

Food consumption rates in *Scotussa lemniscata* (Orthoptera: Acrididae: Melanoplinae) under controlled conditions

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Tasas de consumo en *Scotussa lemniscata* (Orthoptera: Acrididae: Melanoplinae) bajo condiciones controladas

RESUMEN. El melanoplino *Scotussa lemniscata* (Stål), es considerado una de las especies de acridios plaga de los pastizales de la región pampeana. El principal objetivo de este estudio fue estimar las tasas de consumo de machos y hembras de *S. lemniscata* desde el quinto estadio de desarrollo hasta el estadio adulto bajo condiciones controladas (30°C, 14L: 10D, 40% HR). Los ensayos de consumo fueron llevados a cabo utilizando como recurso alimenticio el pasto forrajero perenne *Festuca arundinacea* (Schreber) (Poaceae). El estudio de estos aspectos es importante para realizar una determinación más precisa del estatus de plaga de esta especie. Los resultados muestran que el consumo realizado por los individuos según su sexo y estadio de desarrollo fue significativamente diferente, el consumo incrementó desde el quinto estadio hasta los adultos pre-reproductivo en ambos sexos, también se observó que las hembras adultas consumieron (118,81 ± 9,41 mg/día) significativamente más que el resto de los individuos. Los machos adultos tuvieron un consumo diario similar al de las ninfas hembras de quinto estadio. Estos conocimientos pueden contribuir al desarrollo de estrategias eficaces y sostenibles de manejo de las poblaciones de estos insectos.

PALABRAS CLAVE. Acridio plaga. *Festuca arundinacea*. Región pampeana. *Scotussa lemniscata*. Tasas de consumo.

ABSTRACT. The Melanoplinae *Scotussa lemniscata* (Stål), is considered a pest grasshopper of the Pampa region grasslands of Argentina. The goal of this study was to estimate the consumption rates of males and females *S. lemniscata* as fifth-instar nymphs and adults under controlled conditions (30°C, 14L:10D, 40% RH). The consumption trials were carried out using the perennial grass *Festuca arundinacea* (Schreber) (Poaceae) as food source. The study of these aspects is necessary to determine its current pest status more accurately. Consumption rates differed according to sex and stage of development. These were higher in the pre-reproductive adult stage vs. fifth-instar nymphs for both sexes. Additionally, adult females consumed significantly more (118.81 ± 9.41 mg/day) than the rest of individuals. The consumption of adult males and fifth-instar females was similar. Knowledge on consumption rates could contribute to the development of effective sustainable population management strategies.

KEYWORDS. Consumption rates. *Festuca arundinacea*. Grasshopper's pest. Pampas region. *Scotussa lemniscata*.

Grasshoppers constitute one of the most conspicuous herbivore group of insects in grassland ecosystems. They play a significant ecological role as primary consumers,

as components of the trophic network, and in the cycling of nutrients and energy (Belovsky, 2000; Guo et al., 2006; Song et al., 2018). Some species of grasshoppers are

considered harmful to agriculture and during outbreak years, can destroy crops and compete with livestock for available forage (Branson et al., 2006; Mariottini et al., 2012).

One of the species historically considered as harmful for agriculture in Argentina is the melanopline grasshopper *Scotussa lemniscata* (Stål) (Orthoptera: Acrididae: Melanoplinae), which inhabits grasslands of northern and central Argentina (including Neuquén province in northwestern Patagonia), Uruguay, and southernmost Paraguay and Brazil (Carbonell et al., 2017). The species has been categorized as a regular minor pest (COPR, 1982). *Scotussa lemniscata* has one generation per year (univoltine) with obligatory embryonic diapause (Mariottini et al., 2011; Cigliano et al., 2014) and is polyphagous (Carbonell et al., 2017). Studies carried out by Torrussio et al. (2002) reported that *S. lemniscata* showed a favorable response to disturbed areas and was positively correlated with sown grasses. The species also shows a preference for relatively humid environments with high density vegetation (Cigliano & Ronderos, 1994; Carbonell et al., 2006).

