



Geographical Spatial Distribution and Population Density of Wheat Stem Sawfly, *Cephus pygmeus*, in Wheat Fields in Southeastern, Eastern, and Northeastern Regions of Türkiye

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Abstract: The wheat stem sawfly (*Cephus pygmeus*) is a major pest of wheat crops in many regions of the world, including Eastern Türkiye. This study aimed to investigate the spatial distribution and population density of wheat stem sawfly in Eastern Türkiye and to evaluate the damage caused by this pest on wheat yield and quality. A total of 120 wheat fields were surveyed in six provinces of Eastern Türkiye during the 2018 growing season. The results showed that the population density of wheat stem sawflies varied significantly among the surveyed fields, with an average infestation rate of 37.4%. The highest infestation rate was recorded in the province of Kilis (62.5%) and Diyarbakır (61.9%), while the lowest was in the province of Ağrı (8.3%). The study also identified some factors that affect the population density of wheat stem sawflies, including host plants (mainly wheat, barley, and rye), altitude, temperature, and geographical structure such as mountains and forests. These findings provide valuable information for developing effective management strategies to control wheat stem sawfly populations and minimize the damage caused by this pest in Eastern Türkiye, especially Southeastern Anatolia Region.

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1. Introduction

The wheat stem sawfly [*Cephus pygmeus* L. (1767) (Hymenoptera: Cephidae)], which is a common and important pest of wheat, barley, and rye in Europe, North America, northern Asia, Middle Eastern countries, and the Mediterranean region (Morrill et al., 1992; Chen et al., 2004; Shanower and Hoelmer, 2004; Özberk et al., 2005; Kılıç et al., 2017; Mutlu, 2019; İnce et al., 2022).

The larvae of the sawfly feed on the stems of wheat plants, causing damage that can lead to yield losses and reduced grain quality. They have a biting-chewing mouth structure that allows them to rasp away at the plant tissue. This damage disrupts the vein integrity and impedes nutrient flow to the grains, resulting in delayed grain development, reduced grain weight, and increased susceptibility of weak stems to lodging (Troccoli et al., 2000; Knodel et al., 2010). It also causes losses in the protein content of the plant (Wallace and McNeal, 1966). In Türkiye, the damage caused by this pest has been estimated to be 288 kg/ha in durum wheat and 297 kg ha⁻¹ in bread wheat (Özberk et al., 2005). This

translates to a financial loss of \$68.8 ha⁻¹ and \$68.6 ha⁻¹, respectively (Özberk et al., 2005). The damage caused by the sawfly can vary depending on the variety of wheat, the time of infestation, and the weather conditions. In some cases, the damage can be as high as 23.77% (Özberk et al., 2005). *Cephus cinctus*, a straw bee species common in the Americas, is a serious pest that can cause significant crop losses. In a study by Beres et al. (2011), it was reported that this pest can cause crop losses of more than 30% and economic damage of \$350 million annually.

Cephus pygmeus has one generation in a year and initiates its reproductive activities when the average air temperature reaches 18 °C and the relative humidity reaches 76%. Following a period of winter diapause, the males are the first to emerge from this dormant state within 2-4 days (Mutlu, 2019). These adult insects satisfy their dietary needs by consuming nectar from weed flowers found at the periphery of the wheat fields, while their preferred mating locations are yellow flowers. Once the temperature reaches at least 20 °C approximately 26-27 days after reaching adulthood, the females begin laying their initial eggs inside wheat stems (Fulbright et al., 2017; Mutlu, 2019). Usually, one egg is deposited per talk, and these eggs hatch within a span of 8-12 days. The emergence of the larvae coincides with the milk production period of the wheat plant. Upon reaching maturity, the larvae leave the culm and enter diapause within stubble or other plant debris, where they form a transparent cocoon within two weeks (Gol'berg, 1986; Mutlu, 2019).

In this study, it was aimed to investigate the spatial distribution of *Cephus pygmeus*, a damaging pest in wheat fields, specifically the eastern regions (including Southeastern Anatolia, Eastern Anatolia, and Eastern Black Sea) of Türkiye. The objectives include assessing population densities in areas where the pest is spreading and enhancing the efficacy of integrated pest management programs (IPM) developed against this pest. By understanding the distribution patterns and population dynamics of *Cephus pygmeus*, valuable insights can be gained to support targeted pest control strategies and mitigate the impact of this destructive insect on wheat crops.

