



Density and spatial distribution of different development stages of *Sternechus subsignatus* Boheman (Coleoptera: Curculionidae) in soybean crops

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ABSTRACT

The population recruitment and the spatial distribution of eggs, larvae, overwintering stages and adults of the soybean stalk weevil, *Sternechus subsignatus* Boheman, on soybean were estimated in two commercial farms of the Tucumán province, Argentina, during three consecutive productive cycles. At weekly intervals 30 sampling units were taken in a random distribution from each farm, and the number of adults as well as the number of “rings” and gall-like structures around stems and/or branches recorded, from which the number of eggs and larvae, respectively, were inferred. At fortnightly intervals 20 sampling units of soil were taken at random and the number of overwintering stages recorded. The recruited number of the different developmental stages was analyzed by nested ANOVA, and the spatial distribution was estimated by the Taylor's Power law and Iwao's regression methods. Adults were recorded in all samples while eggs and larvae were found from mid-January to late April. The recruited number of the different stages was low and did not differ between stages or farms, and the spatial disposition of all developmental stages was at random. This study constitutes the first of its kind for this pest, and provides information that will be useful for the purposes of monitoring for biological studies and for insect pest control in the field.

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1. Introduction

The spatial distribution of the members of a local population, particularly insects, depends on the spatial scale considered, characteristics of the habitat, the life cycle and population density as well as interspecific interactions (Benard and McCauley, 2008; Coll and Yuval, 2004; Slansky and Feeny, 1977; Schowalter, 2006). The spatial distribution affects the efficiency of sampling plans as well as the analysis and interpretation of data, and if it is a pest, knowledge of the distribution allows a selective approach in implementing control measures in time and space in the framework of integrated pest management (IPM) (Bechinski and Pedigo, 1981; Nestel et al., 2004).

The soybean stalk weevil, *Sternechus subsignatus* Boheman, 1836 (Coleoptera: Curculionidae: Sternechini), is one of the most important pests on soybean crops in Bolivia, Brazil, Paraguay, and in the northwestern of Argentina (Hoffmann-Campo et al., 1991; Silva, 1999; Socías et al., 2011). This weevil is a Neotropical univoltine species restricted to certain herbaceous leguminous plants among which soybean, *Glycine max* Merrill (Fabaceae), is the preferred host (Silva, 1997). The life cycle comprises the egg, larval (five instars), pupa and adult stages. Eggs develop in five days approximately, with extreme values of three to 11 days (Silva, 1999). Eggs are laid individually, mainly in the middle portion of the stem and principal branches of the soybean plant, and each oviposition point is surrounded by a characteristic “ring” produced with plant tissues and is visible from the outside. Larvae are sedentary and larval feeding produces a characteristic gall-like structure also easily visible from the outside (Hoffmann-Campo et al., 1991). They remain in the plant for around 44 days, when in mid-autumn (end of April) the fully grown larvae leave the plant and burrow into the ground to hibernate. They pupate in early spring (by the end of September),

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reach the adult stage by October, and emerge from late November to early December coinciding with the onset of rains (Socías, 2012). Late instar larvae, pupae and pre-emergent adults are the non-active overwintering stages in the ground (Socías et al., 2011). Adults are long-lived, can disperse over considerable distances and extreme estimates of maximum fecundity are 79–445 eggs per female. Due to an oviposition period longer than 120 days (Hoffmann-Campo et al., 1991; Lorini et al., 1997; Silva, 1999) different developmental stages overlap widely (Socías et al., 2011).

The soybean stalk weevil reduces soybean productivity and it is highly harmful since both larvae and adults damage soybean (Silva et al., 1998). The adult produces a longitudinally fraying in the main stem and branches of the plant due to feeding and females in the form of a “ring” for egg oviposition (Casmuz et al., 2009b) while larval feeding, due to the destruction of the vascular system, reduces the flow of sap in the main stem completely preventing it (Silva, 1999, 2000). Presumably, the status of *S. subsignatus* as a serious pest on soybean was due to the expansion of this culture in the mentioned countries during the last decades, facilitated by non-tillage and minimum tillage systems (Casmuz et al., 2009a; Costilla and Venditti, 1990; Hoffmann-Campo et al., 1999; Panizzi et al., 1977; Pruett et al., 1996). In effect, associated with its high fecundity and a relatively low or null impact of natural enemies of eggs and larvae (Lorini et al., 1990), no-tillage or minimum tillage systems facilitate survival of hibernating stages (Hoffmann-Campo et al., 1991; Socías, 2012), enhancing the numerical response of the local population.