The aim of this study was to estimate the consumption rates of males and females of *S. lemniscata* as fifth-instar nymphs and adults under controlled laboratory conditions (30°C, 14L: 10D, 40% RH). These two developmental stages were selected because most grasshopper species tend to produce significantly more damage during the later stages of their life cycles (Putnam, 1962, 1963; Hewitt & Onsager, 1983).

Individuals used in the experiments were collected with entomological nets as third-instar nymphs in pastures at Tandil County (central Buenos Aires province, Pampas region, 37°04'40"S, 59°04'39"W, 150 masl). After collections, individuals were maintained in a rearing room under controlled conditions (30°C, 14L: 10D, 40% RH) (Mariottini et al., 2008, 2019; Mariottini, 2009). The consumption trials were carried out using the perennial forage grass *Festuca arundinacea* (Schreber) (Poaceae) as food source, which is one of the pastures most extensively grown in much of Argentina (Bazzigalupi & Bertin, 2014).

An estimation of consumption per individual was obtained following the methodology used by Mariottini et al. (2011). A total of 120 individuals were used (30 females and 30 males as fifth-instar nymphs, 30 females and 30 males as pre-reproductive adults) (Fig. 1). Each grasshopper was placed individually in a micro-perforated container (1 l) together with a preweighed fresh ration of *F. arundinaceae*. After 24 h the remaining unconsumed food in each container was retrieved, sorted into fallen and standing material, and oven-dried at 60 °C for 48 h. Thirty control rations were prepared and oven-dried at 60 °C. The average dry weight of control rations was used as a correction factor, and applied to the initial fresh weight of each of the offered rations to calculate the dry weight of

the food offered. The difference in weight between the offered rations and the remaining material after a trial represented the consumption during the test. When analyzing the results, those individuals that molted were not taken into account because during molting there is no feeding. Consumption by sex and stage of development was compared using a non-parametric Kruskal Wallis test followed by a means pair comparison between the treatments range using the statistical software InfoStat (Conover, 1999; Di Rienzo et al., 2011). Additionally, the average biomass (dry weight) of adults of both sexes was determined by individually weighting 50 males and 50 females.



Fig. 1. *Scotussa lemniscata*. a. fifth-instar male. b. Adult male.

The consumption carried out by individuals according to their sex and stage of development was significantly different (Kruskal-Wallis test, $H = 23.77$; $p < 0.0001$). Adult females consumed (118.81 ± 9.41 mg/day) significantly more than the rest of individuals ($p < 0.05$) (Table I, Fig. 2). Consumption of adult males and fifth-instar females was similar ($p > 0.05$), as well as the consumption of fifth-instar males and females ($p > 0.05$). In comparison, adult females consumed approximately 27.4% more than adult males, 39.1% more than fifth-instar females, and 47.8% more than fifth-instar males. Adult males consumed 28.1% more than fifth-instar males.

Table I. Food consumption rates (mg/individual/day) of *Scotussa lemniscata* by sex and stage of development at 30 °C and 14:10 (L: D) photoperiod.

Sex/Stage	N	Mean± SE	VC	Min	Max
Female					
5 th instar	23	72.42 ± 8.88 bc	58.80	22.46	223.48
Adult	24	118.81 ± 9.41 a	38.80	30.44	223.34
Male					
5 th instar	28	62.04 ± 8.16 c	69.61	7.25	178.77
Adult	22	86.27 ± 7.09 b	38.55	12.49	140.73

VC = Variation coefficient. Different letters indicate significant differences (LSD Fisher $p < 0.05$).

Although the present study was conducted with only two developmental stages (fifth-instar nymphs and adults), the results obtained in our assays agree with similar studies conducted with other grasshopper species in the sense that food consumption increases as development progresses (Hewitt & Onsager, 1983). Consumption increased significantly from fifth instar up to the pre-reproductive adult stage in both sexes. Mariottini et al.

(2011) observed that the melanoplines *Dichroplus elongatus* (Giglio-Tos) and *Dichroplus maculipennis* (Blanchard) significantly increased their consumption from the fourth nymphal instar to the pre-reproductive adult stage. On the other hand, females of *S. lemniscata* consumed more than males. The same pattern was observed in *Dichroplus pratensis* (Bruner), *D. maculipennis* and *D. elongatus* (Sánchez & De Wysiecki, 1983; Mariottini et al., 2011). In relation to this, Genovesio et al. (2011) indicated that this increase in consumption in adult females could be attributed to their larger size and higher energetic demand associated with their reproductive activity.

