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Insecticidal action of beer towards different aphid species

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Abstract. *One of the most popular and widely consumed drinks in the world is beer, also one of the oldest in the human mankind. The consummation of the drink has deep historical roots and there are many traditions, especially in Europe such as beer festivals, beer-oriented tourism, and beer drinking games. Although beer is extremely popular in human society, it actually can act as a pesticide - more specifically as a molluscicide approved by the European Commission as a basic substance in 2017 to be used as a molluscicide in traps. In this study the insecticidal effects of popular brands of light beer type „lager“ in Bulgaria: „Pirinsko Svetlo“, „Zagorka“, „Astika“ and „Kamenitza“ with alcohol content: 4.3% (v/v), 5% (v/v), 4.5% (v/v) and 4.4% (v/v) were investigated towards different aphid species. The beer was tested in the original form and with dilution with water: 90%, 80%, 70%, 50%, etc. The conducted trials prove that beer without any dilution can be 100% effective against aphid species: Aphis rosae, Aphis pomi, Myzus cerasi, Aphis nerii, Aphis gossypii. Mortality rate after 24 hours was 100% for all aphid species and all used in the tests beer trade marks were able to achieve this. There were no significant differences (p>0.05) between results received from tests with different aphid species and from different beer trademarks. In this aspect, the cheapest beer available on the local market can provide a safe, low cost, environmental and effective way of pest management in the small gardens, urban agriculture or plants in public spaces like airports, stations, offices, etc.*

Keywords: biocontrol, aphids, beer, lager

Introduction

One of the most popular and widely consumed drinks in the world is beer, also one of oldest for mankind (Rudgley, 1993; Arnold, 2005; McFarland, 2009). Beer is made from fermented liquid (water plus barley – in most cases; but also wheat, maize and even rice). During the fermentation process, the starch sugars are converted into alcohol due to the action of specific beer yeast (Barth, 2013). To achieve the typical bitter taste and smell of the drink, hop is added. Hop also acts as a natural preservative of beer (Lewis and Young, 2002)

The most common and drunk type of beer is lager (Jackson, 1996) with alcohol content between 4% and 6% The consumption of beer has deep historical roots and there are many traditions especially in Europe, such as beer festivals, beer-oriented tourism, beer drinking games (Zong and Zhao, 2013). Although beer is an extremely popular drink in human society, it actually can be a pesticide and more specifically, a molluscicide approved by the European Commission as a basic substance in 2017 to be used as molluscicide in traps (Costantini and La Torre, 2022; Yoon et al., 2007; Dankowska, 2011; Santacruz et al., 2011). Additionally, beer can also manifest repellent abilities towards insects (Bedini et al., 2015; Cosci et al., 2015). However, some studies prove that beer can also be used as a trap attractant for insects (Iqbal and Feng, 2020; Piñero et al., 2017; Wang et al., 2021). Beer is extremely popular as an ingredient for cockroach traps (Jenkins, 1956; Ree et al., 2006). There are no other investigations up to this moment about the insecticidal action of beer. The aphid species are some of the most widely spread and harmful insects around the world. Aphids can

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infest both cultural and ornamental plants and, moreover, they are pest species with high resistance risk (Blackman and Eastop, 2000; Van Emden, 2017).

That is why, the aim of the presented research was to find out that beer can manifest insecticidal properties towards different aphid species: Aphis rosae – a major pest infesting oil-bearing rose (Rosa damascena) and ornamental species (Evenhuis, 1972; Karim, 2011), Aphis pomi – a major and very common pest on apple trees (Oatman and Legner, 1961; Foottit et al., 2009), Myzus cerasi – typical pest on cherry trees causing also a lot of damages on the plants (Wimshurst , 1925; Karczewska, 1970), Aphis gossypii – very abundant aphis species, a typical pest on cucumbers (Kocourek et al., 1994; Ebert and Cartwright, 1997), and Aphis nerii or the so called „oleander aphid" - common pests of ornamental plants in the families of Apocynaceae and Sclepiadaceae, widespread around the world and causing a lot of damages on infested plants, especially oleander (Nerium oleander L.) (Hall and Ehler, 1980; Rouhani et al., 2012). Being extremely abundant, the typical pests, against aphid species are treated with many synthetic and toxic insecticides each year in the world, which causes a serious impact of pollution and a human poisoning risk. Additionally, the numerous treatments cause high resistance risk and strongly decrease the effectiveness of the most commonly used insecticides. (Kerns and Gaylor,1992; Zeb et al., 2016; Van Emden and Harrington, 2017). There is yet another problem – aphids can very often infest ornamental plants in houses, small backyard gardens, public places like offices, railroad or bus stations, airports and so on, where the use of typical synthetic insecticides is completely impossible or very limited. That is why the studies about new, environmentally friendly and safe for humans pesticides towards aphids are very important in pest management, plus ones which will be with multiple modes of action and will cause no resistance risk.