The control of *S. subsignatus* is currently based on cultural and chemical strategies such as crop rotation with grasses, trap crops, delayed planting dates, seed treatment with chemical insecticide and foliar insecticide applications (Casmuz et al., 2009a; Hoffmann-Campo et al., 1999). To optimize the results of such practices, it is necessary to have all available information about the pest in order to realize an efficient management within the guidelines of IPM program, and to our knowledge, information about the spatial distribution of *S. subsignatus* in soybean cultures is lacking. The objective of this work was to analyze the density and spatial distribution of the different developmental stages of *S. subsignatus* in soybean crops cultivated under conventional pest management.

2. Materials and methods

2.1. Sampling sites

Two soybean farms located in Tucumán province, northwestern of Argentina, were used to carry out this study during three consecutive productive cycles: 2007/2008, 2008/2009 and 2009/2010. One farm was located in La Cocha County (farm 1), representative of the southern productive zone, while the second farm, was in Cruz Alta County (farm 2), was representative of the eastern productive zone of Tucumán. Table 1 contains additional information related to each farm under study.

The climate in Tucumán province is subtropical (25 °C mean annual temperature) and characterized by a quasi monsoon

weather: dry winters are followed by rainy summers: 1100 mm of cumulated annual rainfall is distributed from October, early spring (October) to early autumn (March) (Minetti et al., 2005). The main crops are sugarcane (*Saccharum officinarum* L), lemon (*Citrus limon* L) Burm), corn (*Zea mays* L), and soybean.

The soybean crops were kept under conventional management practices: weed management was performed by one glyphosate application prior to seeding and another application between the V6 to R1 phenological stages (Fehr and Caviness, 1977). For weevil control during the first vegetative stages (V1–V3), soybean seeds were treated with thiamethoxam and during older vegetative stages, 1–3 applications of pyrethroids were made according to weevil density. During the initial reproductive stages of the crop (R1 to R3) one insect growth regulator (IGR) application was made for the control of defoliator caterpillars, and during R4 to R6 one application of an organophosphate + pyrethroid was made for stink bug control. For control of diseases, one application of strobilurin + triazol was made at the R2 to R5 stages. In this research, the plots under study were in a soybean monoculture: soybean (summer) – wheat (winter) – soybean (summer).

2.2. Insect sampling

In each farm, sampling of *S. subsignatus* was done during three consecutive soybean productive cycles: 2007/2008, 2008/2009 and 2009/2010.

The size of study areas or plots was 2 ha in each farm. On each plot and approximately at weekly intervals and during sunshine hours, from the V3 phenological stage up to senescence, we randomly took 30 sampling units of 1 lineal meter (the spatial scale used by technicians and farmers to monitor this pest in the field) which include a mean number of 18 plants per sampling unit. The total number of adult weevils as well as the total number of “rings” around stems and/or branches and the total number of galls were recorded. Previous studies showed that each ring generally corresponded to only one egg, and each gall to only one larva (Hoffmann-Campo et al., 1991; Silva et al., 1998), so the number of eggs and larvae were inferred from the number of rings and gall-like structures, respectively, in all plants situated in the linear meter. Due to time restrictions, sampling of the number of overwintering stages (late instar larvae, pupae and pre-emergent adults) was estimated by means of 4–6 ground samples randomly distributed from early autumn up to early spring on a fortnightly basis. Each sample was 1 m length, 0.3 m wide (0.15 m at each side of the row of plants), and 0.2 m depth. The ground was sifted *in situ* with a 20-mesh metallic sieve and the total number of overwintering non-active forms registered (Socías et al., 2011).

2.3. Data analysis

2.3.1. Recruitment

We considered that the number of “rings” and gall-like structures placed in the main stems and lateral branches of the soybean plants represented the number of eggs and larvae, respectively.

Table 1
Consecutive productive cycles (soybean seasons), coordinates of each one of the farms located in the two areas (South and East), soybean variety, maturity groups and growth habit of soybean together with the corresponding sowing date.

Soybean season	Area	Farm	Soybean variety	Maturity group	Growth habit	Sowing date
2007/2008	South	1 (27° 46' S, 65° 30' W)	A 8100 RG	8.1	determinate	29/12/2007
	East	2 (26° 49' S, 64° 51' W)	A 7636 RG	7.6	determinate	21/12/2007
2008/2009	South	1 (27° 46' S, 65° 30' W)	A 8000 RG	8.0	determinate	28/12/2008
	East	2 (26° 49' S, 64° 51' W)	Munasqa RR	8.3	determinate	17/12/2008
2009/2010	South	1 (27° 46' S, 65° 30' W)	A 7636 RG	7.6	determinate	14/12/2009
	East	2 (26° 49' S, 64° 51' W)	Munasqa RR	8.3	determinate	23/12/2009

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