InsectMow – development and evaluation of insect- and spider-friendly mowing techniques

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Abstract: Eine Reihe von Studien belegt, dass ein Großteil der auf landwirtschaftlichem Grünland lebenden Spinnen und Insekten bei der Mahd geschädigt und/oder getötet wird. Daher ist davon auszugehen, dass die intensive Mahd von Wirtschaftsgrünland, die nicht nur adulte Arthropoden, sondern auch deren Larven und Nymphen schädigt, einem „Überfischungseffekt" gleichkommt, der maßgeblich zum aktuellen Insektenrückgang auf Agrarflächen beigetragen hat. Das interdisziplinäre Projekt „InsectMow" der Universitäten Tübingen und Hohenheim untersucht, wie die negativen Auswirkungen der Mahd auf Grünlandökosysteme durch eine technische Modifikation von Standard-Scheibenmähwerken reduziert werden können. Dazu soll ein optimiertes, arthropodenschonendes Scheibenmähwerk entwickelt werden, das die mahdbedingten Spinnen- und Insektenverluste verringert. Dabei werden sowohl direkte als auch mittel- und langfristige Auswirkungen der Mahd mit unterschiedlichen Mähwerken auf Spinnen sowie wichtige bestäubende, herbivore und räuberische Insekten untersucht. Zudem soll eine wirksame Insektenscheuche entwickelt werden, die Insekten zur Flucht veranlasst.

Key words: insect-friendly mowing, insect decline, agricultural grassland use, mowing techniques

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Over the past few decades, the earth has experienced a massive decline in the numbers of insect species and individuals (Hallmann & al. 2017; Seibold & al. 2019; Wagner & al. 2021). Industrialized agriculture is considered as the most important factor in this decline (Goulson 2019), mostly because of large monocultures causing a loss of both habitat and structural diversity (Tscharntke & al. 2021) and because of the intensive use of pesticides (Wood & Goulson 2017) and fertilizers (Kurze & al. 2018). Arthropod diversity and biomass are strongly affected not only by the overall decline of grassland areas in general, but also by indirect negative effects resulting from fertilization and frequent mowing regimes. Both aspects reduce the diversity of host plants (Gossner & al. 2016), with mowing also causing thermally hostile environments for arthropods (Gardiner & Hassal 2009). Since the late 1990s, several studies have shown that a large proportion of agricultural grassland arthropods are directly injured and/or killed during mowing (e.g., Oppermann & Krismann 2001; Fluri & al. 2000; Humbert & al 2010a,b; Betz & al. 2022; Hecker & al. 2022; Steidle & al. 2022), particularly when highly efficient mowing machines are employed, such as disc mowers and conditioners (Gossner & al. 2016). Grassland is mown several times per year and over the course of many years (Niedrist & al. 2009) probably resulting in an overfishing effect on certain insect populations and leading to a drastic decline of grassland insects. In addition, an increasing number of studies suggest the indirect negative effects of intense mowing (Tscharntke & al. 2021; Blüthgen & al. 2022).

For municipal use such as roadside mowing, insect-friendly mowers have been developed and tested with promising first results (Betz & al. 2022; Steidle & al. 2022). Measures to counteract arthropod losses in agricultural grassland, on the other hand, have so far been largely limited to extensification concepts, which are not applicable to intensively maintained grassland because of economic constraints. Therefore, the interdisciplinary project InsectMow (https://insectmow.uni-hohenheim.de; website accessed on 03/12/2024) aims at pursuing the development of (1) a modified disc mower that causes fewer arthropod losses without economic disadvantages, and (2) an effective insect flushing bar that enables insects to flee. Furthermore, the first resilient data has been obtained on the direct and the medium- and long-term effects of mowing with disc versus bar mowers on spider and insect populations in grasslands. The present contribution introduces the experimental design of this project and presents its first results.

Methods:
The effects of the modified disc mowers and the insect flushing bar are investigated on study sites (not fertilized and mowed twice a year) at the University of Hohenheim (Baden-Württemberg, Germany) by using a randomized block design with five replicates. This allows the direct comparison of up to four different treatments and an untreated control (Fig. 1). To minimize interference between neighboring plots because of escaping arthropods during mowing, the individual plots are isolated from each other by a 70-cm-high amphibian protection fence.

