THE POTENTIAL IMPACT OF ECOLOGICAL AND GEOGRAPHICAL PARAMETERS ON THE SPREAD OF THE INVASIVE PEST *NEZARA VIRIDULA*

Viorela Corina MARCU, Ioana GROZEA
Banat's University of Agricultural Sciences and Veterinary Medicine "King Michael I of Romania"
Timisoara, Romania
Corresponding author: ioana_entomol@yahoo.com

Abstract. *The species Nezara viridula (L.) or green stink bug is one of the most recent non-autochthonous species that invaded agroecosystems in our country. The lack of natural enemies makes this insect rapidly spreading from the locality to the locality and from the geographic area to the other. It is not known exactly what causes enlargement to geographically or ecologically different areas. Globally, the insect is present both in warm and temperate areas. At Europe level it is found in almost all geographic points except the northern point. The observations of this scientific paper have been made in the southwest of Romania, more precisely at the level of the Caras-Severin County, which has a great variety of relief forms, from the plain to the mountains (from 168 m to 1000 m). The effective or size of the insect population at a given time, such as spatial distribution, has been the main parameters analyzed in terms of temperature and humidity but also geographical altitude. The observation period was in June-October of 2016 and 2017. Because they are large insects, trapping them with pheromone or colored traps is not conclusive and rather quantification by direct observations on the preferred plants (tomatoes, cucumbers, beans). To analyze population size and distribution in 8 different areas, 10 samples (two monthly sample/area) were processed. Correlations between environmental factors (temperature, humidity) have shown that high temperatures and low humidity favor activity and insect movement. The great presence of the species was mainly observed in areas with lower altitude of the county and less or no in high altitude areas, respectively at values ranging from 168 to 300 m.*

Keywords*: Nezara viridula, spreading, ecological parameters, altitude.*

INTRODUCTION

The insect is present in both hot and warmer areas. In other words, from the southern point (40 degrees South Latitude) to the northern point (55 degrees North Latitude). Respectively, from New Zealand (SALISBURY et al, 2009) to UK (CABI/EPPO, 2008). Globally, there is a massive presence in the southern part, which is also a region of origin, respectively in Africa (TODD, 1989). Over time, it has expanded to the north so that day is frequent in Europe and including Romania (GROZEA et al, 2012) at about 45 degree N Latitude.

In monitoring activities, it was essential to take account of the number of generations of species. In warm countries, the plate has 3-5 generations per year (HILL, 1983) and in moderate generations, 1-2 (SQUITER, 2010). In our country the insect has one generation a year (GROZEA et al, 2015).The research field of the present studies is in a temperate area with sub-Mediterranean influences, hot air. Generally, the average annual recorded temperature is varied, given the geographical diversity, with 10-11 degrees Celsius in the hill and the smooth zone and 4-9 degrees Celsius in the mountains. The precipitation level also varies with 700 mm/m^2 at low and 1400 mm/m^2 in mountain areas (SENCU and BACANU, 1976).

MATERIAL AND METHODS

The research was carried out during two years of study (2016-2017) in 8 localities in Caras Severin County. The county, located in the southwest part of Romania, includes both low altitude (plains) and high (mountain) areas. This founded the consideration of the influence

of the altitude influence on the population level of the species *Nezara viridula*. Also, the temperature and humidity were the ecological factors considered in population analysis.

Observations on the size of the population were made directly on plants during June-October (two monthly sample/locality). Each observation point (locality) had various host plants, generally, frequent species in the area (most of them being vegetables plants).

Short geographic description of research areas. *Anina* is located in a mountainous region in the south of the Western Carpathians and has the following geographical coordinates: 45° N latitude and 21° E longitude. It has an average altitude of 645 m (SENCU, 1993).

Baile Herculane: it is a place at an altitude of 168 m (Table 1), more precisely in a valley called Cerna Valley separating the mountains between them.

Bocsa is located in Banat's historic province, between the plain and the mountain area, on the middle course of the Barzava River. It is surrounded to the north and south by massive hills or habitats. The local resumption consists of a chain of basins on Barzavei (VISAN, 2015).

Caransebes: it is made up of a central, very low, bordered by the terrace. The city borders are surrounded by mountains and the average altitude reaches between 489 m and 639 m (JURMA, 2011).

Moldova Noua: it is situated on the border with Serbia, in the Danube Delta area, in the south of the county. It is also a port on the Danube (Figure 1).

Oravita: it is located in the southwestern part of Caras Severin County and has a pre-mountain relief. However, hills and plains are present that provide conditions for the development of agriculture and viticulture. Of note is the rich hydrographic network. The city is near of parallel 45.

