# A5 Development of biological and technical solutions for blood-sucking insects to reduce numbers around grazing animals

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**Goal**: Development of biological and technical solutions to reduce the number of blood-sucking insects around grazing animals. The innovation activities are carried out in cooperation with the Department of Zoology of the Institute of Agriculture and Environment of the Estonian University of Life Sciences.

# A5 IT22 Determining the species composition and abundance: mosquitoes (*Culicidae*)

**Purpose**: To determine the species composition and abundance ratios of spring-active mosquitoes in the research area, based on which to develop biological and/or technical means of control.

**Evaluation**: Annotated species list of biting mosquitoes with summer activity in the spring of the grazing area was compiled.

## What was done

Field work was conducted in two areas, Põltsamaa municipality in Jõgeva County and Põhja Sakala municipality in Viljandi County. Automatic traps (Mosquito Magnet® Independence, Woodstream Corp., Lititz, USA) were utilized once a month at four different locations in each area for catching insects, specifically mosquitoes. The four locations were divided into two test points and two control points. The control points were situated away from the grazing zones of the beef cattle, either outside the animal yards or in pastures that were vacant during the catching period. On the other hand, test points were placed near the feeding and resting spots of the cattle. Such an experiment design facilitated the collection of maximum information on the insects attacking livestock, allowing for the differentiation of species of mosquitoes that seek the vicinity of livestock from the normal dynamics of insect diversity and abundance in the region. Each catching period lasted for four days, which was an appropriate time period for capturing a good number of insects while also considering the efficiency of the collection equipment and the possibility of technical issues that may arise.

Because of the large amount of material gathered during the spring and summer of 2018, it was only possible to determine a portion (mostly 25%, occasionally 50%) of the total number of mosquitoes caught for each catching period. Only two times was it possible to determine all the mosquitoes collected by a single trap. Based on calculations, approximately 31,888 mosquitoes were caught by the machines in Viljandi and Jõgeva County, with 9,295 individuals examined. However, 1,115 individuals could not be assigned to a specific species due to their poor condition. In order to maintain accuracy, descriptive statistics were based on 25% of all mosquitoes caught in traps.

## Results

The 2018 season proved to be more favorable for mosquitoes than the previous year, possibly due to a mild spring and extremely warm summer. However, the number of insects could have been reduced by drier weather and the lack of meltwater from late spring snow. Forest mosquitoes such as *Ochlerotatus communis*, *Oc. cataphylla*, and *Oc. punctor* were the most numerous species in both Jõgeva and Viljandi County at the end of spring. Compared to late summer and autumn catches in 2017, three species – *Oc. flavescens, Oc. leucomelas, and Oc. pullatus* – were caught in the trap for the first time. In Estonia, they are generally not found in large numbers, and only *Oc. flavescens* is known to attack cattle.
The most important finding from the descriptive statistics was that the species *Ae. cinereus* was more frequently caught at the test points in both municipalities, indicating its preference for large livestock in Estonian conditions. However, it is essential to note that reducing the

abundance of the three most common species would be the best outcome for animal and human welfare.

## A5 IT23 Determining the species composition and abundance: mosquitoes (*Culicidae*) and horseflies (*Tabanidae)* and reviewing natural insecticides

**Purpose**: To determine the species composition and abundance ratios of horseflies and mosquitoes with autumn activity in the research area, on the basis of which a plan will be developed for experimental blood-sucking insect repellents.

**Evaluation**: 1) Annotated list of species of mosquitoes and horseflies active in the late summer at the grazing area was compiled. 2) Literature review of potential natural repellents was compiled.

### What was done

#### Species listing

The fieldwork of IT23 lasted from the second half of the summer of 2017 until the end of September. A total of 5 individual insect traps were used: 2 electric propane Mosquito Magnets (Woodstream Corp.) and 3 passive H-Trap Professional Horsefly Control Systems (Sentomol Ltd.). For both types of traps, one device was used as a control point and set up in places inaccessible to livestock. The rest of the traps (1 Mosquito Magnet and 2 H-Trap Professional Horsefly Control Systems) were installed in the pastures in places visited by cattle as often as possible. Fieldwork took place in Jõgeva and Viljandi counties.