Material and methods

Four popular and cheap beer trade marks in Bulgaria type "lager" were used in the performed trials "Pirinsko Svetlo", "Zagorka", "Astika" and "Kamenitza" with alcohol content: 4.3% (v/v), 5% (v/v), 4.5% (v/v) and 4.4% (v/v). Aphid species such as: Aphis rosae infesting the oil-bearing rose (*Rosa damascena*), *Aphis pomi*, *Myzus cerasi*, *Aphis nerii*, *Aphis gossypii* were determined by standard methodologies (Andreev, 2012; Harizanov and Harizanova, 2018). Plant species such as oil-bearing rose, apple tree, cherry tree, summer lilac (*Buddleja davidii*) and cucumbers infested by aphids were treated with the above-mentioned brands of beer alone or diluted with water in different concentrations – 90%, 80%, 70%, 50%, etc. A solution of pure ethanol at 5% (v/v) with distilled water was used in order to determine if the action of the beer is due to alcohol content or not. A universal surfactant for pesticides solutions Silwet L-77 was added to achieve uniform spread of the tested solutions and beer alone onto the surface of the treated plants at 0.1% concentration. One test variant was repeated in four repetitions. A control variant treated with water plus Silwet L-77 at 0.1% concentration was also used. The number of individuals from the tested aphid species were counted before and after 24 and 48 hours after treatment, and the effectiveness was calculated by the algorithm of Henderson and Tilton (Henderson and Tillton, 1955). Dose – Response Models and Dose – Response Curves were created by R language of statistical commuting (R Core Team, 2016) and "drc" package (Ritz et al., 2016). The major toxicological indexes: NOAEC (No Adverse Effect Concentration = LC05), LOAEC (Lowest Adverse Effect Concentration = LC25), LC50 (Lethal Concentration causing 50% death in the tested individuals) and LC90 (Lethal Concentration causing 90% death in the tested individuals) were calculated. One – Way ANOVA analysis was performed by R language in order to determine any statistically significant differences between the tested variants (Ritz and Streibig, 2005).

Results and discussion

The conducted trials prove that beer without any dilution can be 10% effective against all tested aphid species. The effectiveness rate after 24 hours was 10% for all aphid species and all beer trade marks were able to achieve this. There were no significant changes in the effectiveness 48 hours after treatment ($p>0.05$). The ethanol solution at % (v/v) shows absolutely no effect on the population of the tested aphid species ($p>0.05$ in comparison with the control variant). There were no significant differences ($p>0.05$) between the results received from tests with different aphid species and from different beer trademarks. The Dose – Response Curves and major toxicological data are listed below (Figures 1, 2, 3 and 4).

