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Original Article

Infestation of *Portulaca oleracea* (Portulacaceae) plants by *Neotuerta platensis* (Lepidoptera: Noctuidae) larvae in Brazil: evaluations for five consecutive years

Infestação de plantas de *Portulaca oleracea* (Portulacaceae) por larvas de *Neotuerta platensis* (Lepidoptera: Noctuidae) no Brasil: avaliações por cinco anos consecutivos

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Abstract

The bioecology and infestation aspects of *Neotuerta platensis* Berg, 1882 (Lepidoptera: Noctuidae) on plants are poorly known. This insect fed on the leaves of common purslane, *Portulaca oleracea* L. (Portulacaceae) for two consecutive years, which triggered its study in the following five years in Januária, Minas Gerais State, Brazil. The objective of this work was to study the bioecology and infestation aspects of *N. platensis* on *P. oleracea* plants in the field and laboratory. The mean duration (± SD) of the egg, larva and pupa stages was 3.6 ± 0.89, 11.5 ± 2.81 and 10.7 ± 1.97 days, respectively. The mean numbers of egg masses and eggs per female (± SD) were 3.8 ± 1.16 and 891.6 ± 116.83, respectively. The percentage of infested plants was 59, 74, 0, 78 and 75% and the mean numbers of larvae per plant (± SD) ranged from 0.7 ± 0.45 to 1.6 ± 0.49 individuals, respectively from 2015 to 2019. *Neotuerta platensis* larvae infested *P. oleracea* plants in four out of five years evaluated.

Keywords: Agaristinae, defoliation, medicinal plant, vegetable, weed.

Resumo

Os aspectos de bioecologia e infestação de *Neotuerta platensis* Berg, 1882 (Lepidoptera: Noctuidae) em plantas são pouco conhecidos. Esse inseto se alimentou das folhas de beldroega comum, *Portulaca oleracea* L. (Portulacaceae) por dois anos consecutivos, o que desencadeou seu estudo nos cinco anos seguintes em Januária, Minas Gerais, Brasil. O objetivo deste trabalho foi estudar a bioecologia e os aspectos da infestação de *N. platensis* em plantas de *P. oleracea* em campo e laboratório. A duração média (± DP) dos estágios de ovo, larva e pupa foi de 3,6 ± 0,89, 11,5 ± 2,81 e 10,7 ± 1,97 dias, respectivamente. Os números médios de posturas e ovos por fêmea (± DP) foram de 3,8 ± 1,16 e 891,6 ± 116,83, respectivamente. A porcentagem de plantas infestadas foi de 59, 74, 0, 78 e 75% e os números médios de larvas por planta (± DP) variaram de 0,7 ± 0,45 a 1,6 ± 0,49 indivíduos, respectivamente de 2015 a 2019. Larvas de *N. platensis* infestaram plantas de *P. oleracea* em quatro dos cinco anos avaliados.

Palavras-chave: Agaristinae, desfolha, planta daninha, planta medicinal, vegetal.

1. Introduction

The common purslane, *Portulaca oleracea* L. (Portulacaceae) is an annual and succulent plant that is native possibly from Europe, but it spread throughout the Middle East and North Africa and south of that continent to Malaysia and Australasia in the Indian subcontinent (Danin et al., 2014, 2016). The introduction route of this plant in the American continent is uncertain (Byrne and McAndrews, 1975), but its presence as a weed was reported in South America, mainly in Argentina, Brazil, Colombia and Uruguay, and North America (Petropoulos et al., 2016) in crops of upland cotton, *Gossypium hirsutum* L. (Malvaceae), Asian rice, *Oryza sativa* L., sugarcane, *Saccharum officinarum*

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L. and maize, *Zea mays* L. (Poaceae) with fast propagation, growth, and development, besides resistance to some herbicides (Patil et al., 2018; Rauber et al., 2018).

Portulaca oleracea is also grown as a vegetable for use in different culinary dishes (Iranshahy et al., 2017; Sinha, 2018) with balanced flavor and nutrients, including antioxidants and essential fatty acids, besides vitamins (Khodadadi et al., 2018; Montoya-García et al., 2018). Chemical elements with medicinal properties to prevent some diseases are abundant in this plant and it is used as tea, powder, and its seeds as food (Zhou et al., 2015; Dehghan et al., 2016; Pakdel et al., 2018). The use of *P. oleracea* leaves as food increased the resistance to infection by bacteria of *Aeromonas hydrophila* (Chester, 1901) Stainer, 1943 (Aeromonadaceae) and consequently the survival of Nile tilapia, *Oreochromis niloticus* (L., 1758) (Cichliformes: Cichlidae) (Abdel-Razek et al., 2019).