2. Material and Methods

The study encompassed 30 provinces and a total of 167 districts within the Southeastern Anatolia, Eastern Anatolia, and Eastern Black Sea regions in eastern Türkiye. The provinces included in the study were Adıyaman, Ağrı, Ardahan, Artvin, Batman, Bayburt, Bingöl, Bitlis, Diyarbakır, Elâzığ, Erzincan, Erzurum, Gaziantep, Giresun, Gümüşhane, Hakkâri, Iğdır, Kars, Kilis, Malatya, Mardin, Muş, Ordu, Rize, Siirt, Şanlıurfa, Şırnak, Trabzon, Tunceli, Van.

Samplings occurred from March to August 2019 and were conducted at two different times for each region, based on the tillering-stemming and spike-up periods of the plant, according to the Zadoks growth scale (Zadoks et al., 1974). In order to determine the distribution and density of *Cephus pygmeus* in wheat fields, a sweepnet with a diameter of 35 cm was used in each field. The sweeping process was repeated 200 times in each field. The sampling locations were accurately marked using a GPS device (Garmin BaseCamp) (Figure 1).



Figure 1. Sampling locations in Southeastern Anatolia (SA), Eastern Anatolia (EA), and Eastern Black Sea (EBS) regions of Türkiye (Garmin BaseCamp v4.6.2) (The red lines seen on the map represent the routes taken during the survey).

3. Results and Discussion

During the study, 330 wheat fields were surveyed and specimens of *Cephus pygmeus* were collected in 125 fields, 992 females and 571 males were collected within these areas. Distribution and densities of the *C. pygmeus* in the surveyed areas were represented in Figure 2 and Figure 3. It has been determined that the pest was common in all of the Southeastern Anatolian region and in other provinces of the Eastern Anatolian region except Tunceli and Hakkâri provinces. Sampling could not be conducted in Artvin, Rize, and Trabzon provinces located in Eastern Black Sea region since wheat-producing areas were not encountered enough in these areas. Wheat stem sawfly was not encountered in the sampling in Bayburt, Giresun, and Gümüşhane provinces. Figure 3 shows that the pest is most intense in the Southeastern Anatolia Region, with a small presence in the Northern parts of the Eastern Anatolia Region. There has not been a comprehensive study on the distribution and population density of the pest in these study areas, apart from a few studies that showed that it spread in some provinces in these regions and caused various damages (Özberk et al., 2005; Budak, 2012; Karaca et al., 2012; Durel, 2016; Mutlu, 2019; Mutlu et al., 2019; Özgökçe et al., 2022).

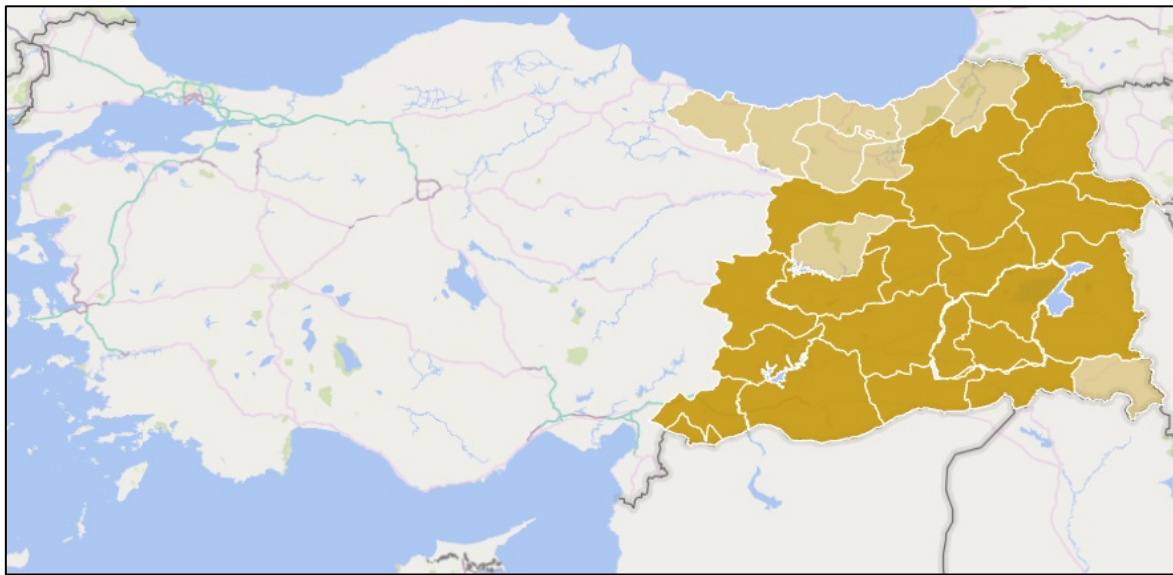


Figure 2. Observed (dark) and not observed (light) places of *Cephus pygmeus* in Southeastern Anatolia, Eastern Anatolia, and Eastern Black Sea regions of Türkiye.