In order to obtain a good data set over the study period, the insect traps were up for 3-4 days every month. The aim of the work was to collect horseflies (*Diptera: Tabanidae*) and mosquitoes (*Diptera: Culicidae*) flying near livestock and to prepare a list (with potential pathogens) of species based on the results.

The species were first identified using morphological characters. Later, DNA barcoding was used to verify the correctness of the identification.

#### Review on potential repellents

Insect repellent or insecticide can be defined as a substance or a mixture of substances designed to prevent, destroy, repel, or manage the insect breeding cycle. To repel insects, it is necessary to know which substances affect specific species. A literature review was compiled on the use of natural plant oils from aromatic plants in insecticides for cattle. This is important, because synthetic chemical insecticides can often have negative side effects to animals, humans and nature.

## Results

### Species listing

The summer of 2017 was unfavourable for blood-sucking insects. As a result, the collection results of the insect traps were also poor. However, it can be seen that the use of two types of traps is justified in the study of livestock-disturbing insects, because during the fieldwork, mosquitoes and horseflies were caught in different traps. Mosquitoes (as well as blackflies and biting midges) were attracted by traps that actively produce heat and carbon dioxide, while horseflies were also caught in passive traps that did not catch any mosquitoes. During the field work, 254 mosquitoes from 15 different species and 179 horseflies from four different species were collected.

Among the mosquitoes, the three most often collected species were *Coquillettidia richiardii, Aedes cinereus* and *Anopheles claviger*. At the same time, it is very interesting that all Estonian mosquito families were represented among the insects. It is also remarkable that the catching sites of Viljandimaa and Jõgevamaa were so different in terms of yield. In the traps of Viljandimaa, four different species of mosquitoes were more often caught in the Mosquito Magnet trap close to the herd than in the one further away. At the same time, in Jõgeva County, representatives of seven species were found more often in the vicinity of cattle than in more distant areas. Four species (*Ae. cinereus, Ae. vexans, An. claviger* and *Oc. caspius*) were associated with paddocks used by livestock in both municipalities, while *Culex pipiens* was trapped only away from the animals.

During the fieldwork, relatively few horseflies got caught in insect traps, and all collected specimens come from Viljandi County traps. Representatives of the species *Haematopota pluvialis* were most commonly caught in the traps, but in the case of the Mosquito Magnet trap, there were much more of them in control site traps. Such a result is extremely surprising, because previous research has shown that *H. pluvialis* prefers large livestock. It is possible that the one-time high abundance of this species at the control site was due to the random characteristics of the trap and the catching site.

Representatives of the species *H. pluvialis* were slightly more often caught in the traps of the H-Trap Professional Horsefly Control System than other species, but this difference is too small to draw conclusions. However, it is interesting that somewhat different species of horseflies were caught in specific type traps. No horseflies were collected in Jõgeva County during the second half of summer and the beginning of autumn. It seems that the horseflies preferred the moist forests typical of Viljandi.

### Review on potential repellents

The main findings of the literature review are presented in Table 1 below.

