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EFFECTS OF GLOBAL CLIMATE CHANGE ON INVASIVE SPECIES, SPOTTED WING DROSOPHILA, *DROSOPHILA SUZUKII* (MATSUMMURA, 1931) (DIPTERA: DROSOPHILIDAE)

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Abstract

Global climate change and increasing human population give rise to the need for food and reveal the importance of agricultural production. Climate change can reduce yield by increasing crop losses, particularly by affecting the distribution of invasive pest species. Drosophila suzukii (Matsumura, 1931), also known as spotted wing drosophid, is a polyphagous invasive species that causes great losses in the fruit industry. Although D. suzukii was first reported in Japan, originated from Southest Asia. The female adult lays eggs inside the fruits using its serrated ovipositor. In the USA alone, the management cost of D. suzukii has been reported to range from $ 129-172 million annually. The aim of this study is to examine the effects of global climate changes on Drosophila suzukii. Temperature is considered to be the most effective abiotic factor on insects life traits and geographic distribution. The effects of temperature on D. suzukii wing morphology and flight parameters were investigated. It has been determined that high temperature negatively affects flight parameters and wing morphology, they have higher flight speed and larger wings at low temperatures (16ºC). In another study, it was found that D. suzukii had a lower survival rate from egg to adult as a result of exposure to heat stress during development, and lifespan and fecundity decreased in survivors. While there was no change in the form of ovipositor at lower temperatures, a visible change in ovipositor shape was detected at higher temperatures. In addition, it has been determined that they have longer development times at lower temperatures, while they have larger body sizes and wider wings. D. suzukii was first reported in strawberries in Erzurum in 2014. Later, it was detected on strawberries in Çanakkale provinces in 2017. Global climate change has caused invasive species such as Drosophila suzukii to increase crop damage and spread over a wider range in worlwide. It has been stated that the ability of D. suzukii to tolerate thermal changes is a risk factor to its expansion to the new continental invasions.

Key words: *Drosophila suzukii, Spotted wings Drosophila, invasive species, global climate change*

1. INTRODUCTION

Global warming, the increase in the earth's temperature as a result of the accumulation of greenhouse gases in the atmosphere; global climate change is the changes in other climate elements that developed due to global warming (Şimşek et al., 2010). The temperature increase of 3-6 °C is estimated to occur in Europe at high latitudes (Peng et al., 2004). Cultivated plants used as human food are damaged by approximately 10000 different types of insects and cause approximately 13.6% annual product loss in the world (Benedict, 2003). The consequences of global warming and climate change are predicted to cause widening in the geographical distribution of insects, rapid population growth, changes in insect-host or insect-parasitoid relationships, the risk of infestation by migratory pests, and an increase in plant diseases carried by insects. It is predicted that product losses will increase with the changes in the variety of crops grown, the increase in insect diversity as a result of global warming (Sharma, 2010).

Drosophila suzukii (Matsumura, 1931), also known as spotted wing drosophid is an invasive polyphagous fruit pest of global importance (Green et al., 2019). It was first reported in Japan and originated from Southeast Asia (Little et al., 2020). Unlike other *Drosophila* species, *D. suzukii* feeds on both ripe healthy fruit on the tree and decaying fruit species that have fallen to the ground. The females lay eggs inside the fruits using its serrated ovipositor. Since more than one larva can feed on a fruit, signs of softening and rot begin to appear quickly then fungal and bacterial infections occur (Cini et al., 2012). It has been reported that *D. suzukii* is capable of passively spreading 1400 km per year with infested fruits (Calabria et al., 2010) and spreading over long distances is by contaminated fruits (EPPO Datasheet, 2013). Simulations by Maino et al. (2021) predict that coastal areas of eastern Australia, particularly people living near major cities of high economic importance, will cause the fastest spread of *D. suzukii*. The estimated management cost of *D. suzukii* has been reported to range from $ 129-172 million annually (Bolda et al., 2010).

Temperature is defined as the most important abiotic factor in insect life. *D. suzukii* was first reported in Turkey on strawberries in Erzurum in 2014 (Orhan et al.,2016) then in Çanakkale (Efil, 2018), Bolu and Düzce (Kaçar and Koca, 2017) in 2017.Global climate change has caused introduction of invasive species such as *D. suzukii* to increase crop damage and spread over a wider range in worldwide. It has been stated that the ability of *D. suzukii* to tolerate thermal changes is a risk factor to its expansion to the new continental invasions. In this study, the effects of global climate change on *Drosophila suzukii* were discussed.

2. GLOBAL CLIMATE CHANGE ON THE *DROSOPHILA SUZUKII*

Global warming changes both the local temperature, the magnitude of the temperature and its seasonal variation (Wang and Dillon, 2014). While global climate change affects various mechanisms in plants, it also causes changes on the population dynamics and phenology of insects (Woiwod, 1997). It has been stated that these effects, climatic change may be directly related to the physiology and behavior of insects (Samways, 2005, Parmesan, 2007; Merrill et al., 2008; Pareek et al., 2017). Thus, the study of the effect of daily temperature changes on the temperature tolerance of insects and their response to measure to different climate scenarios on these organisms (Estay et al., 2014).