Some insect pests of annual, succulent plants have a high damage capacity due to the rapid consumption of the aerial part with population and feeding peak for a short period (Tavares et al., 2014a; Menezes et al., 2019). The population of these insects decreases with food scarcity (Tavares et al., 2014b). These insects reduce their metabolism, migrate or remain in the same area hosting alternative plants waiting for the next period of regrowth or germination of the main host plant (Smith et al., 2018; Chu et al., 2019). Only one study reported the infestation of *Neotuerta platensis* Berg, 1882 (Lepidoptera: Noctuidae) larvae on *P. oleracea* as revealed in Palmira, Colombia (Altieri and Doll, 1977). Larvae of this insect were also reported by three other studies with infestation on plants of other species, as on *Vitis sicyoides* Back. and common grape wine, *Vitis vinifera* L. (Vitaceae) in Guarani and Pelotas, Rio Grande do Sul State, Brazil (Specht et al., 2004) and on *Oenothera indecora* Cambess (Onagraceae) in the northern region of the Pampas and in Tucumán, Argentina (Bulacio et al., 2013; Juaréz et al., 2016).

The knowledge of the infestation capacity of *P. oleracea* by *N. platensis*, if constant or for a certain period, could generate control warning information in commercial crops of this plant. Furthermore, the study of the biology of *N. platensis* fed on *P. oleracea* could generate information for integrated management programs for this pest. Example, the identification of first eggs of this pest in the field and knowledge of the egg stage period (in days) could determine the need and the period of release of egg parasitoids, such as *Trichogramma* Westwood (Hymenoptera: Trichogrammatidae) (Khan et al., 2020) and the requirement to install a higher number of light traps to capture their adults for monitoring and population reduction (Specht and Corseuil, 2002).

In this study, we aim to evaluate the infestation aspects of *N. platensis* on *P. oleracea* grown as a weed for five consecutive years in Januária, Minas Gerais State, Brazil. We also aim to obtain data on the bioecology to support integrated management programs for this insect on *P. oleracea* grown as a vegetable/medicinal plant. We hypothesized that *N. platensis* would have the capacity to infest *P. oleracea* annually, except for those without this plant or with low numbers. We also hypothesized that *N. platensis* would present biological parameters similar to those of other common Noctuidae such as pests on annual plants (Specht and Roque-Specht, 2016).

2. Material and Methods

2.1. Experimental site

The study was carried out in an experimental agricultural area of the Federal Institute of Northern Minas Gerais (IFNMG) in Januária, Minas Gerais State, Brazil at 15° 29' S × 44° 21' O and a 434 m altitude. The evaluations were carried out on *P. oleracea* plants (variety with yellow flowers) grown and infested with *N. platensis* larvae naturally, from December 2015 to 2019. The evaluations were made in December, because the population peak of *N. platensis* larvae on *P. oleracea* in Januária was seen initially in December 2013 and 2014. The total rainfall and average temperature in Januária in December 2015 to 2019 were 210.5, 128.6, 248.8, 134.3 and 96.3 mm and 25.71, 26.27, 25.86, 25.37 and 28.29 °C, respectively, being a month with intense rainfall and high temperatures in the region (Silva et al., 2017; Menezes et al., 2018a). According to preliminary observations to conduct our study, *P. oleracea* starts its growth as a weed at the beginning of the rainy season and decline at the beginning of the dry season (plant survival for about 7-8 months) or after being consumed by *N. platensis*. The regrowth or germination of these plants occurred in the same period of the following year. To obtain more information upon the infestation, an area of 13,590.6 m^2 with *P. oleracea* plants infested by *N. platensis* in 2013 and 2014 was marked in early December 2015. Annual crops of common sunflower, *Helianthus annuus* L. (Asteraceae), cowpea, *Vigna unguiculata* (L.) Walp. (Fabaceae) and *Z. mays* had been established in previous years in this area.

The population survey of *N. platensis* larvae was conducted in an area of 1,027.3 m^2 within the total area (Figure 1) during the five years of evaluation. A 1.0 m^2 (1.0 × 1.0 m) inventory square instrument (Figure 2A) was installed randomly, within that area seven times (10 minutes interval between evaluations) in a day in the morning period per year.