*Table 1. Essential oils tested in livestock insect control*

| **Essential oil plant** | **Ingredients with repellent function** | **Target insects** | **References** |
|---|---|---|---|
| **Family *Poaceae*, grasses** | | | |
| *Cymbopogon winterianus*, java citronella | | *Tabaniadae* | Krčmar et al. 2016 |
| *Cymbopogon citratus*, lemon grass | citral α-pinene | *Stomoxys calcitrans*<br>*Musca domestica* | Baldacchino et al. 2013<br>Kumar et al. 2011 |
| **Family *Lamiaceae*, labials** | | | |
| *Mentha piperita*, peppermint | | *Tabanus tergestinus*, *Haematopota pluvialis*,<br>*Musca domestica* | Krčmar et al. 2016<br>Kumar et al. 2011 |
| *Nepeta cataria*, catnip | nepetalactone | *Stomoxys calcitrans*<br>*Musca domestica* | Zhu et al. 2012; 2010<br>Zhu et al. 2009 |
| *Lavandula angustifolia*, lavender | | *Tabaniadae* | Krčmar et al. 2016 |
| *Thymus vulgaris*, Common thyme | α-terpinene<br>carvacrol<br>thymol<br>p-cymene<br>linalool<br>geraniol | | |
| *Rosmarinus officinalis*, rosemary | | | Khater et al. 2009 |
| *Ocimum basilicum*, basil | | *Culex pipiens* | Erler et al. 2006 |
| *Pogostemon cablin*, patchouli | | | |

| Family *Lauraceae*, laurels | | | |
|---|---|---|---|
| *Litsea citrata*, litsea | | *Tabaniadae* | Krčmar et al. 2016 |
| **Family *Myrtoideae*, myrtles** | | | |
| *Eucalyptus Globulus*, blue gum | | *Musca domestica* | Kumar et al. 2011 |
| *Syzygium aromaticum*, clove | | *Musca domestica* | Soonwera 2015 |
| **Family *Asteraceae*, daisies** | | | |
| *Chrysanthemum cinerariifolium*, pyrethrum | pyrethrins | Mosquitoes, lice, fleas | |

# A5 IT24 Natural enemies & natural repellents suitable for Estonian organic farming

**Purpose**: Continuing to collect and analyze material for compiling species lists for blood-sucking insects. Mapping the possible natural enemies (e.g., diseases, fungi, predators) of blood-sucking insects and reviewing the possibility of their use for decreasing the population numbers of the most important pest species.

**Evaluation**: Literature reviews were compiled to evaluate the natural enemies and natural repellents of blood-sucking insects. Initially, testing the use of natural enemies of blood-sucking insects was planned, but the literature analysis showed that this is not very promising in Estonian organic agriculture. Local conditions and the requirements of organic farming were taken into consideration when compiling the review on natural repellents. Full species lists for biting midges (*Ceratopogonidae*) and black flies (*Simuliidae*) can be found in A5 IT25.

## What was done

### Natural enemies

The purpose of this literature review is to discuss the biological factors that threaten mosquitoes, synanthropic flies, horseflies and blackflies during each possible developmental stage (egg, larva, pupa, adult).

### Natural repellents suitable for Estonian organic agriculture

In this literature review, we summarize a handful of the most important natural insecticides and evaluate their suitability for Estonian organic agriculture.

## Results

### Natural enemies

Obtaining accurate estimates of insect population abundance and fluctuations, while considering their natural predators, is a topic that lacks sufficient objective data. The majority of available literature focuses on the outcomes of exposing insects to a commercially propagated biological agent, such as a parasitic or predatory insect, within a controlled setting. Biological control methods are becoming increasingly popular due to their relative safety for human and animal health as well as the environment, in contrast to chemical pesticides.

Birds and spiders play a significant role in influencing the abundance of insect populations, while pathogenic microbes typically do not have a detrimental effect on blood-sucking insects. However, certain specialized parasites can infect insects. Nonetheless, such insect-specific pathogenic microbes may not be prevalent in Estonia's natural environment. As of yet, there are no studies that investigate the impact of predators and diseases on local populations of blood-sucking dipterans in Estonian conditions. Additionally, no proper research has been conducted to even elucidate the general dynamics and trends in the abundance of blood-sucking dipterans in the area.

### Herd behaviour and natural repellents suitable for Estonian organic agriculture

Animals have developed various behavioral tactics to minimize insect bites. During the peak season of blood-sucking insects, many herds tend to congregate in open and breezy locations, or alternatively, near trees that they can rub against for relief. Biting midges and mosquitoes, in particular, find it challenging to cope with the wind and intense sun. Blackflies and horseflies also prefer to fly more between haystacks than in the open. It may be presumed that mowing pastures during summer could potentially create a less insect-infested environment for livestock. However, this hypothesis requires empirical validation.