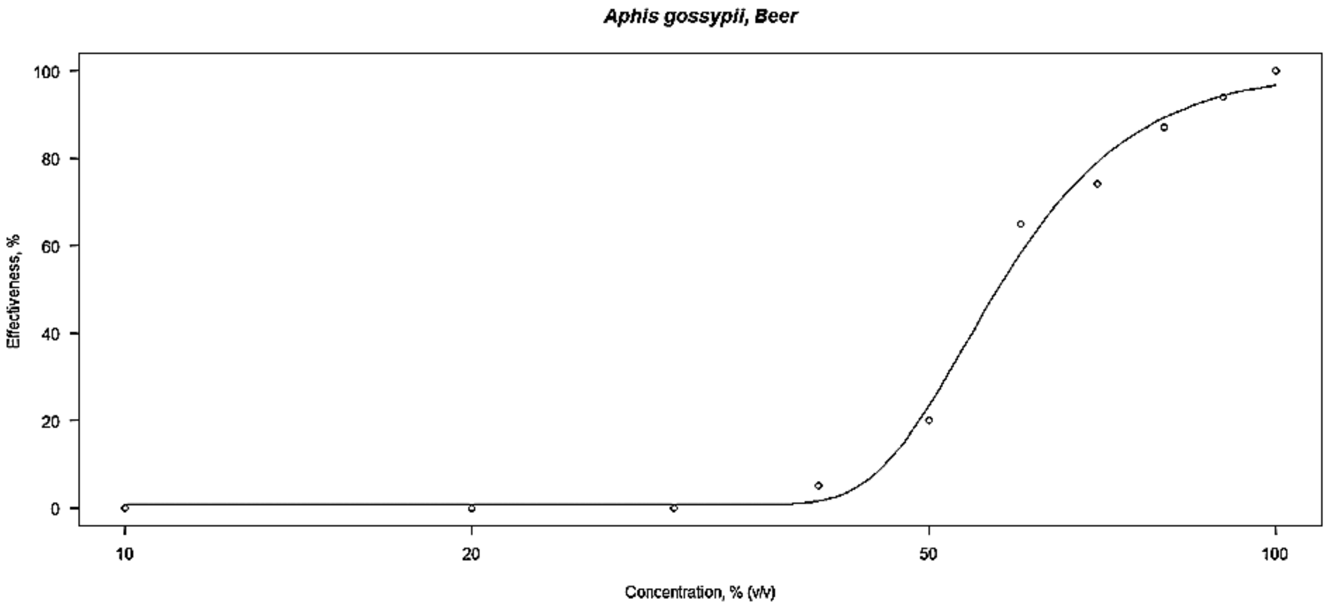

Figure 1. Dose – Response Curve, beer, *Aphis gossypii*

Aphis gossypii toxicological data:

- NOAEC = 40% (v/v)
- LOAEC = 60% (v/v)
- LC50 = 72% (v/v)
- LC90 = 95% (v/v)

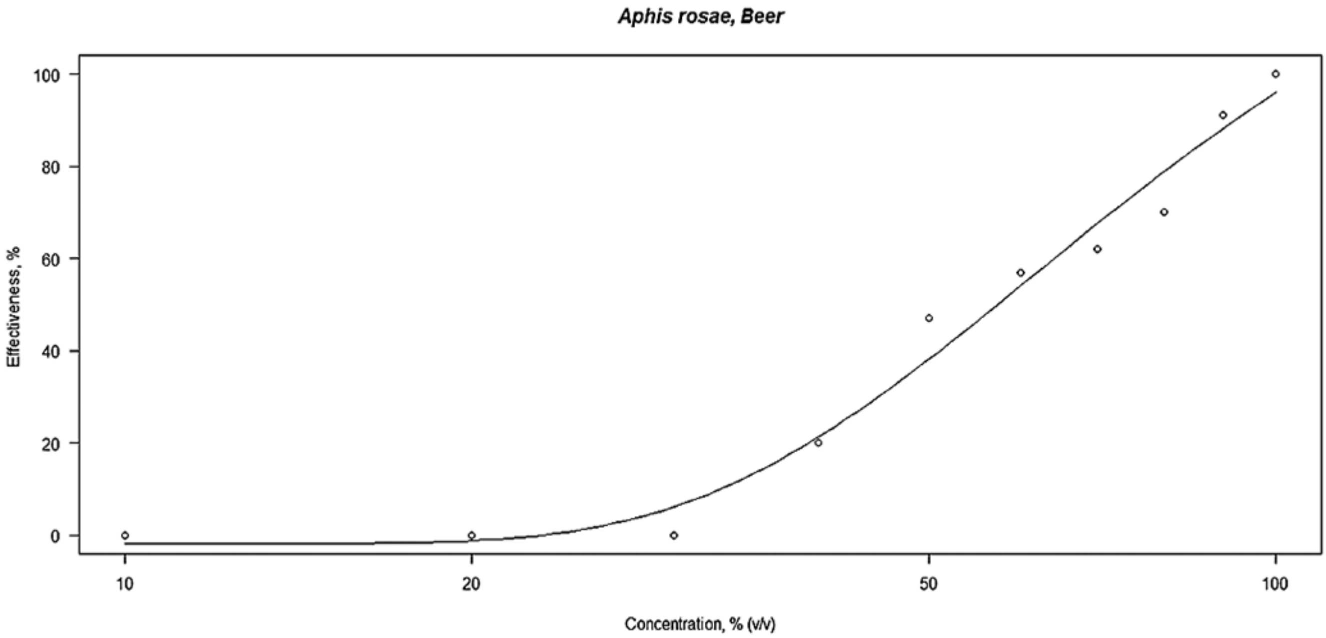

Figure 2. Dose – Response Curve, beer, *Aphis rosae*

Aphis rosae toxicological data:

- NOAEC = 32% (v/v)
- LOAEC = 45% (v/v)
- LC50 = 68% (v/v)
- LC90 = 91% (v/v)

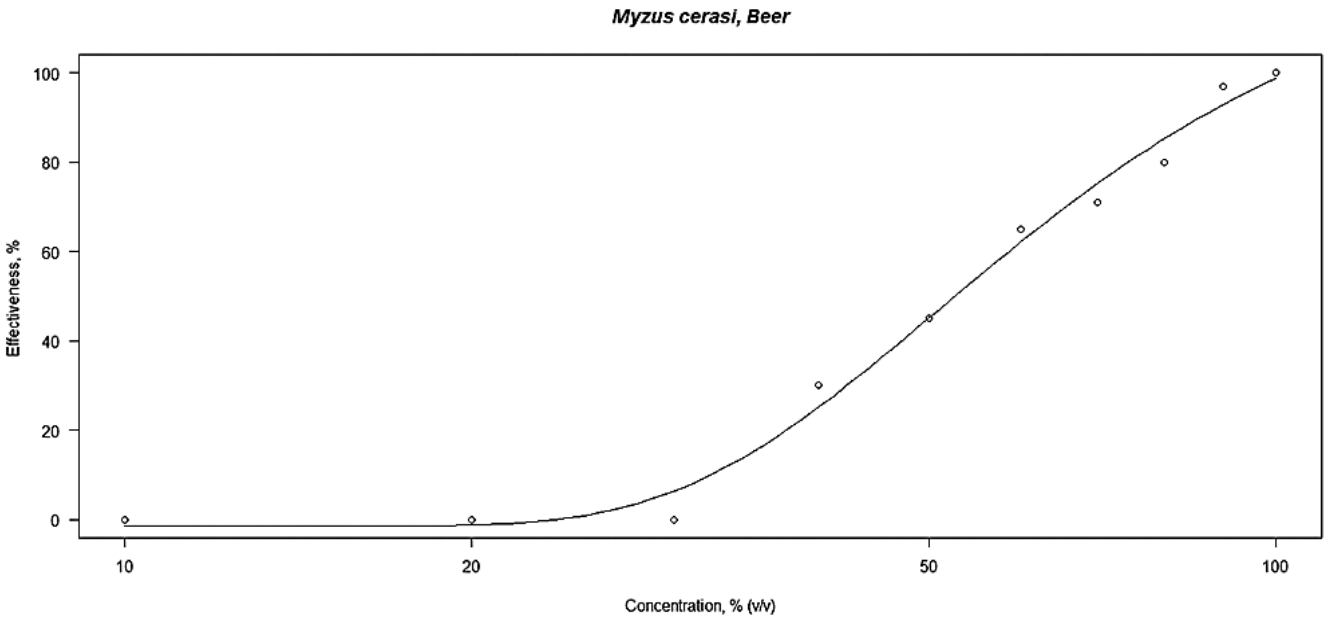

Figure 3. Dose – Response Curve, beer, *Myzus cerasi*

Myzus cerasi toxicological data:

- NOAEC = 37% (v/v)
- LOAEC = 45% (v/v)
- LC50 = 62% (v/v)
- LC90 = 90% (v/v)