The number of larvae of any age of *N. platensis*, within the area delimited by the inventory square instrument, was counted per plant and evaluation. The number of plants with and without injury by *N. plantensis* larvae was also counted per evaluation. Recent or old injuries were assessed. The aerial part of the plants was fully examined and the larvae and sampled plants were left in the area. In addition, a field visit was carried out every 15 days to observe the growth of *P. oleracea* and possible infestation by *N. platensis* on other plant species.

2.2. Rearing of N. platensis

Twenty larvae of any instar of *N. platensis* were collected manually, after each of the last evaluations using an inventory square instrument per year, placed in 500 mL plastic containers, and taken to the Entomology Laboratory of the IFNMG - campus Januária for rearing and

identification. These larvae were individualized in 250 mL plastic containers in an air-conditioned room at 25 ± 2 °C, 70 ± 10% RH, and 12:12 (L:D) h photoperiod at 2,000 lux and received daily fresh leaves of *P. oleracea ad libitum* as a food until the pre-pupa stage. The soil of the superficial layer at a depth of 5.0 cm from the experimental area was placed at the bottom of the containers up to 2.0 cm high as a pupation site. The pre-pupae of this insect were placed in the respective rearing containers of their larvae on the soil until the pupa stage.

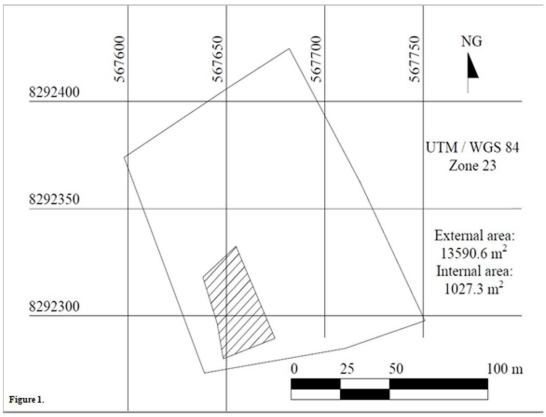

Figure 1. The agricultural area marked (dashed) to study the infestation of *Portulaca oleracea* (Portulacaceae) plants by *Neotuerta platensis* (Lepidoptera: Noctuidae) larvae in Januária, Minas Gerais State, Brazil.

2.3. Identification of N. platensis

Three adults from 2015 and another two from 2016 collections, without gender identification, were mounted and identified by comparing them with the specimens previously deposited at the Uiraçu Institute of the Serra Bonita Reserve in Camacan, Bahia State, Brazil under the registration number 135.062.

2.4. Identification of P. oleracea

Five branches of *P. oleracea* with flowers were collected, placed in 1 Kg capacity brown paper bags, and taken to the Semi-Arid North Laboratory of the IFNMG in Januária, where the species was identified by comparing its reproductive organs with descriptions of this plant (Gorske et al., 1979;