The essential oils of many plants have at least some insect repellent effect, but not all of them are suitable for use as repellents on people or animals. A good repellent must be safe for users and the environment, long-lasting and relatively cheap. Catnip (*Nepeta cataria*), Indian neem tree (*Azadirachta indica*), citronella oil or lemon eucalyptus (*Corymbia citriodora*) extracts could be suitable for Estonian organic agriculture. Additionally, inexpensive base oils like rapeseed or sunflower oil, combined with water containing a small amount of soap, can be used to dilute essential oils. Studies have demonstrated that even the base oil alone can reduce the number of blood-sucking insects that land on livestock. However, these substances require further testing in Estonian agriculture to determine their application methods, the duration of their effectiveness during the rainy summer, and their cost-effectiveness for organic farms.

# A5 IT25 Continued determination of the species composition and abundance & small-scale testing of natural repellents

**Purpose**: Continued research to determine the species composition and abundance ratios of blood-sucking insects in the research areas, to account for variations in climatic conditions across different years. The investigation places particular emphasis on the diversity of horseflies, mosquitoes, biting midges and blackflies. Samples are collected for genetic analysis, while small-scale testing is also being conducted on natural repellents and predators.

**Evaluation**: Analysis of abundance ratios of blood-sucking insect groups/species with late summer activity in the grazing area was concluded. Natural repellents Indian neemtree and birch tar were tested. Catnip was identified and initially tested as a potential future natural repellent suitable for Estonian conditions. Testing the use of natural enemies of blood-sucking insects was initially planned, but previous literature analysis showed that this method is currently not very promising for Estonian organic agriculture.

## What was done

### Species determination

Blood-sucking insects were collected in all years of innovation activities using both battery-operated machines *Mosquito Magnet Independence* (Woodstream Corp., Lancaster, USA) as well as passive *H-trap* (Sentomol Ltd., Monmouth, UK) traps. Diversity research of blackflies (*Simuliidae*) and biting midges (*Ceratopogonidae*) focused on the catch results of 2018 and 2019, where both genera were most numerous. Genetic methods were used for species identification.

### Natural insect repellent experiment

An experiment was carried out with plant extracts, which have been attributed in the scientific literature with an insect repellent effect. The study tested the insect repellent effects of Indian neemtree (*Azadirachta indica*) oil (I consigli dell esparto, Rome, Italy; Dyna-Gro, Richmond, USA) and birch tar (*pix Betulina*) (Mäeotsa talu, Maalasti village, Estonia), using rapeseed oil (*oleum Brassica napus*) (AS Scanola Baltic, Paniküla, Estonia) as a control substance. In a second experiment, the effectiveness of catnip (*Nepeta Cataria*) as a natural insect repellent was also investigated.

The aim of the work was to investigate whether the volatile substances contained in neem oil and/or birch tar can repel arthropods from a distance, thereby reducing the number of insects that get caught in the traps. A data analysis was performed based on the number of horseflies collected in the experiment.

## Results

### Species determination

The following species of blackflies were identified and discussed:

- *Simulium* (*Boophthora*) *erythrocephalum* (De Geer)
- *Simulium* (*Nevermannia*) *angustitarse* (Lundström)

- *Simulium* (*Nevermannia*) *lundstromi* (Enderlein)
- *Simulium* (*Schoenbaueria*) *pusillum* Fries
- *Simulium* (*Simulium*) *noelleri* Friederichs
- *Simulium* (*Simulium*) *ornatum* (Meigen) complex
- *Simulium* (*Simulium*) *reptans* (Linnaeus)
- *Simulium* (*Wilhelmia*) *equinum* (Linnaeus)
- *Simulium* (*Wilhelmia*) *lineatum* (Meigen)

The following species of biting midges were identified and discussed:

- *Culicoides* (*Avaritia*) *chiopterus* (Meigen)
- *Culicoides* (*Culicoides*) *grisescens* Edwards
- *Culicoides* (*Culicoides*) *impunctatus* Goetghebuer
- *Culicoides* (*Culicoides*) *newsteadi* Austen
- *Culicoides* (*Avaritia*) *obsoletus* (Meigen)
- *Culicoides* (*Avaritia*) *scoticus* Downes & Kettle
- *Culicoides* (*Silvaticulicoides*) *pallidicornis* Kieffer
- *Culicoides* (*Culicoides*) *punctatus* (Meigen)
- *Culicoides* (*Monoculicoides*) *riethi* Kieffer

### Natural insect repellent experiment

In the comparison of the at distance repellent effects of neem oil, birch bark and rapeseed oil, no statistically significant differences were found. It is important to note that the effect size of the different levels of categorical factors used in the model was very small, with all numbers falling below +/- 1. Even if such a result were statistically significant, it would represent a negligible effect size for repellents, rendering it practically useless. Conducting more experiments would improve the accuracy of the final estimates, but would unlikely alter the effect sizes significantly.

Therefore, we can conclude that neem oil and birch tar likely have no general deterrent effect on horseflies from a distance of approximately half a meter, or the effect diminishes quickly. However, this does not exclude the possibility that repulsive properties may be observed in close contact.

The findings from this experiment indicate that the tested natural repellents may not be suitable for use in ear tags or collars to protect livestock, as birch tar and neem oil do not appear to possess the necessary insect deterrent properties from a distance. Additionally, it is important to consider that livestock are highly attractive to arthropods due to their specific scent and movements, making the repellent effect even less effective in such circumstances. Therefore, future research should not only focus on the search for repellents, but also on developing effective methods for directly applying essential oils or their mixtures to the animal fur. This approach would maximize the effectiveness of aromatic compounds and create an unpleasant surface for insects to land on. However, safety considerations must be taken into account when selecting the substances for use. Ideally, locally grown plants with a known growing environment and controlled cultivation should be used. At the same time, it is crucial that the local cultivation and processing of such plants are cost-effective, as this will determine their practicality for use.

### Catnip experiment

Catnip (*Nepeta cataria*), a perennial plant that belongs to the Lamiaceae family, has been naturalized in Northern Europe. The beneficial properties exhibited by its chemical components support the cultivation of catnip in Estonia. Due to its high potential as a repellent, Liivimaa Lihaveis decided to invest in the cultivation of catnip. As a result, a separate experimental field was established in 2021. In the summer of 2022 (June-September), a total of 18 distiller-fulls (18 x 200 l) of hydrosols were produced from the inflorescences of catnip, which produced a total of 270 liters of hydrosols. One distillation yielded an average of 15 liters of a rich hydrosol of essential oils, which contained nepetalactone as the main component.

According to the scientific literature and our own animal experiments (cattle, horses), an insect repellent with natural components was developed with the main components being nepetalactone contained in the hydrosol of catnip, lavender essential oil, pure pine tar and rapeseed oil. Different emulsifiers were also tested to find the most skin-friendly and effective emulsifier. Field testing showed that this recipe for insect repellent is effective against both mosquitoes and horseflies. Experiments must be continued to find a suitable repellent for flies as well.

*Table 2. Insect repellent recipe, 1 liter*

| Component | Amount, ml |
|---|---|
| Catnip (*Nepeta cataria*) hydrosol | 350 |
| Lavender (*Lavandula angustifolia*) essential oil | 1 |
| Lecithin (emulsifier) | 2 |
| Polysorbate 80 (emulsifier) | 45.5 |
| Rapeseed oil | 500 |
| Pine tar | 100 |
| Tansy (*Tanacetum vulgare*) essential oil | 0.5 |
| Garlic (*Allium sativum*) essential oil | 1 |

## A2 IT26 & IT27 Testing an innovative scratching post with mechanical insect traps

**Purpose**: To test the effectiveness of innovative mechanical traps in catching 1) various spring and early summer blood-sucking insect groups, and 2) various summer and early autumn blood-sucking insect groups with a particular focus on horseflies. To analyze the species composition of the collected insects and the effect of the traps on the population size and viability. This was tested together with an innovative scratching post which disperses natural insect repellent.