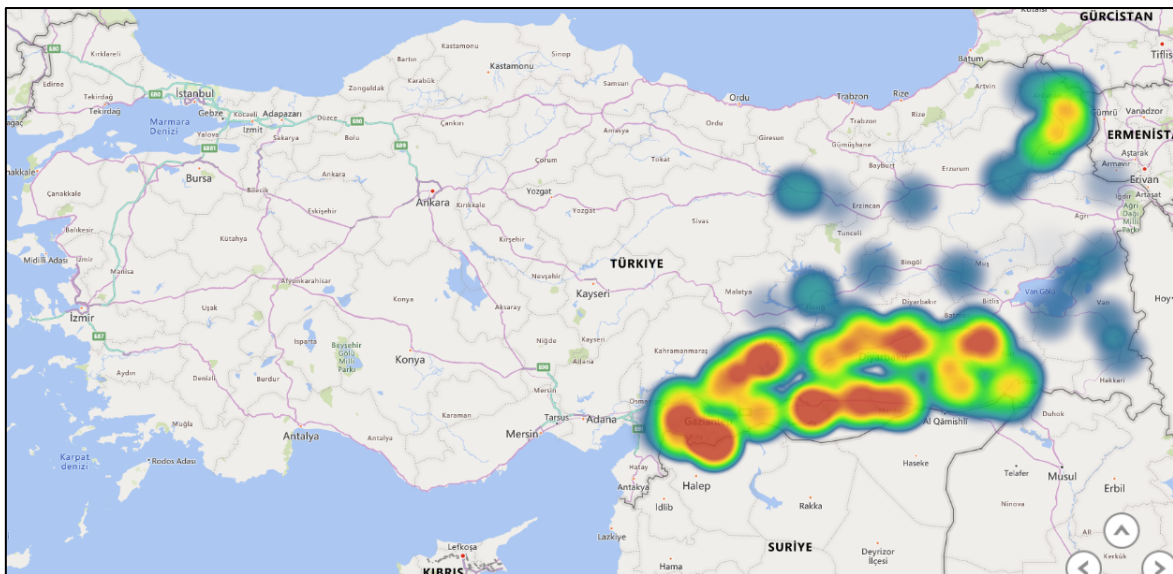


Figure 3. Heatmap of the density and distribution of *Cephus pygmeus*.

When examining the sampling sites where *Cephus pygmeus* individuals were collected, it was determined that the lowest elevation recorded was 371 m (Şırnak-Silopi), while the highest elevation reached 2222 m (Van-Başkale). Notably, the wheat stem sawfly individuals were predominantly found in the field margins of wheat fields. Adult individuals of the wheat stem sawfly, known for their slow flight, displayed a distinct pattern when disturbed during sampling, making them easily recognizable. Furthermore, it was observed that the adults of the wheat stem sawfly could be captured using a sweepnet at any time of the day, as they tended to rest on the stalks.

In terms of activity, the male individuals appeared to be more active than the females. Morphological examinations revealed that female individuals were larger and had a darker coloration compared to their male counterparts (Figure 4a, 4b). Furthermore, the male individuals predominantly exhibited a yellow coloration, particularly in the ventral part of the thorax (Figure 4c, 4d).

