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SEASONAL FLUCTUATION IN THE POPULATION OF *HARMONIA AXYRIDIS* (PALLAS, 1773) (COLEOPTERA: COCCINELLIDAE) AND CO-OCCURRENCE WITH OTHER COCCINELLIDS IN THE FEDERAL DISTRICT OF BRAZIL

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ABSTRACT

The multicolored Asian lady beetle, *Harmonia axyridis* (Pallas, 1773), was first recorded in Brazil in 2002 in Paraná state and subsequently observed in Santa Catarina, Rio Grande do Sul and Minas Gerais. This species can spread to new areas and become dominant in the local community, reducing the density and diversity of native species, mainly Coccinellidae. The objective of this work was to record for the first time the occurrence of *H. axyridis* in the Federal District and its co-occurrence with other Coccinellidae species. The individuals were collected directly from plants at an organic farm in Taguatinga and in experimental fields of Embrapa Hortaliças, located in the Federal District, from August 2008 to January 2010. We collected 881 Coccinellids, and of these, 110 belong to the species *H. axyridis*. These were found exclusively on the following plants of the succinea group: maize, cabbage, cauliflower, broccoli, kale, cucumber, cotton, tomato and coriander. We also observed its co-occurrence with the following lady beetle species: *Cycloneda sanguinea* (Linnaeus, 1763), *Hippodamia convergens* (Guerin-Meneville 1842), *Eriopis connexa* (German, 1824), *Scymnus* sp., *Nephaspis* sp., *Azya luteipes* (Mulsant, 1850), *Hyperaspis festiva* (Mulsant, 1850), *Olla v-nigrum* (Mulsant, 1866), *Psyllobora* sp. and *Coleomegilla maculata* (De Geer, 1775). So far, we have

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not found any negative interactions between *H. axyridis* and these species. This is the northernmost *H. axyridis* record in Brazil. Moreover, the region was previously considered to have a low probability of occurrence for this species. Therefore, this record confirms that *H. axyridis* presents great adaptive plasticity to new habitats.

KEY-WORDS: Biological Control; Diversity; Exotic species; Invasion; Predator.

INTRODUCTION

The lady beetle *Harmonia axyridis* is an introduced species of Coccinellidae originally from the Palaearctic region (Koch, 2003). It is a voracious predator of aphids, also feeding on other insects such as psilids (Koch, 2003), eggs of Lepidoptera (Santos *et al.*, 2009) and pollen (Berkvens *et al.*, 2008). Due to this, *H. axyridis* has been used successfully in several biological control programs worldwide (Koch *et al.*, 2006). In Europe (Brown *et al.*, 2008), China (Zhang, 1992), the United States and Mexico (Brown & Miller, 1998), for example, the species is already widespread and is considered one of the main agents for biological control of aphids on different crops. The current widespread distribution of this species is related to its natural dispersal (Osawa, 2000), dispersal facilitated by human action (Brown *et al.*, 2008), and adaptability to climates different from its original region (Koch *et al.*, 2006).

However, the characteristics that make *H. axyridis* an efficient predator and a good biological control agent have also led to it becoming a threat to native guilds of aphid-eaters in regions where it has been introduced. *H. axyridis* is bigger than other coccinellids, has high predatory capacity (Elliott *et al.*, 1996), high fecundity (Iablokoff-Khnzorian, 1982), and can act as an intraguild predator mainly on other coccinellids (*e.g.*, Burgio *et al.*, 2003, Santos *et al.*, 2009). This means that it can displace several native aphid predators, becoming dominant in the local community, as observed in southern Brazil (Martins *et al.*, 2009).

H. axyridis was introduced in the early 1990s in South America through the province of Mendoza in Argentina as a means of biologically controlling aphids on peaches (Saini, 2004). Currently there are reports of this species in Chile (Grež *et al.*, 2010) and Perú (González, 2007). In Brazil, it was first recorded in Curitiba, Paraná state, in April 2002 feeding on *Tinocallis kahawaluokalani* (Kirkaldy) (Hemiptera: Aphididae), *Lagerstroemia indica* (Linnaeus) (Lythraceae), *Cinara* spp. (Hemiptera: Aphididae), and *Pinus* spp. (Pinaceae) (Almeida & Silva, 2002). In 2006 it was recorded in Viçosa, Minas Gerais, feeding on aphids and psyllids in ornamental plants and

vegetables (Rezende *et al.*, 2010). Although the presence of this species is recent in Brazil, significant reduction in the abundance of other native species of coccinellids has been recorded (Milléo *et al.*, 2008), demonstrating the potential threat of this species to the guild of aphid predators in Brazil (Martins *et al.*, 2009).

