Estuarine, Coastal and Shelf Science 197 (2017) 1–9

Contents lists available at ScienceDirect

Estuarine, Coastal and Shelf Science

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

Spatio-temporal structure and influence of environmental parameters on the Tipuloidea (Insecta: Diptera) assemblage of Neotropical salt marshes

Lucas Rodrigues [a, b, *], Daiane Carrasco [c], Maíra Proietti [b]

[a] Laboratório de Crustáceos Decápodes, Instituto de Oceanografia, Universidade Federal do Rio Grande, FURG. Av. Itália, km 8, CEP: 96203-000, Rio Grande, RS, Brazil
[b] Laboratório de Ecologia Molecular Marinha, Instituto de Oceanografia, Universidade Federal do Rio Grande, FURG. Av. Itália, km 8, CEP: 96203-000, Rio Grande, RS, Brazil
[c] Laboratório de Genética, bloco 5, Instituto de Ciências Biológicas, Universidade Federal do Rio Grande, FURG. Av. Itália, km 8, CEP: 96203-000, Rio Grande, RS, Brazil

ARTICLE INFO

Article history:
Received 15 March 2017
Received in revised form
25 July 2017
Accepted 6 August 2017
Available online 8 August 2017

Keywords:
Assemblage structure
Crane-flies
Diversity
Seasonality
Symplecta pilipes

ABSTRACT

Estuaries and salt marshes are important coastal ecosystems that present unique characteristics in terms of nutrient cycling, salinity, habitats, flora and fauna. Despite their ecological importance, there is scarce knowledge on the occupation, distribution and ecology of insects, including Tipuloidea, in these environments. This study aimed to evaluate the composition, seasonality and effect of abiotic factors on the abundance, diversity and structure of a Tipuloidea assemblage at the Patos Lagoon salt marshes, located at the south of the Neotropical region. We sampled crane-flies from three zones along the estuary by installing two Malaise traps at the low and high vegetation strata of each zone. Sampling was conducted uninterruptedly every fifteen days between August/2015 and July/2016, and collected insects were identified morphologically based on specific literature. 5248 crane-flies were identified covering six species and twenty-five morphospecies. Abundance and frenquency of occurrence of species revealed a gap in the presence of constant species at the middle estuary. *Dicranomyia*, *Gonomyia*, *Teucholabis* and *Zelandotipula* species were additional (accessory) species only in the upper estuary, while *Symplecta cana* only in the lower estuary. This shows that different species prefer distinct points along the estuary. Higher abundance of crane-flies was correlated with elevated temperature and humidity. *Symplecta pilipes* was an exception, presenting increase in abundance under lower temperatures. Seasonal change in Tipuloidea species composition was observed, with higher evenness of *Dicranomyia*, *Geranomyia*, *Rhipidia domestica* and *Symplecta cana* (15–20%) during summer, and dominance of *Symplecta pilipes* in winter (80%). The gap at the middle estuary can possibly be due to stress caused by large fluctuations in salinity in the zone. In addition, the seasonal differences can have significant ecological consequences such as the modification of the Tipuloid species that compose the detritivorous and/or succivorous trophic guild, and consequently influence the upper trophic levels of the salt marsh environment.

1. Introduction

Coastal ecosystems represent vast areas around the globe, and present singular characteristics in terms of nutrient cycling, climate changes, geomorphological characteristics and composition of fauna and flora (Lalli and Parsons, 2006; Rezende et al., 2009). Among these environments, estuarine complexes are dynamic bodies of water with a marine and freshwater interface created by freshwater discharge and intrusion of saltwater from the ocean, leading to unique species composition and distribution. These communities require high physiological plasticity to tolerate the highly variable physical-chemical parameters (Williams and Williams, 1998; Berezina, 2003; Silberbush et al., 2005; Chainho et al., 2006).

Salt marshes are common in estuarine ecosystems, and are

* Corresponding author. Laboratório de Crustáceos Decápodes, Instituto de Oceanografia, Universidade Federal do Rio Grande, FURG. Av. Itália, km 8, CEP: 96203-000, Rio Grande, RS, Brazil.
E-mail address: lucasentomologia@gmail.com (L. Rodrigues).

http://dx.doi.org/10.1016/j.ecss.2017.08.002
0272-7714/

known for their high productivity. The water that permeates this vegetation carries organic matter into the estuary/ocean, and has an important ecological role in sustaining aquatic food webs (Boesch and Turner, 1984; Huiskes, 1988; Polis et al., 1997; Costa and Marangoni, 2010). *Spartina* species are commonly the dominant halophyte vegetation in Atlantic salt marshes (Pennings et al., 2005), mainly of the low vegetation stratum, and present a wide diversity of organisms associated with their roots and stalks (Curado et al., 2014) due to the abundant organic plant matter, creating a favorable niche for suspension and deposit-feeders, as well as decomposers. Pennings and Bertness (2001) estimate that around 10% of the carbon fixed in this environment flows through such organisms. At the high marsh stratum, vegetation is mostly shrubbery and provides refuge, shade and food for animals, including insects. Aquatic plants and animals are influenced mainly by two factors: tide and/or salinity oscillation (Wilson et al., 2015). The multiple combinations of these factors, together with the distance to estuarine or marine waters, creates a stratified mosaic of plant species known as high and low vegetation marshes (Costa and Marangoni, 2010). However, daily tides can vary geographically: for example, salt marshes along the Western coast of the United States are subjected to 200–300 cm oscillations (Pennings and Bertness, 2001), while salt marshes along the Gulf of Mexico and the Patos Lagoon estuary (Brazil) only experience variations of 20–40 cm (Stout, 1984; Costa and Marangoni, 2010). At these latter regions, salinity is the main abiotic parameter that influences how salt marshes are structured in terms of flora and fauna.