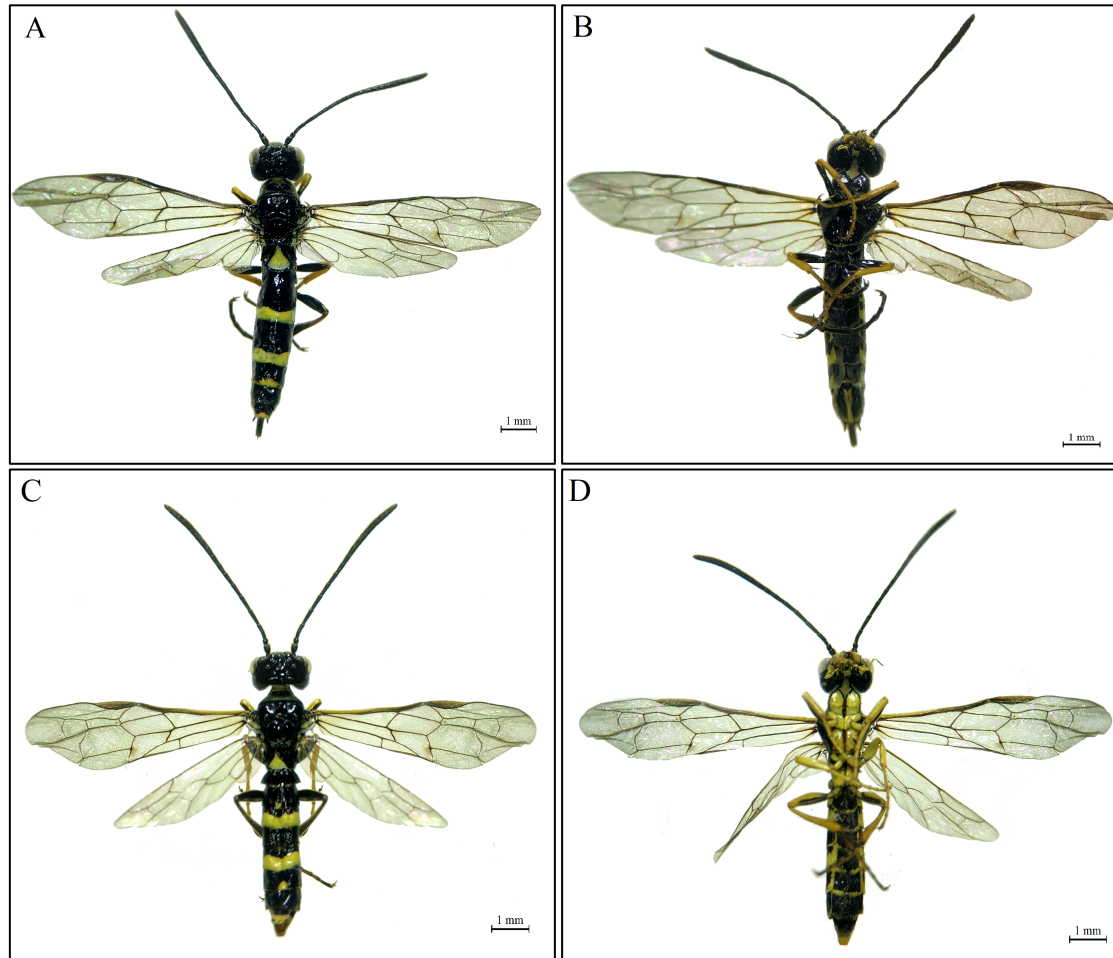


Figure 4. Morphological views of adult individuals; dorsal (A) and ventral (B) views of females, and dorsal (C) and ventral (D) views of males.

The population densities of the pests according to provinces and the pest infestation rates of the fields in each province are represented in Figure 5 and Figure 6. In the Southeastern Anatolia Region, the average number of adult individuals collected varied across the provinces. The average numbers of the individuals ranged from 3.70 (Batman) to 17.63 (Kilis) per 200 sweeping, indicating variations in the population densities of adult *C. pygmeus* individuals according to provinces. Within this region, the infestation rates of the wheat stem sawfly in the wheat fields exhibited a similar pattern to the pest densities across the provinces (Figure 5). The lowest recorded infestation rate was observed in Batman at 30%, while the highest adult infestation rate was found in Kilis and Diyarbakır, reaching 62.5% and 61.9%, respectively (Figure 5).