**Evaluation**: The species composition was analysed. The efficiency of the innovative scratching post with mechanical traps was analysed.

## What was done

Organic farming animals are vulnerable to insects as they cannot be moved indoors or treated with common repellents and insecticides. Animals have evolved behavioral methods to avoid insect attacks such as hiding in the forest or moving to windy areas, but these solutions are not always possible for farm animals. Even a change of location may not protect livestock from blood-sucking insects like horseflies. Therefore, insect traps may be a useful addition, helping to reduce the number of arthropods around the animals. Several different types of traps have been developed for catching blood-sucking insects, but some of them may not be suitable for use in pastures.

In the spring of 2020, Liivimaa Lihaveis ordered a robust livestock scratching post from a local craftsman, to which essential oils can be added to repel blood-sucking insects and from which insect traps and other accessories can be hung (Figure 5).

*Figure 1. Scratching post made to order for Liivimaa Lihaveis with salt, H-Trap and essential oil additives. Picture: H. Church.*

Insect traps and scratching posts were used around organic cattle from June 18 to July 22 and from August 14 to August 20. During the experimental period, the traps were moved together with the animals to different paddocks. Collected insects were determined by species.

## Results

### Scratching post test

During the field work, a total of 1,775 female horseflies from six different genera and at least 12 different species were caught. However, there were probably even more species present in the pasture. Particularly seeing that no representatives of the *Hybomitra* family were identified, of which there are at least 17 different species of *Hybomitra* in Estonia (Jürison 2016). The most likely reason why they were not caught was that during the experiment some technical complexities were encountered. The most numerous species turned out to be by far the common horsefly (*Haematopota pluvialis*), of which 1,419 were caught. Moreover, 98.80% of them were collected from around the scratching post. Based on this, it is clear that the H-trap is much more effective when attached to a scratching post than when standing alone.

### Species identification

Compared to the results of previous innovation activities, this time many new species of horseflies were caught from around the cattle. The following species of horseflies were identified and their importance as pests discussed:

- *Atylotus fulvus* Meigen
- *Chrysops caecutiens* (Linnaeus)
- *Chrysops relictus* Meigen
- *Chrysops viduatus* (Fabricius)
- *Haematopota crassicornis* Wahlberg
- *Haematopota pluvialis* (Linnaeus)
- *Heptatoma pellucens* (Fabricius)
- *Tabanus bovinus* Linnaeus
- *Tabanus bromius* Linnaeus
- *Tabanus maculicornis* (Zetterstedt)
- *Tabanus miki* (Brauer)
- *Tabanus sudeticus* (Zeller)

# A2 IT28 & IT29 Effects of pasture management and intensive and extensive grazing & innovative spray gates

**Purpose**: To study the local distribution of blood-sucking insects with a) spring activity and b) autumn activity is investigated depending on their biological (including developmental) characteristics. The grazing schedule will be adjusted accordingly. The possible effect of pasture care in combination with the use of repellents on the number of blood-sucking insects is being investigated.

**Evaluation**: The effectiveness of pasture mowing on insects was evaluated; results were inconclusive. The effectiveness of insect traps on extensive and intensive pastures were evaluated. Initially, adjusting the grazing pattern based on insect activity was planned, but this was considered impractical in the end, especially in the light of other considerations dictating the farmer’s choice of grazing pattern or farming type. The effectiveness of spray gates on insects was tested. The use of activity monitors to assess cattle stress levels was tested. The development of the repellent and spray gates still need further setup and then large-scale testing.

## What was done

### Effect of pasture management on the abundance of blood-sucking insects

Blood-sucking insects were captured every two weeks during innovation activities that took place from July until September 2019. The traps were set up for three consecutive days, some in mowed and others in unmown pasture. In a single paddock, four insect traps were set up at the same time, testing different types and set-ups of the traps. The adjacent fields in one area were used for field work, some of which were mowed around Midsummer. Two herds of beef cattle, red Aberdeen Angus and Simmentals, were moved between the paddocks. The herds consisted of bulls, cows, and calves of the same year, varying only slightly in size.