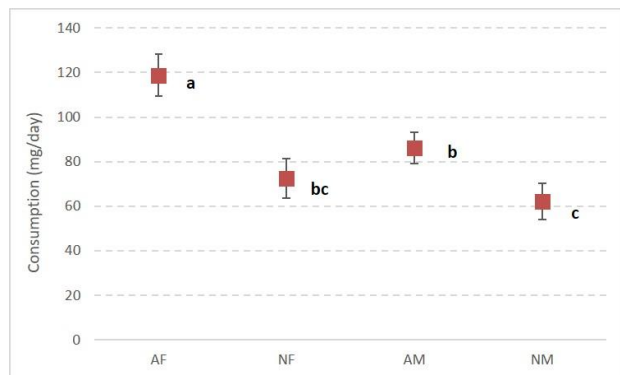


Fig. 2. Consumption rates (mg/individual/day) of *Scotussa lemniscata* under laboratory conditions (30 °C, 14L:10D). Different letters indicate significant differences (LSD Fisher $p < 0.05$). References = AF: adult female, NF: nymph female, AM: adult male, NM: nymph male.

One particular aspect to highlight is the variability recorded in the consumption rate of different individuals within the same sex and stage of development. We consider that when evaluating consumption individually, as was done in the present work, the results could indicate a daily maximum potential consumption. Mariottini et al. (2019) evaluated in the laboratory under similar conditions, the consumption rates of nymphs and adults individually (males and females) of *D. maculipennis* fed with soybean (*Glycine max* (L.) Merr.), corn (*Zea mays* L.), wheat (*Triticum aestivum* L.), and oat (*Avena sativa* L.), four of the most economically important crop-plants of the Pampas region. Results showed a significant variation in food consumption rates with respect to development stage and sex. Additionally, the consumption rates recorded for wheat and oat were significantly higher than for corn and soybean, possibly due to variations in nutritional quality of the plants offered. Soybean was the highest quality food; with approximately twice the amount of nitrogen vs. the other species. The nutritional needs of *D. maculipennis* could have been satisfied by feeding on low quantities of soybean, which is the most “nutritionally balanced food” among the food offered.

Different studies point out that the quantitative and qualitative nutritional requirements of grasshoppers are not static and variable, as in any animal with growth and

development, reproductive status, and behavior (Bernays & Simpson 1990).

Taking into account that the highest consumption is carried out by adult females, the consumption rate of the pre-reproductive females of *S. lemniscata* (118.81 ± 9.41 mg/individual/day) were lower than that recorded by Mariottini et al. (2019) for females of *D. maculipennis* on oat (322.24 ± 45.50 mg/individual/day), wheat (274.81 ± 39.31 mg/individual/day), and corn (222.41 ± 22.73 mg/individual/day) under laboratory conditions. On the other hand, Mariottini et al. (2018) evaluated under field conditions the loss of forage caused by adults of *D. maculipennis* on a pasture of *F. arundinaceae*, and recorded a mean consumption of 236.0 ± 0.02 mg/individual/day. The difference in consumption within the species could be related to the size of individuals. Slansky and Scriber (1985) indicated that body size can significantly influence the foraging behavior and compensatory responses in insects. In this regard, adult females of *D. maculipennis* have an average weight of 326.5 ± 8.70 mg and the males of 192.9 ± 5.60 mg (Mariottini et al., 2011). While both, females and males of *S. lemniscata* are smaller, females have an average weight of 101.83 ± 4.58 mg and males 58.81 ± 1.44 mg.

In spite of its wide geographic distribution and commonness in a variety of grasshopper communities in grasslands of Argentina (the Pampa region in particular), *S. lemniscata* has received relatively little attention when it comes to studies relating to its biological and ecological attributes. In this context, studying aspects related to the feeding patterns of harmful or potentially harmful grasshopper species to determine its actual pest status with better precision is relevant. Generating such knowledge could contribute to the development of effective sustainable population management strategies, possibly reducing the use of chemical insecticides.

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