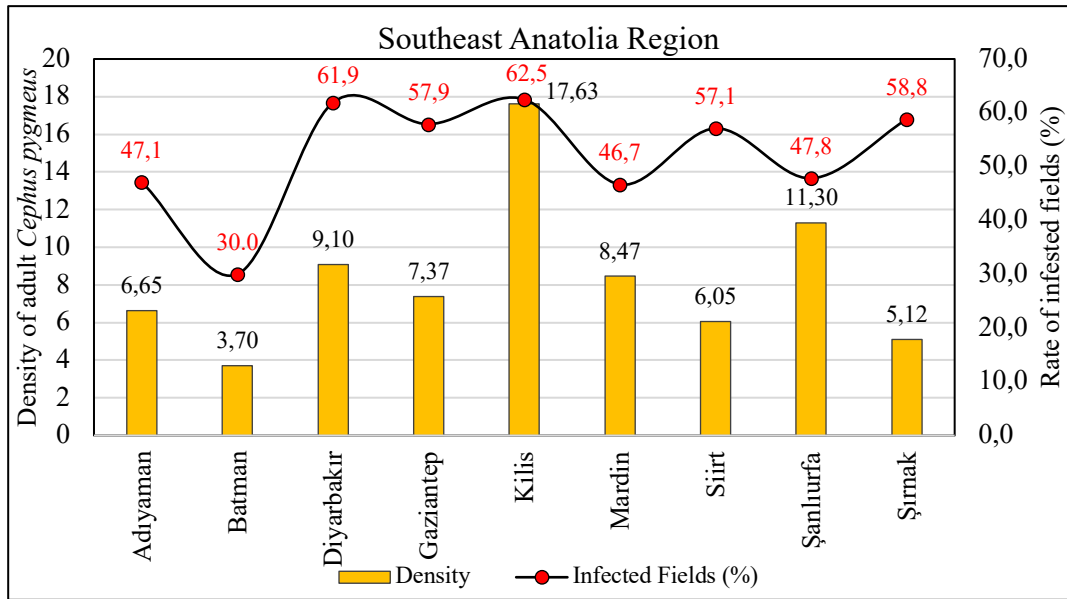


Figure 5. Density of adult *C. pygmeus* (adults/200 sweepnet) (primary axis) and rate of infested fields (%) (secondary axis) in the Southeast Anatolia region.

The infestation rate of *C. pygmeus* adults in wheat fields in the provinces of the Eastern Anatolia Region were found between 8.3% (Ağrı) and 50% (Kars). However, the population density of this pest in these provinces was significantly lower compared to the Southeastern Anatolia Region. The densities of the pests were determined from 0.14 to 7.21 individuals per 200 sweeps in Bingöl and Kars, respectively.

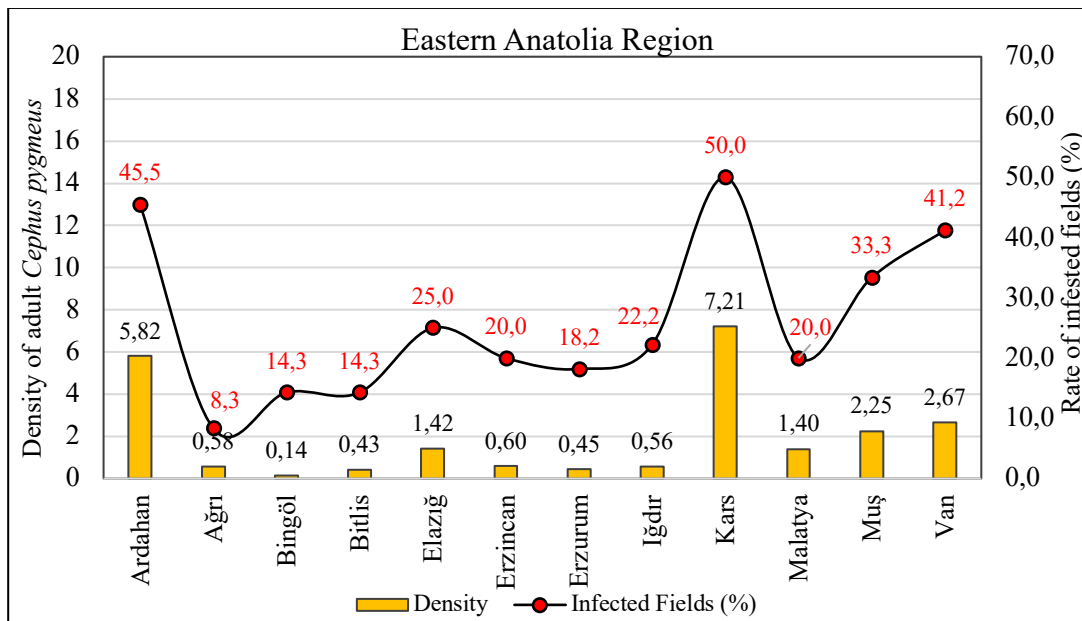


Figure 6. Density of adult *C. pygmeus* (adults/200 sweepnet) (primary axis) and rate of infested fields (%) (secondary axis) in the Eastern Anatolia region.