### Abundance of blood-sucking insects in areas of intensive and extensive grazing

During innovation activities conducted in July, August, and September of 2018, blood-sucking two-winged insects were captured in the areas of both intensive and extensive beef cattle grazing. Fieldwork was carried out in the vicinity of Mustjõe in Valga and Võru County. Two types of traps, Mosquito Magnet machines and H-trap traps, were used to collect insects. Four traps of each type were set up simultaneously and equally distributed between intensively and extensively grazed beef cattle paddocks. The traps were left near the animal feeding areas for four days once a month to increase the probability of capturing insects roaming around the cattle.

### Testing spray gates and cattle activity monitors

In 2022, there was a focus on further testing insect repellents and developing long-term solutions based on past experiences. The aim was to improve the efficiency of assessing animal activity, stress levels, and behavior. While catching blood-sucking insects from pastures provided an idea of the biological diversity in the area and the potential pests of the animals, it was challenging to assess the actual stress experienced by the cattle. To better understand their biorhythm, the WiseCow (Piimaklaster MTÜ) project introduced a system of activity sensors placed on collars, stations, and an internet-based user interface. However, the system was still in its experimental phase and required time and configuration to be fully operational.

Meanwhile, WalleyWood OÜ was commissioned to design and build a prototype of an automatic spray gate ( Annex 1) to facilitate the application of organic repellents to cattle. In the past, scratching posts had been used, but it was difficult to assess how much deterrent was actually transferred to the animals. The spray gates could provide a more effective and cost-efficient solution. The company designed a towed sprayer that operates on solar batteries and can be connected to an electric fence for better directing the cattle. An animal counter was also added to the gate. During the summer, both the activity monitors and spray gates were implemented, and reliability testing and fine-tuning took place. The test took place in Tõrve village in Järva County in August 2022. Two herds of cattle were used, consisting of six-month- to eight-year-old animals:

Herd 1: 14 animals, aged 13 to 30 months. Young females.
Herd 2: 12 animals, aged 6 months to 8 years. Mothers and calves.

In both herds, five animals wore test collars as part of the WiseCow project. For technical reasons, the data of one of the control group's activity monitors for the observed period could not be used later. The results of nine activity monitors were analyzed between 02.08.2022 and 15.08.2022. The data showed the approximate number of steps taken by the cattle in each hour of the day.

## Results

### Effect of pasture management on the abundance of blood-sucking insects

The generalized linear model showed that the number of insects caught in the Mosquito Magnet traps did not depend on whether the field was mowed or not. The results of the H-trap traps show a slight trend that traps in unmown fields collect fewer horseflies and houseflies than traps in mown fields, but it was not statistically significant. However, it turned out that the further the Mosquito magnet traps are from the trees, the smaller the number of insects caught, although this relationship is quite weak. Outdoor H-traps next to Mosquito Magnet machines also captured statistically significantly more insects compared to traps hung on trees. The Mosquito Magnet caught statistically significantly more blackflies than biting midges, but at the same time significantly fewer biting midges compared to mosquitoes. In general, blackflies were very numerous in the Mosquito Magnet traps that year, but the difference between the number of blackflies and mosquitoes is more surprising.

To summarize, the number of dipteran bloodsucking insects attracted by the traps is not significantly affected by mowing the pasture. There is a weak trend that fewer insects were trapped in the unmown field, but this could also be due to the slight difference in the sizes of some of the mowed and unmowed paddocks, as cattle may be less likely to approach the traps in larger pastures. H-traps work better in the open field and near other insect attractors than when hung from branches in animal resting or feeding areas. However, Mosquito Magnet machines collect more biting midges, blackflies, and mosquitoes when placed closer to trees, as these insects are more sheltered by trees from direct sun and wind. Based on the results, it is inconclusive whether mowed or unmowed terrain provides more protection from flying insects for livestock.