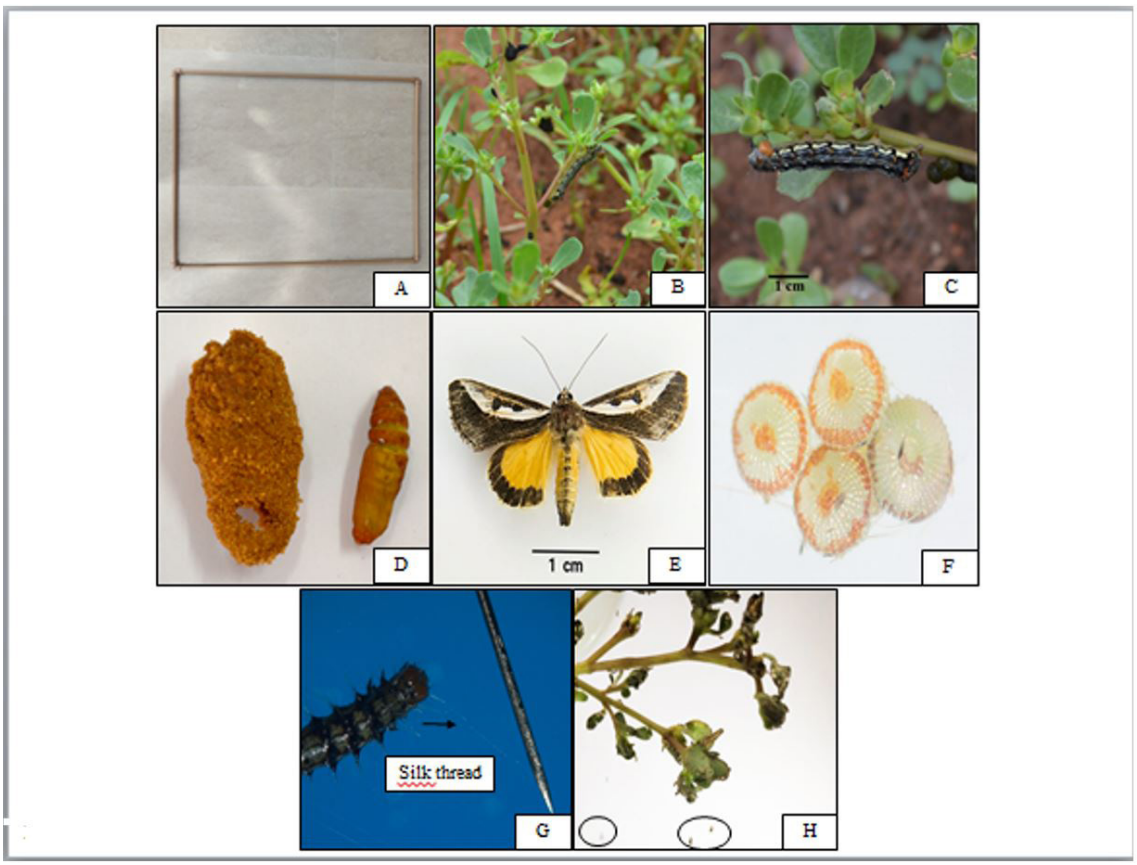

Figure 2. Inventory square instrument (A), *Neotuerta platensis* (Lepidoptera: Noctuidae) larva feeding on the aerial part of *Portulaca oleracea* (Portulacaceae) (B), larvae feces (C), cocoon and pupa (D). The pupa is naturally, surrounded by the cocoon. The pupa was removed from it manually, for photography. An adult (E), about two days old eggs showing the appendices of the larva forming inside them (F), silk thread secreted by the larva on a pin placed nearby (G), and first and second instar larvae suspended in a *P. oleracea* plant infested by this insect in the laboratory (H).

Matthews et al., 1993; Alam et al., 2014) and preserved specimens deposited at the Herbarium of the Federal University of Viçosa (UFV) in Viçosa, Minas Gerais State under the registration number VIC 44512.

2.5. Notes on the bioecology of N. platensis

This topic was studied in the field and laboratory. In the field, the host plants, parts consumed and injury features by *N. platensis* larvae were described. The spots on the plants with larva feces were identified and the identification of recent injuries on plants was discussed. The flight period of adults and the place where they landed on the plants were identified.

In the laboratory, five adult couples, obtained from the rearing of this insect, were formed with individuals of similar ages, individualized in 250 mL plastic containers and fed with a solution of distilled water:honey (90%:10%) in an air-conditioned room at 25 ± 2 °C, 70 ± 10% RH and 12:12 (L:D) h photoperiod at 2,000 lux for mating and oviposition.

The egg masses were removed daily from the inner surface of the containers using a brush and transferred to glass Petri dishes for incubation. The larvae, pupae, adults, and eggs of the F1 generation were kept as described for the evaluations of some bioecological aspects of this insect. Small egg masses that were deposited by the same female near each other were considered as one. The mean duration of the egg (N= 2000), larva (N= 25), and pupa (N= 25) stages (days, ± SD), and the mean number of eggs and egg masses per female (± SD; N= 25) were evaluated.

The shape, mean diameter (mm, ± SD; N= 200), place in the plastic containers where they were deposited, number of egg layers and pubescence on the eggs were evaluated. The diameter of the eggs was measured with a built-in ruler in one of the eyepieces of a binocular stereomicroscope.

The feeding of newly-hatched larvae on their eggshells and their aggregation after hatching were described. The mortality of larvae (N= 25) in plastic containers without soil was evaluated in a preliminary study to determine the need to place soil in containers for pupation of the species.

2.6. Data gathering

The data of the mean number of sampled plants (± SD), mean number (± SD) and percentage of plants infested and the mean number of larvae per plant (± SD), per inventory square instrument installation per year, were presented.