Due to the threat that this species may represent to predators of the local insect fauna, such as coccinellids, the objective of this study was to evaluate seasonal variation in the abundance of *H. axyridis* and other species of Coccinellidae on some organic vegetable crops in the Federal District. This would make possible the evaluation of shifts in richness and diversity of *H. axyridis* at an early point of establishment in the region.

MATERIAL AND METHODS

Sampling was done on plantations of organic vegetables in the Federal District from August 2008 to January 2010. In order to collect natural enemies of tomato, initial surveys were performed on tomatoes and cilantro crops in the experimental field of Embrapa Hortaliças Research Center in the region of Gama (15°56'S and 48°08'W). Samples were taken weekly from August to November 2008 (end of drought in the region) by directly collecting individuals of Coccinellidae from 240 randomly designed tomato plants. The first record of *H. axyridis* was in 2008 at Embrapa Hortaliças and it was collected again in 2009 in an intercropping area of vegetables (corn, cabbage, kale, cauliflower, cucumbers, broccoli, tomato and cilantro) at an organic farm in Taguatinga (15°49'S and 48°04'W). After that, monitoring of Coccinellidae species population at this property was done monthly from February 2009 to January 2010. Collection of insects was made directly from plants with a sampling effort of two hours.

Different patterns of color and spot distribution were found for *H. axyridis* occurring in the Federal District. Some specimens of each pattern were mounted, photographed and sent for identification by a specialist (Dr. Lúcia Massuti from the

Universidade Federal do Paraná). Specimens were deposited in the Entomological PE. J.S. Moure, Department of Zoology, Universidade Federal do Paraná, where they were numbered sequentially from DZUP/144661 DZUP/144676. The remaining specimens were compared and deposited in the Insect Collection at Embrapa Recursos Genéticos e Biotecnologia.

Abundance of *H. axyridis* and other species of lady beetle was recorded for each date, place and culture in order to assess the community structure of coccinellids by comparing the relative abundances of *H. axyridis* in relation to the total abundance of species. Species richness of each area was estimated by rarefaction curves. Diversity was compared by t test, calculating the Shannon-Wiener diversity index and

Renyi profile index through use of the statistical program PAST (Hammer *et al.*, 2001).

RESULTS

We collected 881 coccinellids, with 110 of these belonging to the species *H. axyridis* exclusively in the succinae group. Color ranged from red to orange with a variable number of black spots or complete lack thereof (Fig. 1). Other coccinellid species that co-occurred in the two sampling areas were *Azya luteipes*, *Coleomegilla maculate*, *Cycloneda sanguinea*, *Eriopis connexa*, *Hippodamia convergens*, *Hyperaspis festiva*, *Nephaspis* sp., *Olla v-nigrum*, *Psyllobora* spp. and *Scymnus* spp. (Table 1).

