Acta Ecologica Sinica 37 (2017) 148–155

Contents lists available at ScienceDirect

Acta Ecologica Sinica

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

Pollinator diversity in different habitats of the agricultural landscape in the middle and lower reaches of the Yellow River based on the three-color pan trap method☆

Meina Wang, Xunling Lu, Shengyan Ding *, Jiayan Ren, Ziqi Bian, Zheng Xu

Key Laboratory of Geospatial Technology For the Middle and Lower Yellow River Regions, Ministry of Education, Kaifeng 475004, China
College of Environment and Planning, Henan University, Kaifeng 475004, China

ARTICLE INFO

Article history:
Received 25 October 2016
Received in revised form 10 March 2017
Accepted 27 April 2017

Keywords:
Pollinator diversity
Color preference
Pan traps
Middle and lower reaches of the Yellow River
Agricultural landscape

ABSTRACT

The middle and lower reaches of the Yellow River constitute one of the most important grain-producing areas in China and strategic position for national food security. The maintenance of pollinator diversity in agricultural landscapes is not only meaningful for biodiversity protection, but also a guarantee of food security and crop production. Pollinators have response preferences to the color of nectar and pollen plants in different habitats. The diversity of pollinator in different habitats was analyzed by using multivariable ANOVA. Results showed that a total of 23,264 individuals were captured, which belong to 7 orders and 84 families. The difference individuals of pollinators in two habitats was highly significant ($P < 0.001$). Approximately twice as many individuals were captured in farmland habitat than that in woodland habitat. The values of the Margalef richness index and the Berger-Parker dominance index were also greater in farmland habitat than that in woodland habitat. In both habitats, differences in pollinator diversity were significantly higher for the yellow traps than that for the other two colors ($P < 0.01$); differences in the individual abundance in the yellow traps are highly significantly greater ($P < 0.001$) than that for the other two colors, while there was no significant difference between the white and blue traps. The sensitivity of orders Diptera and Hymenoptera was greatest to yellow traps, followed by that to white and blue traps, while order Coleoptera showed no obvious preference among the three colors. With respect to species richness, white traps could capture the most pollinators in different habitat types; with respect to the individual abundance, yellow traps attracted the most pollinators. The results also show that some species had a specific preference for color. For example, Drosophilidae in both farmland and woodland habitats preferred white, and Eulophidae preferred yellow only in farmland. This is because pollinators respond differently to different intensities, wavelengths, and reflectivity, which is as a result of both innate preferences and learning. Pollinators respond differently to the three colored traps, and these traps could be used in a complementary manner for pollinator capture. Color pan traps can be seen as an effective method to obtain pollinators, which can use in various studies on pollinators in this research area.

1. Introduction

Human beings are directly or indirectly benefited from ecosystem services. Pollination services are indispensable to ensure food security and improve crop yields. So, insect pollination is necessary for the stable development of society [1–2]. The entomogamy plant uses floral traits such as color, smell, pollen, size, or shape to attract pollinators. Flying insects show high spectral sensitivity to different visible wavelengths that are reflected from different light-emitting plants. According to these floral traits, color is an important factor in attracting pollinators. In recent years, the abundance of pollinators show a significant downward trend, which has attracted widespread concerns of researchers. Several studies carried out by using traps were proposed by European and American scholars with different colors, such as colors pan traps, Malaise traps, and water-pan traps [3–6]. Among these sampling methods, the color trap method is a simple operation with low-cost and high-efficiency, which is suitable for various monitoring pollinator diversity indexes and used extensively in previous studies.

In recent years, European and American countries have attached great importance to crop pollinators. In order to improve the agricultural ecological environment and grain yields, researchers suggested to establish a global monitoring and evaluating systems for pollinators, and also improve data sets that based on systematic studies on the status of pollinators and its influencing factors [7–9]. Moreover, many scholars have used color pan traps to study the effects of colors on pollinating

☆ Foundation project: Projects from the National Natural Science Foundation of China (41371195, 41071118).

* Corresponding author at: Key Laboratory of Geospatial Technology For the Middle and Lower Yellow River Regions, Ministry of Education, Kaifeng 475004, China.
E-mail address: syding@henu.edu.cn (S. Ding).

http://dx.doi.org/10.1016/j.chnaes.2017.06.007
1872-2032/

insects in different ecosystems. Disney et al. (1980s) observed that some unique insect groups were caught by other color traps rather than the yellow traps, in the swamp forest ecosystem of the Arabian Peninsula [5]. Joshua (2007) reported that, blue and white traps were better than yellow traps, and blue traps showed the highest efficiency for capturing pollinators in the Clemson forest ecosystem in the United States [6]. At the same time, by comparing the responses of pollinators to different visible wavelength bands, some scholars argued that many insects were able to recognize low reflectivity visible light, and only a few kinds of flying insects could recognize high reflectivity visible light, while blue traps have the lowest reflectivity, which may explain the mentioned observations to some extent [10]. However, the results showed slight change with the development of this research area. Gollan et al. found that the yellow trap captured the most of pollinators in the northern Australian forest ecosystem [11]. Saunders and Luck did similar experiments in the agro-forestry ecosystem in northern Australia, and the results showed that the number of pollinators that captured by yellow traps was significantly higher than that of white and blue ones [12]. Heneberg and Bogusch have also found that the yellow trap captured the most pollinators in different habitats of the grassland, wetlands, forests and subalpine of Czech [13]. In addition, Moreira et al. considered that yellow and blue traps were more likely to attract pollinators by color (yellow, white, blue) trap methods in the agro-forestry ecosystem in Brazil [14]. These studies all show that pollinators have certain response to the color of flowering plants, and different habitat conditions may affect their diversity.