This study presents the first large-scale, comprehensive survey of the pest's distribution and density in the study areas, providing valuable insights into its distribution, population dynamics, and potential impact. According to the results obtained, it has been determined that the pest is more common and intense in the Southeastern Anatolia Region compared to other regions. Considering the geographical structures and climatic characteristics of the regions, it is seen that the spread and density of the pest increases from mountainous and forested areas to plains, from cold regions to warmer regions.

This situation also creates differences in wheat production areas and amounts between regions. According to the last 5 years data of TUIK, the Southeastern Anatolia Region has an area of 9.3% and a production amount of 11% in terms of wheat production, while the Eastern Anatolia Region is 5.5% and 4%, and the Black Sea Region has an area of 0.3% and 0.2% wheat, respectively (TUIK, 2023).

In this study, the adult infestation rates and densities of the pests in the wheat fields were compared according to the regions. In the Southeastern Anatolia Region, the adult infestation rate was 52.2%, with an average of 8.4 individuals/sweeping. On the other hand, the adult infestation rate in the Eastern Anatolia Region was determined as 26.0% and an average of 1.96 individuals/sweeping.

In a study conducted by Mutlu et al. (2019) in some provinces of the Southeastern Anatolia Region, it was determined that pests' infestations at a rate of 5.73%, 54.66, 15.27 and 27.05 in Adıyaman, Diyarbakır, Mardin and Şanlıurfa, respectively. In this study, the adult infestation rates in the provinces in question were found to be 47.1%, 61.9, 46.7 and 47.8%, respectively. No other research on the infestation rate of the pest in our study area was found. However, Korkmaz et al. (2010) determined the infection rate of *Cepheus* species (mostly *C. pygmeus*) in wheat fields as approximately 60% in their survey study covering all provinces of Central Anatolia Region. In addition, İnce et al. (2022) determined the infection rate of *C. pygmeus* as 77.4% in their study conducted in wheat fields in Yozgat province. According to these results, there is a similarity between the pest infestation rates in the Central Anatolia and Southeastern regions of Türkiye, while a relatively lower level of infestation was found in the Eastern Anatolia Region. This difference may be due to the parallelism between wheat production areas and amounts and pest infestation rates across the regions.

4. Conclusion

At the end of the study, it was found that the wheat stem sawfly, *Cephus pygmeus*, was distributed in the vast majority of wheat fields in the Southeastern Anatolia and Eastern Anatolia regions of Türkiye.

In the density of pest populations in the areas where the wheat stem sawfly and *Cephus pygmeus* are distributed, the Southeastern Anatolia region is at the lead. The pest was found to be spreading in all provinces of this region, with Kilis being the province with the highest pest density among these provinces. According to these provinces, it was found that wheat production is quite high and the provinces with large cultivated areas are Şanlıurfa, Diyarbakır, Mardin, and Gaziantep (including 2018-2022) (TUIK, 2023). *Cephus pygmeus* was found to be widespread in almost all provinces of the Eastern Anatolia region, which accounts for 10% of Türkiye's wheat production. The provinces with the highest density of *Cephus pygmeus* populations in this region were identified as Kars and Ardahan. *Cephus pygmeus* was not encountered during surveys in the eastern Black Sea region, which does not have a soil structure suitable for wheat cultivation.

According to the results of this study, it was determined that the pest significantly increased its population density and distribution in the Southeastern Anatolia Region compared to previous years. It is reported that the current global climate change increases the density and harmfulness of wheat stem sawflies in the West Siberian pest focus within Altai Territory (Kaplin and Lysikov, 2022). The increase of the pests in the Southeastern Anatolia Region from the population density and distribution areas determined in 2014-2015 (Mutlu et al., 2019) to the increase rate determined in the current study may be related to the same reasons. Although it is less common and dense in the Eastern Anatolia region, it is difficult to have an idea about the development of the distribution and density of the pest, since no research has been done in the region before. Although there is no direct control in the Southeastern Anatolia Region or other regions against the pest in the current situation, it is extremely important to carefully monitor the pest population and economic damage in the coming years.

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