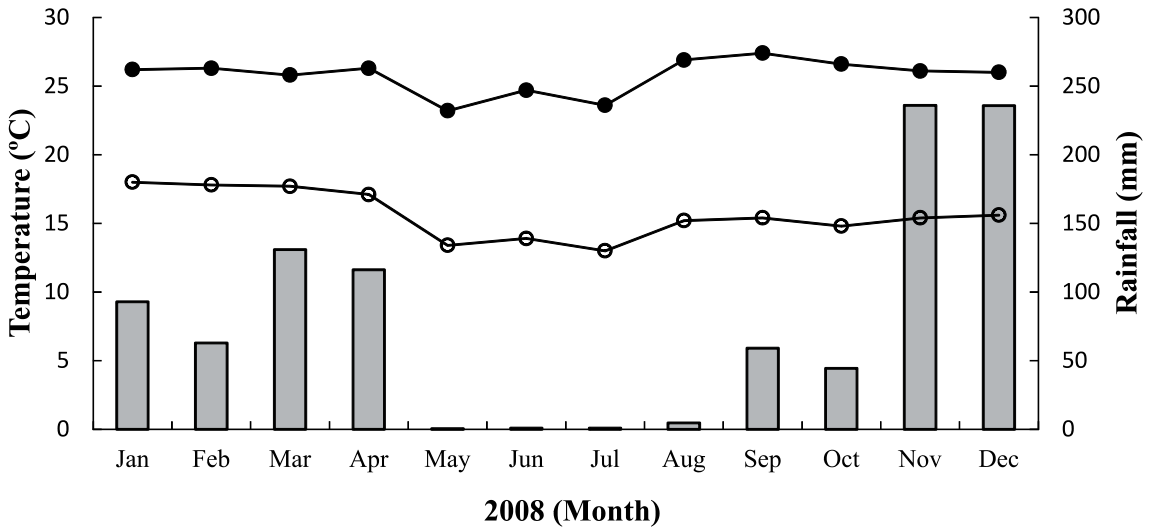


FIGURE 1: Coloration patterns of *Harmonia axyridis* collected in the region of the Federal District, Brazil. The scale bar above the photos of the specimens corresponds to 4 mm.

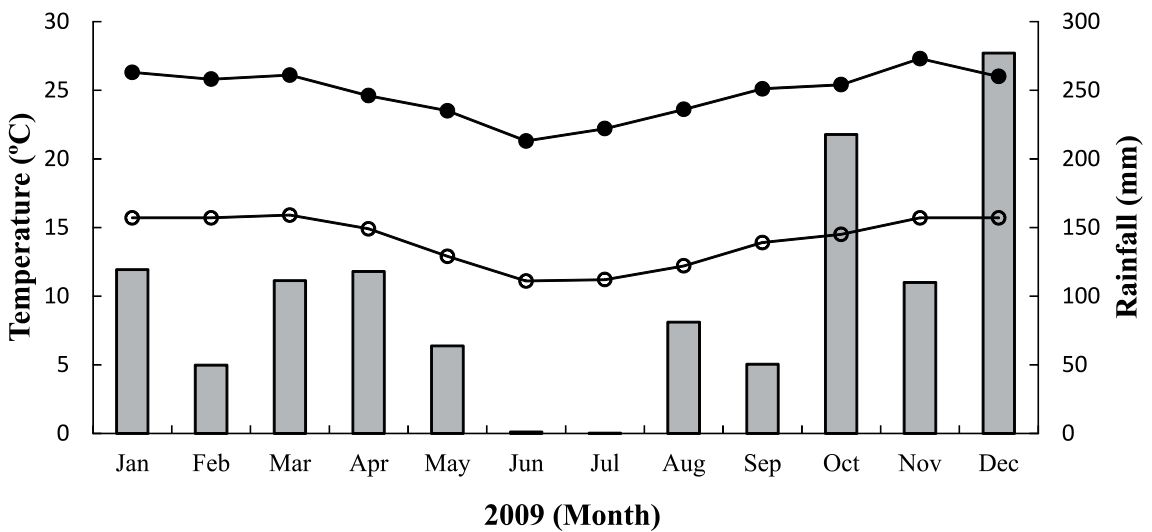
Only one specimen of *Harmonia axyridis* was collected in mixed stands of tomato and cilantro in Gama. The most abundant species collected from the local community of coccinellids were *Hippodamia convergens*, *Eriopis connexa*, *Scymnus* spp. and *Cycloneda sanguinea*. In the intercropping of vegetables in Taguatinga, however, *H. axyridis* was the dominant species in the local community of coccinellids (Table 1). On this property, the proportion of *H. axyridis* compared with other coccinellid species accounted

for 39.4% of specimens (Table 1). Although the climate of the region shows a strong variation in rainfall (Fig. 2), specimens of *H. axyridis* were collected both in the rainy season and during the dry season, with higher peaks of abundance during the dry season in August and October (Fig. 3).