The region of the middle and lower reaches of the Yellow River is one of the major grain producing areas in China. It has an important strategic position for safeguarding national food security. Study of regional biodiversity is essential for ecosystem to maintain stable service functions [15]. In this study, a typical agricultural region in the middle and lower reaches of the Yellow River in Fengqiu County was chosen as the research area. The sampling was carried out in two types of habitats, which are farmland and woodland. Combined with the field investigation of vegetation characteristics, coupling analysis of habitat and pollinators was used to study pollinator diversity and the response of pollinators to colors in different habitats. This study attempted to provide a new research approach of agro-ecosystem management for protecting natural resources and the biodiversity.

2. Materials and methods

2.1. Study area and data

Fengqiu is located in north-eastern Henan (34° 53′–35° 14′N, 114° 14′–114° 46′ E) with a total area of about 1221 km^2 and a population of 723,100. The study area belongs to warm temperate continental monsoon climate, which is hot and rainy in summer, cold and dry in winter. The average annual precipitation is 615.1 mm and the average temperature of 13.9 °C. Agricultural landscape is the typical type, moreover, the area has a variety of geomorphic types such as alluvial plain, depression, sand hill and other landforms, and the terrain is tilted from southwest to northeast, 65–72.5 m above the sea level (Fig. 1), which is suitable for agricultural planting.

The vegetation types in this area are mostly artificial vegetation, while natural, semi-natural vegetation areas are small and with scattered distribution of secondary trees, wet plants and shrubs. The main vegetation types include Salicaceae, Compositae, Labiatae, Cruciferae, Gramineae, Cyperaceae, Leguminosae, Solanaceae, honey plants to Compositae, followed by Solanaceae, Cruciferae and Labiatae [16]. The variety of crops in the farmland, such as wheat, peanut, soybean, sesame and corn, and *Lonicera japonica* is one of the most important cash crops.

2.2. Data sampling

21 plots in total were set up in each experiment, and two types of habitats, farmland and woodland were selected in each sampling site. The same amounts of color pan traps were separately layout in two habitats. Three circular plastic pans (diameter 11.4 cm, deep 5.7 cm) painted with yellow (Y, the maximum reflection wavelength ~ 580 nm), blue (B, ~450 nm) and white (W, ~410 nm) [17] were

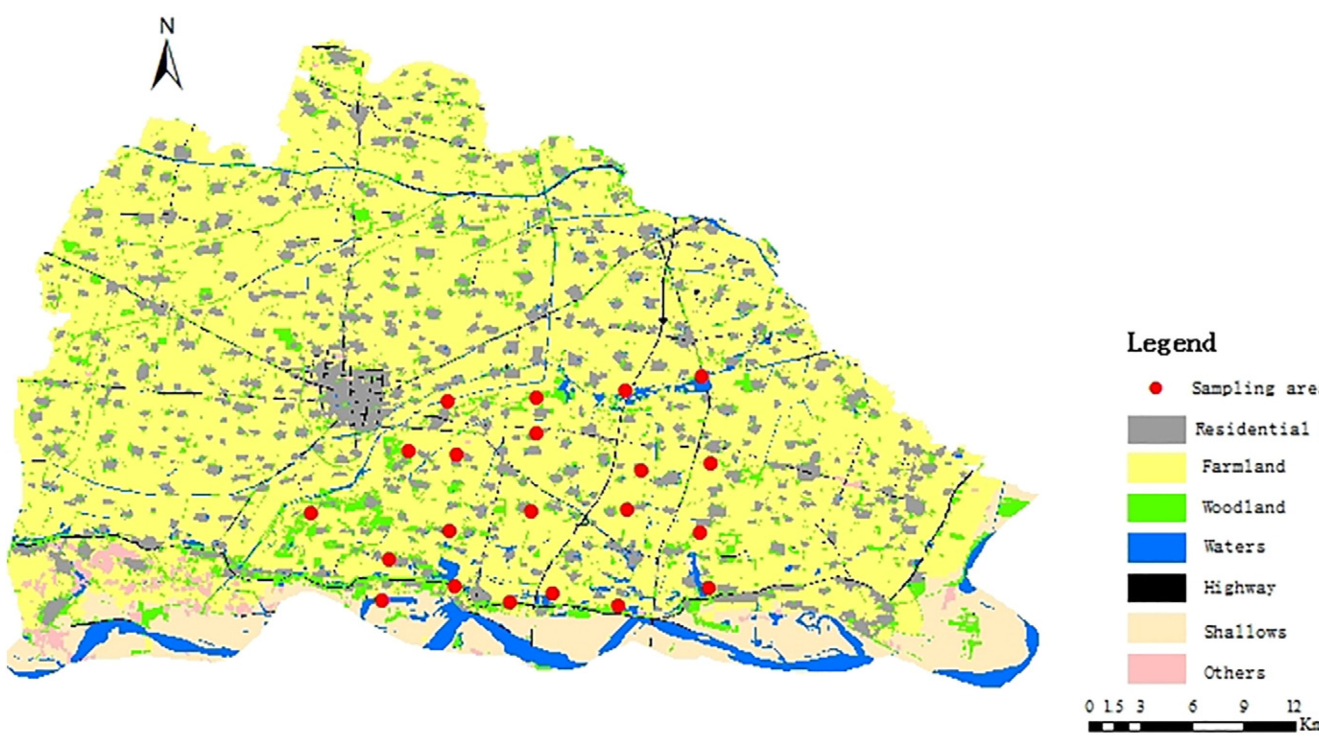

Fig. 1. Landscape classification map and the schematic diagram of sampling points.