The *Oţelu Roşu* locality: it is located on an alluvial terrace, at an average altitude of 268 m (Table1). The city is located in the north-eastern part of Caraş-Severin County (Figure 1) and has the geographical coordinates of 45 ° 31'7 "N 22 ° 21'10" E / 45.51861 ° N.

Reşiţa is the capital city of Caraş-Severin County and includes generally mountains whose altitudes are between 600 - 1200 m and piedmont areas ranging from 700 - 800 m to 200 m at contact with the plain (ZAHIU ET AL, 1971).

Figure 1. The research places in different geographic areas and altitudes in Caras Severin County (representation on the map in the public domain)

Table 1

Altitude and general geographic characteristics of research sites in Caras Severin County

No. crt.	Place/locality	Altitude (m)	Research place through geographic description
1	Anina	1000	mountain
2	Caransebes	550	plateau
3	Resita	500	piedmont area
4	Oravita	300	hill area
5	Moldova Noua	280	hill area
6	Otelu Rosu	268	inter-mountain terrace
7	Bocsa	170	plain
8	Baile Herculane	168	valley located in the depression

RESULTS AND DISCUSSION

The research underlying this paper focused on two approaches. The first focused on how the flight of the Nezara insects is influenced by the main environmental factors (air temperature (T) and relative air humidity (RH). And the second, focused on the ability of the insect to fly, develop and cause damage to different altitudes.

During the biological activity (flight, copulation, feeding), stinkbugs were observed flying but more on the plants, feeding intensely. The month in which it was monitored and quantified (as a total value/month) were June, July, August, September and October. At the beginning of the active period (June) the insect was present in small numbers or not at all (0-2 ind), with no relation to temperature and relative humidity factors (24.74°C and 76.3% RU). Then, starting July, the number of insects observed on the plants increased and the maximum population was recorded in August and September. Here we can discuss the influence of factors. However, although it is mentioned this insect is oriented to warm and droughty regions (KIRITANI, 2006), our results in the year 2016 showed the opposite very well-functioning in term of the temperatures between average values of 16.44 and 19.93˚C commixed with UR values of 74.2 and 75.46% (Figure 2). The total values of individuals in all observation points during this period were high (371-377 ind.).

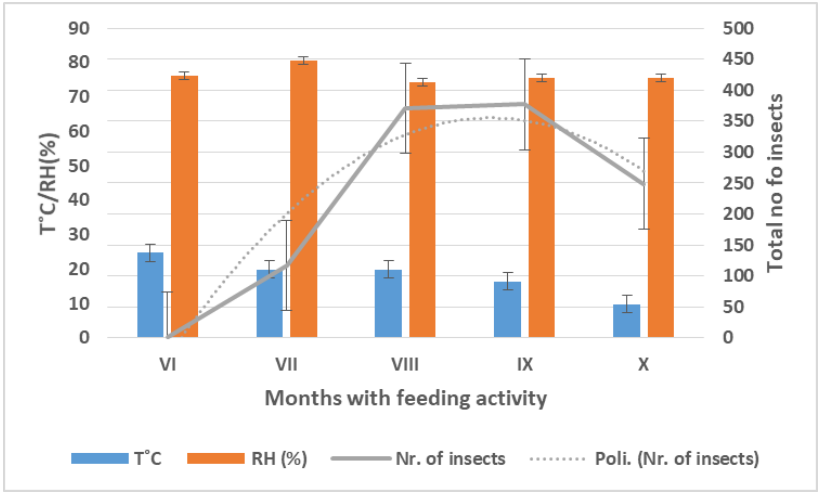

Figure 2. Correlations between temperature and relative humidity relative to the total number of insects of the *Nezara viridula* in 2016 in Caras Severin County

In October, although the temperatures were low and the humidity was present, the populations remained fairly high, 249 ind./all OPs). In November, it was not observed in crops, only in sheltered places, without feeding. In the year 2017, the situation changed with respect to the correlation between the total number of stinkbugs and the average values of the temperature. In other words, the temperature had higher values, (combined with moderate values of relative humidity), and this led to an increase in the population level, reflected by the 510 ind/OPs recorded in August (with a peak in flight dynamics) (Figure 3). These confirm research in Asia (KIRITANI, 2006), which found that at high temperatures the insects can reached the maximum.