The comparison of coccinellid communities collected from the two areas showed the same number of species (Table 1), although the richness estimated by rarefaction curves (Fig. 4) was higher in Taguatinga.



A Rainfall Higher temperature Lower temperature



B Rainfall Higher temperature Lower temperature

FIGURE 2: Seasonal pattern of rainfall distribution and variation in mean maximum and minimum temperatures in the Federal District, (A) 2008 and (B) 2009.

TABLE 1: Relative abundance of coccinellids, diversity indices and proportion of *Harmonia axyridis* at two different sites in the Federal District during the period of August 2008 to January 2010.

| Species | Collection sites | | Total |
|------------------------------|------------------|------------|-------|
| | Gama | Taguatinga | |
| <i>Azya luteipes</i> | 0 | 7 | 7 |
| <i>Coleomegilla maculata</i> | 1 | 0 | 1 |
| <i>Cycloneda sanguinea</i> | 50 | 32 | 82 |
| <i>Eriopis connexa</i> | 199 | 19 | 218 |
| <i>Harmonia axyridis</i> | 1 | 109 | 110 |
| <i>Hippodamia convergens</i> | 266 | 27 | 293 |
| <i>Hyperaspis festiva</i> | 5 | 6 | 11 |
| <i>Nephaspis</i> spp. | 14 | 0 | 14 |
| <i>Olla v-nigrum</i> | 0 | 17 | 17 |
| <i>Psyllobora</i> spp. | 3 | 21 | 24 |
| <i>Scymnus</i> spp. | 65 | 39 | 104 |
| Richness (S) | 9 | 9 | |
| Abundance | 604 | 277 | |
| Dominance Index | 0.321 | 0.212 | |
| Shannon Wiener (H) | 1.346 | 1.846 | |
| Simpson | 0.678 | 0.787 | |

Species diversity was also higher in Taguatinga than in Gama when compared by the Shannon-Wiener index ($t = -8.045$, $P < 0.001$). The profile of diversity based on the Renyi index (Fig. 5) and the Simpson index

supports this as well, as it reflects that the dominance of the community was higher in Gama (Table 1).

DISCUSSION

We recorded only succinae group individuals, in the same way as that observed by Rezende *et al.* (2010) in Minas Gerais, despite the polymorphism of colors displayed by the species in Brazil. From previous records in Brazil (Almeida & Silva, 2002; Rezende *et al.*, 2010), as well as records in the United States and Mexico (Brown & Miller, 1998), we can infer that this staining pattern is predominant in America. This is in contrast with the Palaearctic region and Europe as a whole where dark shapes are also found (Koch, 2003).

The Gama region was the site where the first specimen of *H. axyridis* was collected on mixed stands of tomato and cilantro in August 2008. According to Osawa (2000), populations of *H. axyridis* show a pattern of dispersal among subpopulations in which their establishment is conditioned by availability and accessibility of aphid colonies. In places such as Gama where there was a low occurrence of aphids, *H. axyridis* may have used this type of habitat as a temporary