Insects are the most diverse and abundant group inhabiting salt marshes, with significant ecological functions (Cheng, 1976). For instance, ants and beetles have an important role in the aeration of upper soil layers (Pétillon et al., 2008; Dummel et al., 2011; Bolico et al., 2012; Mourglia et al., 2015). Additionally, Insecta is one of the few groups capable of directly transferring energy from the aquatic to the terrestrial environment, since many species have aquatic larvae and winged-terrestrial adults (Keltz, 1979; Polis et al., 1997). This is the case of flies and gnats, which are the dominating insects of salt marsh ecosystems (Cameron, 1972; Kubátová-Hiršová, 2005). Despite the abundance and importance of Insecta for salt marshes, little is known on the ecology, diversity and distribution patterns of insects at these environments.

The abundance of insects is highly seasonal, with marked fluctuations at temperate zones where seasons are well defined (Wolda, 1988; Silva et al., 2011; Kishimoto-Yamada and Itioka, 2015). This is due to their direct relation with temperature, humidity, and precipitation (Gonçalves-Alvim and Fernandes, 2001; Oliveira et al., 2006; Carrasco et al., 2014). Wind intensity is also an important variable since it carries winged insects to other areas or forces their landing, especially in the case of large species with wide wingspans such as those of the Tipuloidea superfamily (3–36 mm; Gelhaus, 2009).

Tipuloidea, also known as crane-flies, is the largest fly superfamily (Oosterbroek, 2017), and its representatives are usually associated with humid ecosystems, such as the margins of bodies of water. Their aquatic or semi-aquatic detritivorous larvae occupy a wide range of habitats, while adults are found on adjacent vegetation (Gelhaus, 2009), which makes salt marshes a potential nursery for this family. The aquatic larval phase could represent an important source of energy transfer between the marine/estuarine environment and organisms that occupy upper trophic levels of salt marshes (e.g. birds, amphibians, spiders and other invertebrates). The adult phase is relatively short when compared to the larval phase, many species do not feed during this period, but instead use it for dispersion, nuptial flight and oviposition (Pritchard, 1983). This short timeframe is advantageous for establishing the influence of abiotic factors on crane-flies assemblages, and better understanding their flight and reproduction. For example, most adult crane-flies present peak abundance in the summer and spring, when temperature and humidity are high (Freeman, 1968; Freeman and Adams, 1972; Pritchard, 1983); however, some species can flourish during the winter, being capable of tolerating even freezing (Vanin and Masutti, 2008; Taschereau et al., 2009; Hågvar et al., 2010).

Despite the importance of Tipuloidea to salt marshes and trophic webs, their distribution and ecology in these ecosystems, as well as their response to different environmental factors, is poorly understood (Pritchard, 1983). This study therefore aimed to better understand ecological aspects of crane-flies, and how they respond to environmental factors. To achieve this, we evaluated density, diversity and distribution of these insects between seasons (climate variation), zones (distance from saltwater) and strata (vegetation composition) of salt marshes at the Patos Lagoon Estuary, in South Brazil. We also evaluated the influence of environmental factors such as temperature, humidity, wind velocity, salinity and precipitation on the studied crane-fly assemblages.

2. Materials and methods

2.1. Study area

The Patos Lagoon Estuary in South Brazil presents vast salt marshes, dominated by few plant species: in the low vegetation stratum (low marsh) by *Spartina alterniflora* and *Spartina densiflora*; in the high vegetation stratum (high marsh) by *Scirpus maritimus*, *Scirpus olneyi* and shrubs (including *Myrsine parvifolia*) (Costa et al., 2003). Three salt marsh zones of the estuary were selected for sampling, approximately 13 km from each other (Fig. 1). The first zone was at Torotama Island located in the Upper Estuary (UE) (31° 55′ 9.649” S; 52° 8′ 25.300” W). This island has around 40 km in extension, is covered almost exclusively by salt marshes, and has the highest lacustrine influence (~26.5 km from estuary mouth). The second zone was more central, located at Pólvora Island (~14 km from estuary mouth) in the Middle Estuary (ME) (32° 1′ 19.538” S; 52° 6′ 17.971” W). The marshes of this point present a clear stratification between high and low vegetation strata. The third zone, at the estuary mouth and with the highest marine influence, was at the Barra Villa, Lower Estuary (LE) (32° 9′ 13.028” S; 52° 6′ 21.629” W). The low tide oscillation and large seasonal variation in precipitation (Costa and Marangoni, 2010) lead to irregular flooding of these salt marshes, configuring hypersaline conditions during summer and oligo-mesohaline conditions throughout winter (D'Incao et al., 1992).

2.2. Sampling

Tipuloidea were sampled by installing two Malaise traps (one in each vegetation stratum; 1.5 m height; ~0.20 km from each other) at each zone, close to the dominant vegetation, in a total of six traps. These traps function by intercepting flight, and are ideal for Tipuloidea due to their lack of selectivity, leading to a representative capture of species with high reliability for seasonality studies (Kishimoto-Yamata and Itioka, 2015). Sampling was conducted every fifteen days over twelve months, from August 2015 to July 2016. Some samples were lost (26%) due to winds and storms, leading to a total of 107 samples (38 UE, 38 ME, 31 LE). Collection cups containing 70% alcohol were changed every fifteen days (throughout this paper each collection cup corresponds to one sampling unit) and collected insects were taken to the laboratory for morphological identification using a magnifier and stereoscopic microscope. Insects were then stored in labelled tubes, and after identification were deposited in the collection of the Rio Grande do