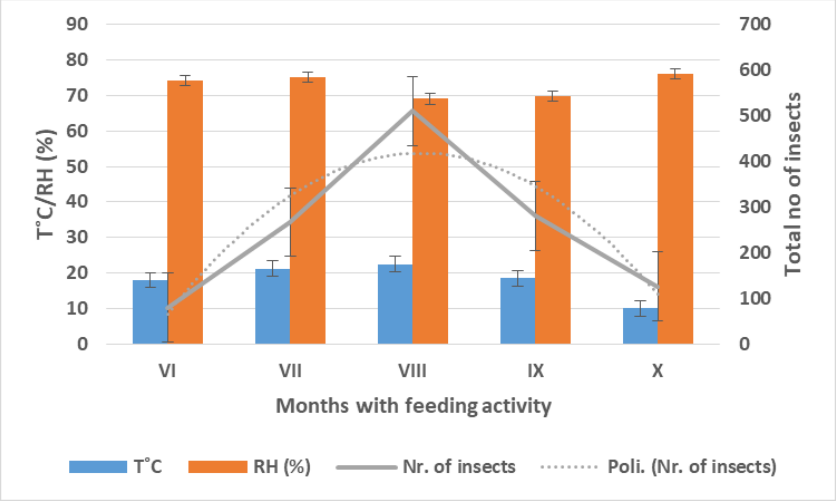

Figure 3. Correlations between temperature and relative humidity relative to the total number of insects of the *Nezara viridula* in 2017, in Caras Severin County

Situations recorded in the two years of study (2016 and 2017) show a contrasting picture as environmental factors have shown different values. If in 2016 the maximum population was observed between August and September, in 2017 it was recorded only in August. If we are referring strictly to the number of stinkbugs registered, categorically the year 2017 was favorable (and this may be due to higher temperatures than in 2016). Humidity, which was maintained at an average level in 2017, with lower values in 2017 than in 2016, also contributes to maintaining a period without excess moisture, which appears to be favorable in insect activity.

In both years, the insect activated intensively in September, which is rarely found in most pests. At a population level of 249-281 ind, it can be concluded that it was continues to feed in autumn, as it is observed consuming plants and producing damages.

It can be mentioned that the temperature and humidity influenced the extremely high population (for this period) in the autumn, but the higher temperature values in 2017 determined higher numerical values of individuals than 2016.

In the populations, both adult and immature (larvae and nymphs) were observed. Sometimes all active forms (which cause damage) are present on plants only at one biological form. In the individual crops (either tomatoes, beans or cucumbers) and mixed (tomatoes + beans + cucumbers), all forms of *Nezara viridula* were present.

On the same plant species, monitored, several stages of development of *Nezara viridula* were observed (Figure 4). The most frequent stages observed in 2016-2017 were larvae and nymph.

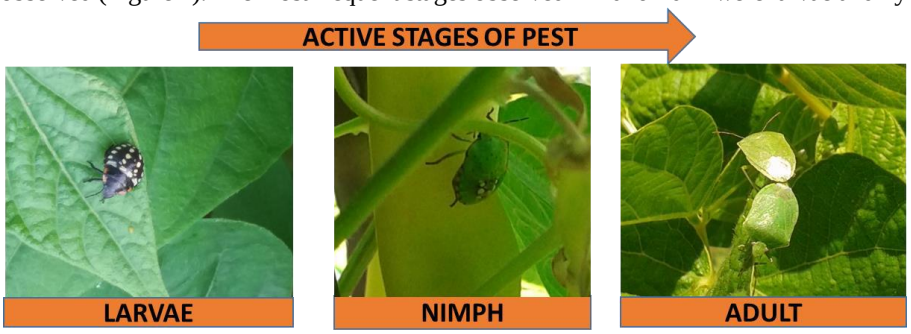

Figure 4. The active stages of insect pest *Nezara viridula*: larvae (left side), nymph (middle) and adult (right side) on the host plants from research places

Altitude is another factor that has been analyzed against the average number of stinkbugs. Since Caras Severin County offers a diverse range of altitudes, it has been easy to make comparisons between observation points. Each OP/locality could be associated with one of the altitude/relief form intervals.

Observations made in the OPs have shown different levels, ranging from zero to values that outweigh the economic damage threshold (EDS) (5-7 adults or 2-3 nymphs / plant). Thus, in Figure 5, it can be seen that the maximum of insects were present in the crops from Bocsa ($\bar{x}$ = 20.56 ind.), which is situated at 170 m altitude. The lowest or null values ($\bar{x}$ = 0-1.9 ind.) were recorded at different altitudes (from 268 to 1000m), respectively in OPs in Moldova Noua, Otelu Rosu, Caransebes and Anina. Average values of the population level were recorded at the research points in Resita ($\bar{x}$ =2.68 ind at 500m), Oravita ($\bar{x}$ =9.08 ind at 300 m) and Baile Herculane ($\bar{x}$ =10.56 ind at 168 m). These values are not very high but are at on minim limit or above the EDS and this must be taken into account.

