likely to hamper their function for biodiversity conservation (Fuentes-Rodríguez et al., 2013).

The Chironomidae is an abundant, diverse and ubiquitous family of insects in the benthos of wetlands, with high indicator value when identified to species level, therefore useful to track changing natural conditions and anthropogenic impacts on aquatic ecosystems (e.g. Porinchu and McDonald, 2003), including Mediterranean coastal wetlands (Cañedo-Argüelles et al., 2012).

This study aims to analyze how two faces of agricultural intensification— i.e. the eutrophication of coastal wetlands together with the proliferation of intensively managed irrigation ponds—affect local (α-) and inter-local (β-) diversity, and how they interplay configuring regional diversity of chironomid species. We hypothesized that despite the structural simplicity and intensive management of irrigation ponds, they may still be valuable to improve regional diversity of chironomids under the current situation of eutrophication of coastal wetlands.

2. Material and methods

2.1. Study area

We studied a total of 22 farm ponds and 16 natural wetlands, all located in the littoral of the province of Almería (southeast of Spain) (Fig. 1). This region has a semi-arid Mediterranean climate (average annual precipitation between 190 and 300 mm), with relatively hot summers and mild winters (average annual temperature 18 °C). Since the 1980s, this area harbors one of the world largest greenhouse concentrations dedicated to out-of-season vegetable production, and the largest area in Europe (27,000 ha in 2010) (Casas et al., 2014). This gave rise to the construction of many private artificial irrigation ponds (approx. 9000 ponds; Casas et al., 2011b) to ensure the water supply for drip-irrigation. Groundwater is the main water source, but due to severe long-term groundwater imbalances, alternative water sources are increasingly used (recycled wastewater, rainwater collected from greenhouse covers and desalinized water) (Juan et al., 2012). These ponds are made of artificial substrata (reinforced concrete or hollows lined with plastic film) with pronounced slope angle at the margins (over 65° on average), which impedes the settlement of hydrophytic marginal vegetation, have small surface area (Appendix A) and are shallow (between 1.5 and 4 m depth). Their small size and primary function for irrigation determine marked water-level fluctuations and short water turnover time (~30 d) (Juan et al., 2012). Moreover, ponds are managed by farmers with varying frequency and intensity, using two main procedures: pond dredging (in summer, at the end of the crop season) and application of biocides: i.e. copper sulfate, more often in early autumn at the onset of the crop season, using an average dose of 15 ppm $CuSO_4$ y^{-1} (more detailed information is given in: Juan et al., 2012; Bonachela et al., 2013).

Most natural wetlands in the area are located along the coast, show much larger surface area than farm ponds (Appendix A), are permanent and shallow (<3 m depth). However, these wetlands are widely varying with regards to their origin and hydrological functioning, and can be essentially grouped in four main types: coastal lagoons in deltas, lagoons at the mouth of ephemeral rivers, abandoned salt pans and marshes (Ortega et al., 2000). Despite this heterogeneity, their hydrological functioning can be approximately summarized as fundamentally dependent on the balance among continental discharges (from aquifer and/or flood events in flushed systems), seawater intrusion and evaporation. Thus, these wetlands often exhibit high levels of eutrophication, due to aquifer or surface water contamination with agricultural run-off, and/or their water shows relatively high salinity when sea water intrusion and/or evaporation are important (Ortega et al., 2000; Casas et al., 2012).

2.2. Physical and chemical characterization of waterbodies

Surface area, perimeter, shoreline complexity (the ratio waterbody perimeter:perimeter of the circumference of a circle with the same area of the waterbody), and the %perimeter with marginal vegetation of each water body (Appendix A) were determined from digital orthophotos (2007) by means of the geographical information system ArcGIS (ESRI, 2010).

We carried out a field survey of farm ponds and natural wetlands during spring 2007 (April and June). In each water body and sampling event, we measured electric conductivity and pH in situ with a multi-parametric probe (Hanna, model 9828, Padova, Italy). A 2 L water sample was taken integrating the depth profile. A volume between 0.25 and 1 L was filtered (APFC, Millipore, Billerica, MA, USA) in the field. The filter, with the algae retained, was used to measure chlorophyll *a* (trichromatic method using acetone extracts; Wetzel and Likens, 2000), which was taken as a proxy of phytoplankton biomass. The remaining unfiltered water volume was transported (4 °C) to the laboratory and frozen (−20 °C) until analyzed. In this water we determined total nitrogen (TN) and total phosphorus (TP) by standard methods described in APHA (2005). The two measurements (April and June) of physic-chemical variables taken in each water body were averaged for statistical analyses.

2.3. Chironomid sampling and species identification

We collected chironomid pupal exuviae twice (April and June) in each water body during spring 2007. In spring most chironomid species emerge in Mediterranean coastal wetlands (e.g. Cañedo-Argüelles et al., 2012) and it is likely that the most mature community stage occurs in the studied farm ponds, before dredging (early summer) and long after the application of biocides (early autumn). Samples were collected following the CPET protocol (Chironomid Pupal Exuviae Technique: Wilson and Bright, 1973; Further details at: http://www.wiser.eu/results/method-database/): we used a handnet (250 μm mesh size) to scoop floating material along leeward shores and, in general, in all shoreline areas where accumulation of floating debris and foam were observed. A

Download English Version:

https://daneshyari.com/en/article/4539490

Download Persian Version:

https://daneshyari.com/article/4539490

Daneshyari.com