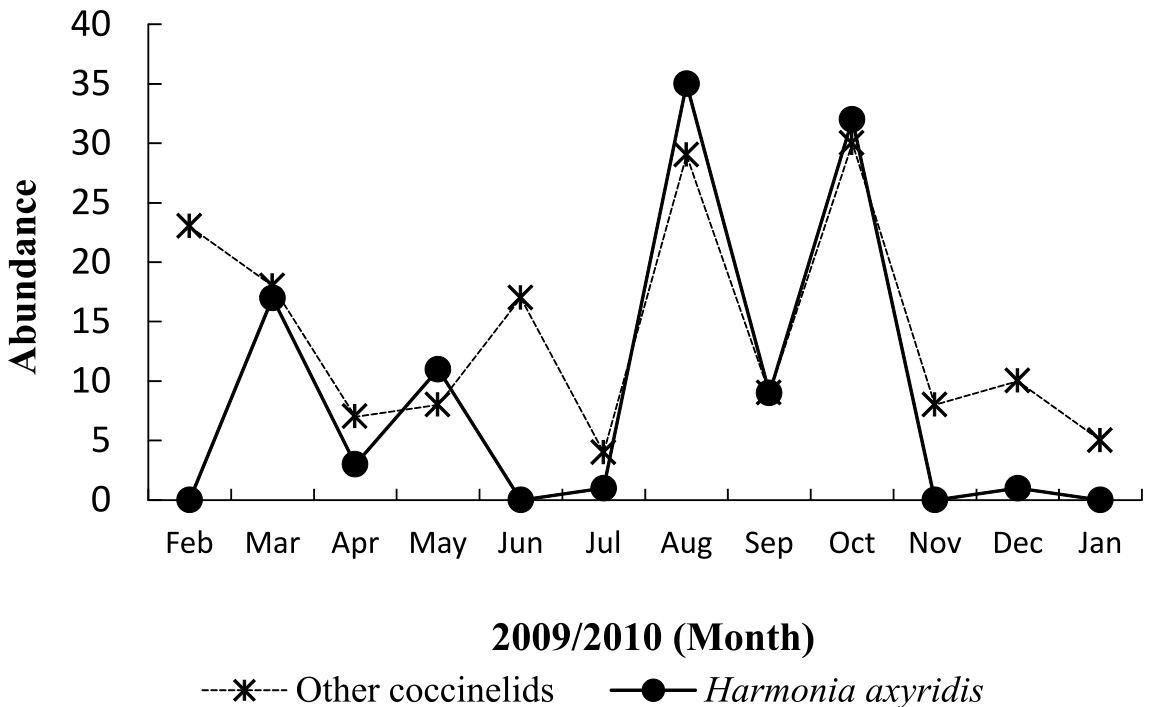


FIGURE 3: Seasonal variation in the population of *Harmonia axyridis* and other coccinellid (*Cycloneda sanguinea*, *Hippodamia convergens*, *Eriopis connexa*, *Scymnus* spp. *Azya luteipes*, *Hyperaspis festiva*, *Olla v-nigrum* and *Psyllobora* sp.) collected in an area of vegetable intercropping in organic systems from February 2009 to January 2010 in Taguatinga, Federal District.

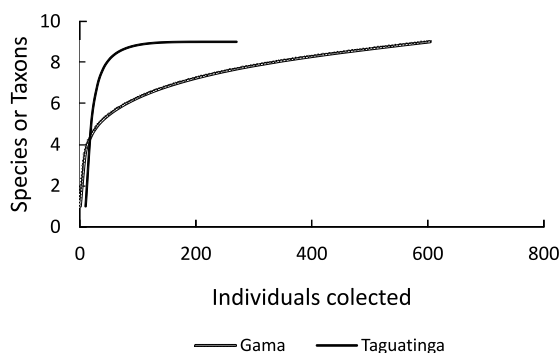


FIGURE 4: Estimated richness of species or genera of the coccinellid community through rarefaction curves in vegetable crops in two regions of the Federal District.

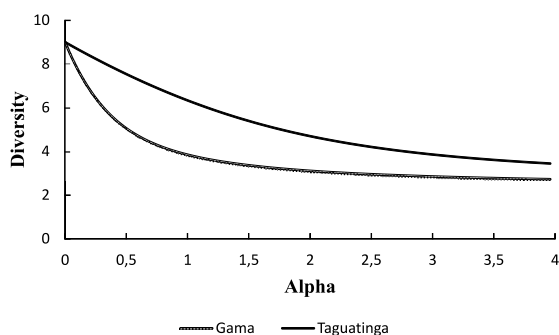


FIGURE 5: Diversity profile of coccinellid communities collected among organic vegetable crops in two regions of the Federal District.

refuge in search of better quality patches of resources. The collection of only one specimen, with no observation of any other specimen, is associated with a low occurrence of colonies of aphids in the area. This suggests that their arrival has been recent and migrant populations have not yet been established. In the region of Taguatinga, *H. axyridis* was a constant presence during the collections of coccinellids among vegetables grown in intercropping systems during the year 2009/10. This species presented a seasonal variation related to rainfall distribution in the region and constancy of prey throughout the year, suggesting a possible local establishment. This pattern of seasonal variation according to the region's climate was also observed in the south of the country where the species is already established but where it fluctuates throughout the year (Milléo *et al.*, 2008; Martins *et al.*, 2009).