3. Results

3.1. Notes on the bioecology of N. platensis in the field

The *N. platensis* larvae fed only on *P. oleracea* plants (Figure 2B) without causing injury to cultivated plants or other weeds. These larvae fed on the green parts of the leaves, leaving the petiole and stem intact. The most common weeds seen growing together with *P. oleracea* were *Alternanthera tenella* Colla, *Amaranthus deflexus* L., *Amaranthus viridis* L. (Amaranthaceae), *Bidens pilosa* L., *Conyza bonariensis* (S. Moore) Cufod. (Asteraceae), *Commelina benghalensis* L. (Commelinaceae), *Ipomoea purpurea* L., *Ipomoea triloba* L., *Merremia cissoides* (Lam.) Hallier f. (Convolvulaceae), *Cyperus rotundus* L. (Cyperaceae), *Euphorbia heterophylla* L. (Euphorbiaceae), *Desmodium tortuosum* (Sw.) DC., *Senna obtusifolia* (L.) H.S.Irwin & Barneby (Fabaceae), and *Cenchrus echinatus* L., *Eleusine indica* (L.) Gaertn., and *Urochloa plantaginea* (Link) RD Webster (Poaceae).

The larvae started feeding on the edge towards the center of the leaves, defecating on them and the petiole (Figure 2C). The presence of larvae feeding on the plants was identified by feces on the leaves or the soil and by recent injury to the leaves and petioles.

The larvae pupated on the soil surface in the field and laboratory with the pupae surrounded by a cocoon formed by sand and a sticky secretion produced by the larvae and closed (Figure 2D).

Neotuerta platensis adults were observed flying or landed on *P. oleracea* plants in the field during the day and night (Figure 2E).

The *N. platensis* larvae infested *P. oleracea* plants in all evaluated years, except in 2017. The mean number of plants sampled (± SD) (percentage of plants infested) and the mean number of larvae per plant (± SD), per inventory square instrument installation, in December 2015, 2016, 2018 and 2019 were 16.0 ± 1.60 (59%) and 1.6 ± 0.90; 14.0 ± 0.80 (74%) and 1.4 ± 0.72; 7.0 ± 1.00 (78%) and 0.7 ± 0.45; and 15.0 ± 0.69 (75%) and 1.6 ± 0.49, respectively (Table 1).

3.2. Notes on the bioecology of N. platensis in the laboratory

The mean duration of the egg (N= 2000), larva (N= 25) and pupa (N= 25) stages (± SD) was 3.6 ± 0.89, 11.5 ± 2.81 and 10.7 ± 1.97 days, respectively. The mean number of egg masses and eggs per female (± SD; N= 25) was 3.8 ± 1.16 and 891.6 ± 116.83, respectively.

The eggs of *N. platensis* are sub-spherical, translucent soon after being deposited and with a mean diameter (± SD) of 1.0 ± 0.1 mm (N= 200). The appendices of the forming larvae could be observed visually, inside the eggs from the second day after their deposition (Figure 2F). The eggs were deposited on the inner surface of the containers in a single layer, without pubescence on them and became completely black after the third day of oviposition.

Table 1. Sampling year (Year), mean number of plants sampled (NPS) (± SD), mean number (NPI) (± SD) and percentage (PPI) of plants infested and mean number of larvae (± SD) (NL) of *Neotuerta platensis* (Lepidoptera: Noctuidae), per inventory square instrument installation per plant of *Portulaca oleracea* (Portulacaceae), in agricultural area in Januária, Minas Gerais State, Brazil.

Year	NPS	NPI	PPI (%)	NL
2015	27	16.0 ± 1.60	59.25	1.6 ± 0.90
2016	19	14.0 ± 0.80	73.68	1.4 ± 0.72
2017	4	-	-	-
2018	9	7.0 ± 1.00	77.77	0.7 ± 0.45
2019	20	15.0 ± 0.69	75.00	1.6 ± 0.49

The *N. platensis* pre-pupa (N= 25) died without soil inside the containers. Newly-hatched larvae fed on the eggshell and climbed through the inner surface of the plastic container to the lid where they produced a silk thread (Figure 2G) on which they hung (Figure 2H).

4. Discussion

Our results demonstrated that *N. platensis* have the ability to infest *P. oleracea* anually. Our results also demonstrated that *N. platensis* present most biological parameters similar to other common Noctuidae.