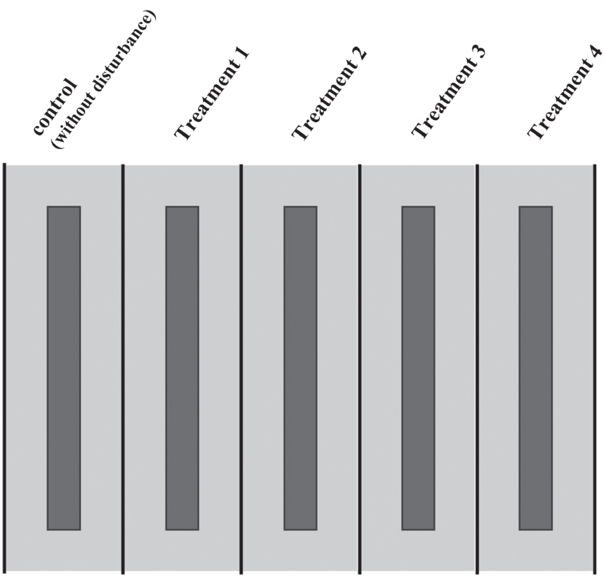


Fig. 1: Arrangement of the experimental plots to determine the direct and medium- and long-term effects of various types of mowing equipment. One plot consists of a 3 x 30 m sampling site (dark gray) and a 4-m-broad border area (light gray) for driving on. The plots are separated by a 70-cm-high amphibian protection fence (black).

Mowing takes place twice a year, in June and September, during sunny weather and under windless conditions. Direct and medium-term effects of mowing are recorded using various (complementary) sampling methods, whereas the long-term effects are to be determined by a comparison of the collected data over several years. For direct effects, sampling is carried out immediately after mowing by so-called biocenometers (Mühlenberg 1989) in combination with an insect vacuum (“ecoVac”, ecoTech Umwelt-Meßsysteme GmbH, Bonn, Germany). Three 1-m^2 biocenometers are used per plot and thoroughly vacuumed for 5 minutes each. Each sample is then transferred to zip lock bags and frozen for further processing. Pitfall traps (three per plot) and standardized sweep net catches (50 sweep movements per plot) are used to record medium-term effects of mowing. Pitfall traps consist of plastic cups (Ø 10 cm) equipped with wire mesh fence as vertebrate protection and covers made from gray PVC and are filled with 50 % propylene glycol as trapping fluid. The traps are maintained from two weeks before mowing to four weeks after mowing and emptied fortnightly. The standardized sweep net catches are carried out at the same interval. Regardless of the sampling method, samples are sorted and counted at order or family level for 12 groups: Araneae, Orthoptera, Cicadina, Heteroptera, parasitoid wasps, Anthophila, Carabidae, Staphylinidae, other Coleoptera, Lepidoptera (larvae), Syrphidae, and other Diptera. Any individuals that do not belong to one of these groups are recorded as “other”. Araneae, Orthoptera, Heteroptera, Anthophila, Carabidae, Staphylinidae, Lepidoptera, and Syrphidae are to be further identified to at least genus level, but preferably to species level, in order to calculate various diversity parameters (e.g., Simpson’s index, Shannon’s H, abundance, dominance structure).

In 2022, further experiments were conducted, in addition to testing the first insect flushing bar: the effects of tedding and raking, as hay-harvesting steps following mowing; the use of various cutting heights with a standard disc mower; and the influence of tractor tires on grassland fauna. The first experiments on technically modified disc mowers have been conducted in 2023 (results not shown here).

Results:

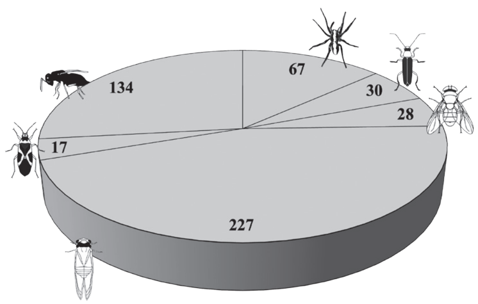
Various sampling methods were used to record the broad spectrum of the arthropod fauna at the study sites (Fig. 2). Sampling was conducted between 06/27/2022 and 07/06/2022 on untreated control plots or prior to any treatment. The biocenometer/vacuum samples (503 individuals m^{-2}; Fig. 2a) were dominated by cicadas (45 %), parasitoid hymenopterans (27 %), and spiders (13 %) but also contained Coleoptera, Diptera, and Heteroptera. The pitfall traps (41 individuals per trap) gave the most diverse data (Fig. 2b). Again, spiders (24 %) and parasitoid hymenopterans (17 %) were among the most represented groups, together with Carabidae and Diptera (both 15 %). In addition, other Coleoptera, Staphylinidae, Heteroptera, Cicadina, and Orthoptera were sampled. Mainly Heteroptera (38 %) were recorded when sweep nets (210 individuals per sweep net catch) were used. Additionally, Cicadina (15 %), Diptera (without Syrphidae), and Araneae (both 13 %) were represented in high numbers (Fig. 2c). Furthermore, Syrphidae, Coleoptera, and parasitoid hymenopterans were recorded with the standardized sweep net catches. Across all trapping methods, we found that the study site (farm grassland) was mainly dominated by Cicadina, Araneae, parasitoid hymenopterans, and Heteroptera. Typical meadow insects such as wild bees (Anthophila), Lepidoptera, and Orthoptera were only present in low numbers.