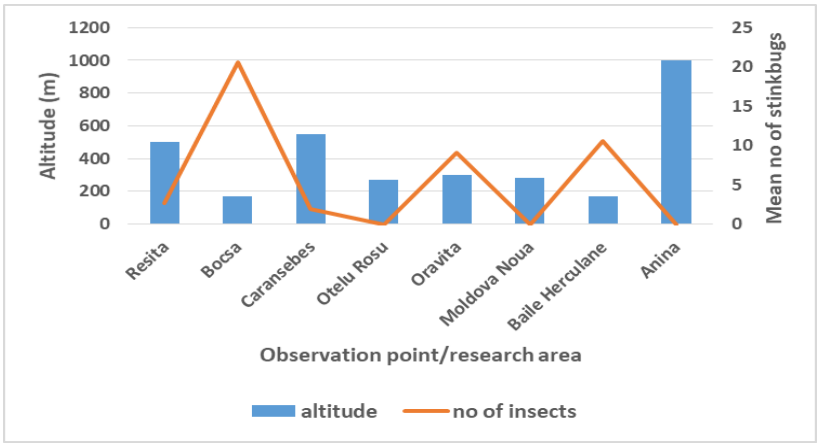

Figure 5. Correlations between altitude/OP and mean number of insects of the genus Nezara in 2016, in Caras Severin County

The 2017 monitoring activity has highlighted an increase in the size of populations, regardless of altitude; valid only in the OPs in which it was present (Figure 6). Practically, as compared to 2017, the average of individuals increased, so at Bocsa (low altitude) the population value increased ($\bar{x}$ =23.76 ind). The values also increased at OP level in Caransebes and Baile Herculane ($\bar{x}$ =6.44 ind; $\bar{x}$ =11.72 ind).

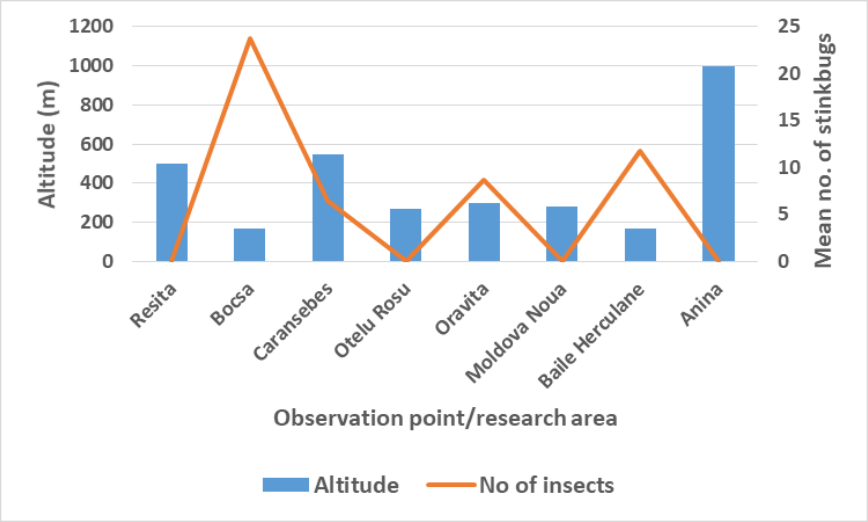

Figure 6. Correlations between altitude/OP and mean number of insects of the genus Nezara in 2017, in Caras Severin County

In addition to 2016, in 2017 in the OP in Resita no biological form of the species was observed besides Anina, Otelu Rosu and Moldova Noua.

A major role, however, has the shape of the relief, but also the way to protect the area and no ultimately the strict altitude/surface analyzed. It is certain that in the mountain area (over 1000 m) the species was not present, but was present in the high hill, piedmont, mountain valley (only if it was surrounded by mountains) and plains. If the POs were located in high, even mountainous areas, but in valley or depressions (protected around), the stinkbugs were observed, even in high population. For example, in the PO/Baile Herculane at 168 m altitude, but surrounded by mountains, the population level was high ($\bar{x}$ =11.72 ind).

CONCLUSIONS

The correlations between environmental factors (temperature, humidity) and population size of Nezara have shown that high temperatures and moderate or low humidity favor insect activity and movement. In areas with lower altitudes and warmer conditions of the county (plain, hill and low valleys in mountainous areas) there were large populations of insects, but fewer or no in the high altitude associate with cold mountain areas.

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