The infestation of *P. oleracea* by *N. platensis* for five consecutive years shows the adaptability of this insect. Plants of the genus *Portulaca* L. have a diversity of chemical compounds, but with low toxic potential (Khodadadi et al., 2018; Montoya-García et al., 2018), as most of them are edible (Iranshahy et al., 2017; Sinha, 2018) and with high propagation capacity (Patil et al., 2018; Rauber et al., 2018). This shows that, even infested by *N. platensis*, in many cases with total consumption of the aerial part, these plants can regrow. This explains the weed status of *P. oleracea* on various areas of crops (Altieri and Doll, 1977; Specht et al., 2004; Bulacio et al., 2013; Juaréz et al., 2016). The mean number of larvae sampled per plant (± SD), ranging between 0.7 ± 0.45 ± and 1.6 ± 0.90, is small compared to other annual succulent plants. The low number of larvae per plant may indicate environments with insufficient food availability for larger numbers of larvae, with the need to migrate to feed on other plants (Menezes et al., 2018a, 2018b). This explains the fact that larvae hang on silk threads soon after emergence, which can be an adaptation of migration to other plants to search for food (Tavares et al., 2014a).

The number of plants infested by *N. platensis* larvae was above 59.25% in all samplings, except in 2017 without presence of injuries and larvae. The lack of larvae in 2017 may be due to the lower size of plants or low number of *P. oleracea* plants in the area, possibly due to competition with others, such as *C. echinatus*, *E. heterophylla* and *C. rotundus*. The lower plant size or momentary reduction in the number of *P. oleracea* plants have been reported to be due to competition with others such as sage, *Salvia macrochlamys* Boiss. & Kotschy (Lamiaceae) with greater allelopathic potential in the seed germination of that plant (Erez and Fidan, 2015). Other factors, such as natural enemies, may reduce momentarily the number of *P. oleracea* plants as reported in Trinidad and other locations in the Caribbean and South America and used in biological control programs for this plant in Papua New Guinea, where it reached status of aggressive invader (CruttwellMcFadyen and Bennett, 1995). The purslane sawfly, *Schizocerella pilicornis* (Hohmgren, 1868) (Hymenoptera: Argidae) and the portulaca leafmining weevil, *Hypurus bertrandi* (Perris, 1852) (Coleoptera: Curculionidae) migrated from Europe and the Mediterranean region to the United States of America, respectively where fed on 80% of the leaf area of *P. oleracea* plants grown as a weed per year in common walnut, *Juglans regia* L. (Juglandaceae), peach, *Prunus persica* (L.) Batsch not Stokes nor (L.) Siebold & Zucc. (Rosaceae) and tomato, *Solanum lycopersicum* L. (Solanaceae) crops (Clement and Norris, 1982; Norris, 1997).

The presence of *N. platensis* larvae on *P. oleracea* plants in December in Januária is presumably due to the higher rainfall and temperatures of this month (Silva et al., 2017), favoring the *P. oleracea* germination, growth and development (Gomes Junior and Christoffoleti, 2008) as a fresh, abundant and nutritious food for the larvae of *N. platensis*. In a similar situation, this insect infested *V. sicyoides* and *V. vinifera* in February and from October to December representing rainy periods in Guarani and Pelotas (Specht et al., 2004).

The high variation in the number of eggs and egg masses per female and without covering its eggs with pubescence by *N. platensis* is characteristic of noctuids, such as *Aucula franclemonti* Todd & Poole, 1981 and *Aucula magnifica* (Schaus, 1904) (Lepidoptera: Noctuidae) in the laboratory on plants of *Vitis labrusca* L. (Vitaceae) in Bento Gonçalves, Rio Grande do Sul State (Poletto et al., 2010). The duration of the pupa stage of *N. platensis* was similar to that of other noctuid species, such as the velvet armyworm, *Spodoptera cosmioides* Walker, 1856 (Lepidoptera: Noctuidae) fed with plants of *P. oleracea* in laboratory in Planaltina, Distrito Federal, Brazil (Specht and Roque-Specht, 2016).

The silk thread produced by *N. platensis* larvae, for hanging, is important for their movement in different plant parts and the colonization of other hosts, in addition to helping to protect against predators, as reported for *Thyrinteina arnobia* (Stoll in Cramer, 1782) (Lepidoptera: Geometridae) larvae in organza bags involving *Eucalyptus* L'Hér. (Myrtales) branches. This defensive behavior was effective against attacks by adults of the predator *Podisus distinctus* (Stål, 1860) (Heteroptera: Pentatomidae) (Soares et al., 2009).

The annual defoliation of *P. oleracea* plants by a low number of *N. platensis* larvae per plant results in a rapid decline of these plants, but they have a high regrowth capacity.

The bioecology and injury aspects provided are important information for management strategies of *N. platensis* on *P. oleracea*. These aspects may also be important for management programs of this plant as a weed, with the formation of adequate environments that allow its natural control by *N. platensis* larvae. Infestation of *P. oleracea* as a weed by *N. platensis* could reduce control costs and contamination with the use of synthetic herbicides.

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