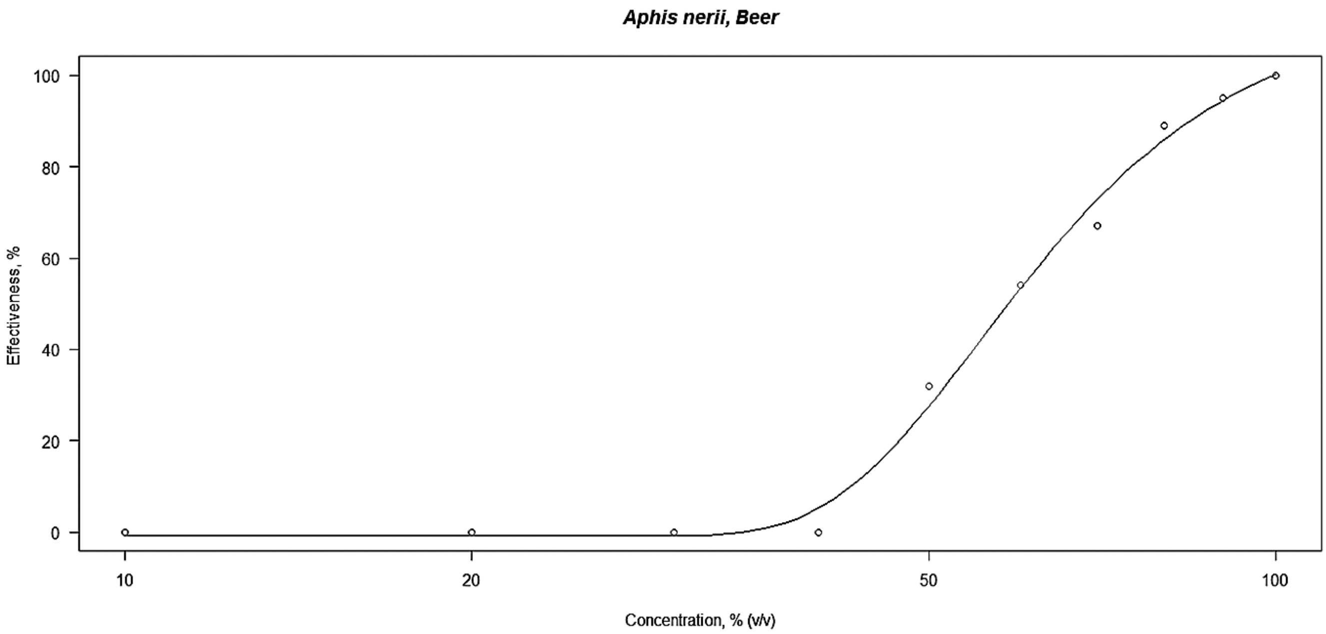

Figure 4. Dose – Response Curve, beer, *Aphis nerii*

Aphis nerii toxicological data:

- NOAEC = 40% (v/v)
- LOAEC = 50% (v/v)
- LC50 = 66% (v/v)
- LC90 = 94% (v/v)

On the next Figure 5 is shown the summarized insecticidal action of beer towards tested aphis species.

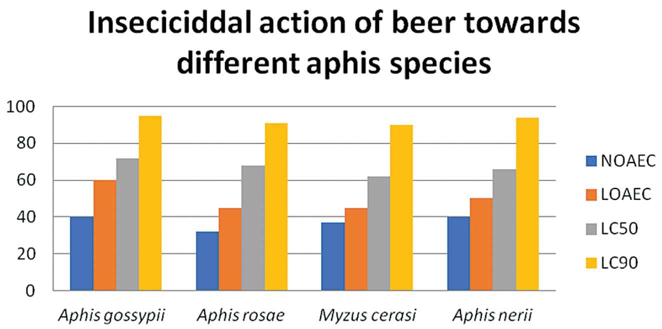

Figure 5. Insecticidal action of beer towards tested aphis species

Figure 6. Oil-bearing rose infested with *Aphis rosae* and sprayed with beer trade brand „Astika" (without dilution with water), 24 hours after treatment. On the left – Control variant, on the right – sprayed variant

In all conducted tests all tested trademarks of beer („Pirinsko Svetlo", „Zagorka", „Astika" and „Kamenitza") were able to kill all individuals of the tested aphid species (*Aphis rosae, Aphis pomi, Myzus cerasi, Aphis nerii, Aphis gossypii)* in the pure (without dilution with water) form. The calculated LC90 from Dose – Response Modeling was between 90-95% concentration (LC50 was between 60 and 70% concentration), without significant differences (calculated from conducted One-Way ANOVA) between the different trademarks of beer and between different aphis species (p>0.05), which means that beer acts non-specifically towards aphid species and the content of beer type „lager" does not play role on the insecticidal action of the drink. The water solutions of beer below 30-40% concentration (NOAEC) have no significant insecticidal effect on the tested aphid species in the present study.

Conclusion

Beer proves that except a molluscicide it can be an effective insecticide, too. In view of the fact that there is no difference between the effectiveness of different trademarks of beer, the cheapest one available on the market can provide a safe, low cost, environmental and effective way of pest management in small gardens, urban agriculture or plants in public spaces like airports, stations, offices and so on, instead of using commercial insecticides. Moreover, there is no resistance risk to using beer as an insecticide.

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