Considering the previous reports of *H. axyridis* in Brazil, this work may be considered thus far to be the northernmost record of the species in the country. Koch *et al.* (2006) used climate models by comparing climate of the Neotropics with climate of the original areas of *H. axyridis* in the Palearctic region. In this model, authors indicated the south of the country as

the most likely location for establishment, and the Central region of Brazil as a place with low probability for this species to occur. In the Central region, temperatures range between 15° and 30°C and air humidity in the dry season may go as low as 15%, which is a limiting factor for the establishment of this population in the area. However, individuals have been collected during the rainy season and especially during the dry period in the Federal District, demonstrating its great capacity to adapt to new climatic conditions, including areas previously considered unsuitable for its establishment.

After the first record of *H. axyridis* in southern Brazil, the density of this species continued to increase and cause negative impacts on native coccinellid species in the region (Milléo *et al.*, 2008; Martins *et al.*, 2009). Considering the stages of biological invasion, colonization, establishment and spread (Koch *et al.*, 2006), we can infer that this species is already established in Brazil and is in the process of spreading to new areas.

In the Federal District, *H. axyridis* is apparently still in the process of establishment due to low abundance or absence in some sampling sites. Analysis of richness and diversity of the coccinellid community allows us to infer that, despite high relative abundance of *H. axyridis* against coccinellid fauna in Taguatinga, there is no apparent negative impact on diversity of the local community. This inference is based on estimates made in the two sampling areas, showing the greatest richness and diversity of coccinellids in the region of Taguatinga. In this area relative abundance of *H. axyridis* was higher, suggesting that there is still a shift of species as suggested by Milléo *et al.* (2008) and Martins *et al.* (2009) in southern Brazil.

However, relatively low abundance of species in some sampling sites does not exclude the risk of *H. axyridis* becoming a threat to native aphid predators in the future. Since the arrival of the species is apparently new to the region, this work highlights the need to constantly monitor this species' impact on the native community of coccinellids and other aphidofagous insects in the Federal District.

RESUMO

A joaninha asiática, Harmonia axyridis (Pallas, 1773), foi primeiramente registrada no Brasil em 2002 no Estado do Paraná, sendo posteriormente registrada nos estados de São Paulo e Minas Gerais. Essa espécie pode colonizar novas áreas e tornar-se dominante na comunidade local, reduzindo a densidade e diversidade de espécies nativas,

principalmente de coccinélidos. O objetivo deste trabalho foi registrar a presença de *H. axyridis* no Distrito Federal, a flutuação populacional e a sua co-ocorrência com outros coccinélidos. As coletas foram realizadas em uma propriedade rural particular em Taguatinga e no campo experimental da Embrapa Hortaliças no Gama, Distrito Federal, entre agosto/2008-janeiro/2010, utilizando coleta direta dos indivíduos sobre as plantas. Foram coletados 881 coccinélidos, sendo que destes 110 pertencem à espécie *H. axyridis* exclusivamente do grupo *succinea*, nas seguintes plantas: tomate, coentro, milho verde, repolho, couve, couve-flor, brócolis, pepino. Também foi observada a sua co-ocorrência com outras espécies de joaninhas: *Cycloneda sanguinea* (Linnaeus, 1763), *Hippodamia convergens* (Guerin-Meneville 1842), *Eriopis connexa* (German, 1824), *Scymnus* sp., *Nephaspis* sp., *Azya luteipes* (Mulsant, 1850), *Hyperaspis festiva* (Mulsant, 1850), *Olla v-nigrum* (Mulsant, 1866), *Psyllobora* sp. e *Coleomegilla maculata* (De Geer, 1775). Até o momento, não foram registradas interações negativas de *H. axyridis* com essas espécies no Distrito Federal. Além disso, esta região foi apontado anteriormente como tendo uma baixa probabilidade de ocorrência para esta espécie, refletindo *H. axyridis* grande plasticidade adaptativa para novos habitats.

PALAVRAS-CHAVE: Controle Biológico; Diversidade; Espécie exótica; Invasão; Predador.

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