The biological development of *D. suzukii* varies with temperature and it becomes shorter with increasing temperature (Hamby et al., 2016). Green et al (2019) investigated egg-to-adult survival, fertility and reproduction quality under heat stress in *D. suzukii*. Results showed that heat stress causes lower survival rate from egg to adult stage during the development of *D. suzukii* and decrease in lifespan and fecundity for survivors. Supports that these responses to heat stress are intended to shorten the exposure time of *D. suzukii* to thermal damages (Krebs and Loeschcke, 1994; Krebs and Feder, 1998; Green et al., 2019). Tochen et al. (2014) also examined the effects of increasing temperature on the developmental period, survival and fecundity of *D. suzukii*. It has been observed that the development period shortens when the temperature approaches 28 °C, and the development period begins to lengthen when it reaches 30 °C, the highest temperature tested. Evans et al. (2018) examined the reproduction of *D. suzukii* under constant and high heat stress and observed that as the temperature approached from 24 °C to 33 °C, reproduction decreased and almost stopped completely. In addition, it was observed that the adult lifespan decreased as a result of temperature increase. This suggests that the final temperature level for the development of *D. suzukii* is approaching. It is important to determine the rate and amount of reproduction of invasive species such as *D. suzukii*. It has also been stated that organisms capable of overwintering in reproductive diapause may be the most important feature in invasion success (Rossi-Stacconi et al., 2016). *D. suzukii* is known to be an invasive species that can adapt to wide temperature fluctuations and cold conditions (Tonina et al., 2016). Wallingford et al. (2016) examined the cold tolerance and reproductive diapause of spotted wing *Drosophila*. In this study, wild *D. suzukii* were used and grown under laboratory conditions, it was observed that egg production decreased from July to December and stopped completely in December. In addition, egg maturation decreased in short daylight (below 14 hours) and in moderate temperature conditions (15°C-20°C).

Abiotic factors, especially temperature and humidity, are mentioned as factors that directly affect the survival and reproduction of *D. suzukii* (Wiman et al., 2016). Eben et al. (2018) studied that, extremely high temperature and low humidity have been shown to reduce the survival of *D. suzukii* adults under laboratory conditions. Guedot et al. (2018) examined the effects of temperature and humidity on the phenology, seasonal change and reproduction of *D. suzukii*. It has been determined that the abundance of *D. suzukii* in Wisconsin differs from year to year. It has been reported that *D. suzukii* males are more sensitive to winter temperatures (0-30 °C). It has been observed that the fecundity and longevity increase with increasing humidity. Diepenbrock and Burrack (2017) found more damage in the shaded part of the blackberry infested by *D. suzukii* than in the sunlit part. In addition, higher humidity was detected in the shaded part. It has been predicted that a difference in abiotic conditions may create microhabitats that allow increased *D. suzukii* infestation. The relative humidity level can change the physiological parameters of insects, such that low humidity level can cause a decrease in the fertility of insects (Yadav and Sharma, 2014). Tochen et al. (2015) investigated the effects of humidity factor on *D. suzukii* larval development, longevity, fecundity and reproduction. It was observed that spotted wings *Drosophila*, which were examined at 5 different humidity levels, increased fecundity and longevity as the humidity level increased and had the highest reproduction rate at the highest level, 94% relative humidity.

Phenotypic plasticity is the change in an organism caused by stimuli or inputs from the environment (West-Eberhard, 2008). Extreme heat events caused by climate changes can cause the species to emerge early. Although the female adults that emerge early will age, they will be exposed to heat stress and wait for the males to mate. Xue and Ma (2020) studied the effects of mating on heat tolerance of adults during aging. It was revealed that mating females had higher basal heat tolerance than virgin females, while mating males had lower tolerance than virgin males. It has been postulated that mating can generally reduce the plasticity of heat tolerance. The findings suggest that the phenotypic plasticity of heat tolerance may be the most important strategic method used by virgin adults to tolerate heat events. It has been stated that *D. suzukii* adults in temperate regions have wider and darker wings than those in regions where summer heat is experienced (Shearer et al., 2016). Fraimout et al., (2018) revealed that the growth temperature changed the flight parameters of *D. suzukii* and flies reared at 16 °C, the lowest temperature, reached the highest flight speed and acceleration. It is predicted that *D. suzukii* grown in cold conditions will be able to fly longer distances compared to those grown in warmer conditions, thus causing a range expansion (Tail et al., 2018). Clemente et al., (2018) observed that the ovipositor size of *D. suzukii* changed significantly at high temperatures, and that they had larger body sizes, wider wings and longer life at low temperatures.

3. CONCLUSION

Climate change is a reality that manifests itself on a global scale. Insect pests affect many characteristics such as development, phenology, physiology, distribution, population growth or decline, interaction with natural enemies. Considering the product losses caused by the depletion of natural resources, increasing human population and increasing insect diversity and abundance due to climate change, it is predicted that a serious food problem awaits humanity in the 21st century (Paeek, 2017). In addition to all these results, from a socio-economic point of view, crop losses will have serious negative effects on farmers and many related sectors.

Further studies are required to understand how biotic or abiotic stresses due to climate change effect crop yield, host plant-insect and host-parasitoid interactions.

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