Discussion:

The composition of spiders and insect taxa revealed by our study of an extensively mowed grassland area shows good correspondence with other entomofaunistic surveys performed on grasslands such as cultivated meadows (e.g., Boness 1953, Tscharntke & Greiler 1995), the herb layer often being dominated by homopterans, dipterans, and parasitoid hymenopterans. In terms of insect abundance (in our case 500 individuals m^{-2}), comparable studies (sampling with biocenometer and insect vacuum) show similar mean abundances, ranging from 368 individuals m^{-2} (Betz et al.; unpublished data) to 550 individuals m^{-2} (Fleske et al.; unpublished data) on a nutrient-rich, rather moist valley meadow, and 520 individuals m^{-2} (Steidle et al.; unpublished data) recorded in the Botanical Garden of the University of Hohenheim. The differences between the sampling methods with regard to the relative proportion of insect groups (Fig. 2) suggests that complementary sampling methods should be applied to improve capture at all the different strata of a meadow.

In general, as for meadow plants, the potential species pool of meadow insects is reduced with increasing intensity of mowing (e.g., Humbert & al. 2009, Buri & al. 2016, von Klink & al. 2019). This affects, for example, the guilds of seed feeders, pollinators, web spiders, and some gall-inducing insects (e.g., Boness 1953) for which effects are more detrimental with increasing mowing intensity. Previous studies of arthropod damage or losses caused by mowing (reviewed in von Berg & al. 2023) have mainly considered prominent insects such as grasshoppers (e.g., Humbert & al. 2010a,b) or honeybees (Fluri & al. 2000). Furthermore, some studies have used wax models (Humbert & al. 2010b) or artificially released non-native insects (Hemman & al. 1987). Here, we have found mainly smaller individuals that are less likely to be affected by mowing machines than large individuals such as grasshoppers. Moreover, many of the previous studies have not been carried out under standardized conditions and with sufficiently large sample sizes. Conclusions about the damage to groups occurring on farm grassland can therefore only be drawn with caution. Hence, experimental studies of mowing-induced damage to arthropods (such as “InsectMow”) that include previously unstudied or poorly studied groups are of crucial importance. The development of arthropod-friendly mowing equipment (Betz & al. 2022; Steidle & al. 2022) and the use of insect flushing bars, together with untreated refuge areas, can be expected to contribute to the conservation and promotion of arthropod diversity and abundance on agricultural grassland.

a



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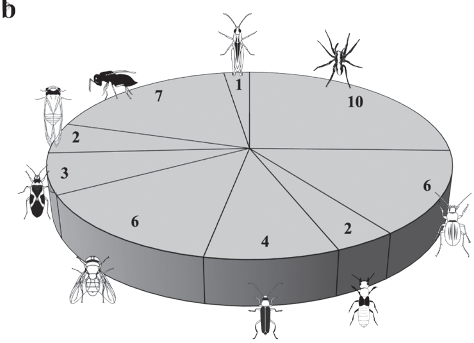

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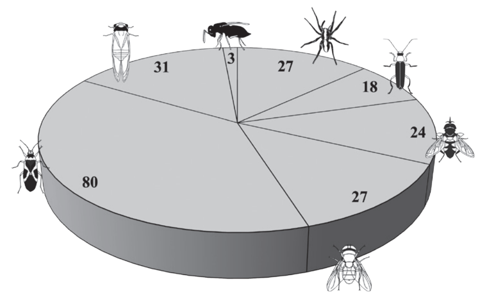

Fig. 2: Mean number (arithmetic) of individuals out of 10 groups: Araneae, Orthoptera, Cicadina, Heteroptera, parasitoid hymenopterans, Carabidae, Staphylinidae, other Coleoptera, Syrphidae, and other Diptera recorded on untreated control plots or prior to any treatment when using various sampling methods on a study site (farm grassland) located in Kleinhohenheim, Stuttgart.

(a) Mean number of individuals m^{-2} recorded on 07/06/2022 with a biocenometer/insect vacuum; n=15

(b) Mean number of individuals per pitfall trap (Ø 10 cm, trapping fluid: 50% propylene glycol); n=45. The trap was maintained for 2 weeks and emptied on 06/29/2022.

(c) Mean number of individuals per sweep net catch (50 sweep movements) on 27/06/2022; n=15.

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