### Trapping success of blood-sucking insects in areas of intensive and extensive grazing

The number of horseflies was unusually low during the test year and this made their statistical analysis difficult, as there simply aren't enough data points to assess trends. It is noteworthy that in the year under review, the probability of the representatives of all three genera – mosquitoes, blackflies, biting midges – falling into the Mosquito Magnet trap was relatively similar. This differs from the results of the fieldwork carried out in Jõgeva County in 2019, where blackflies were statistically significantly more numerous than other insects. Here, annual variation is likely to play a role rather than the difference in location. However, it clearly shows how much the numbers of insects can vary according to the year and situation.

Mosquito Magnet traps in intensively grazed fields collected statistically significantly more blood-sucking insects. However, the H-trap traps caught very few insects at that time. This dataset was therefore too small for further statistical conclusions. At the same time, it can be seen that at least in the case of blackflies and horseflies, the trend persists that more individuals are trapped in intensively grazed pastures than in extensive grazed pastures. In the case of biting midges, however, the opposite trend can be seen here: in the extensive field, more individuals were caught in the H-trap trap than elsewhere. Unfortunately, the number of insects is again too small to draw any real conclusions. More work is needed.

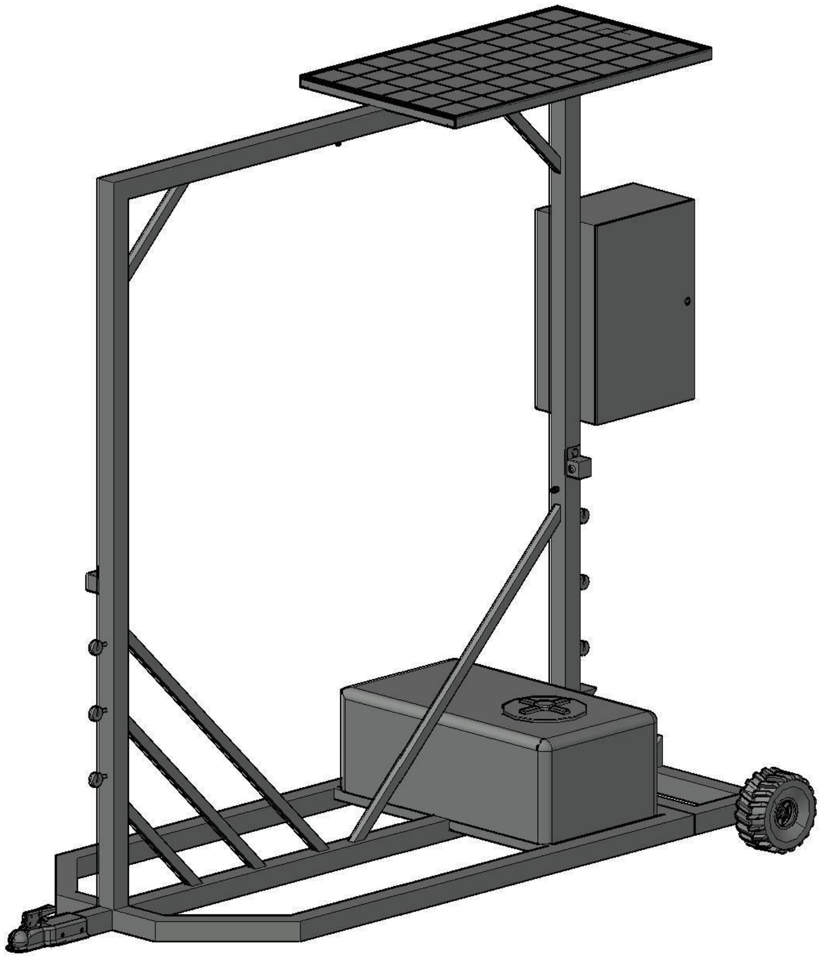
In intensively grazed pastures, finding scratching posts and hiding places from insect attacks may be more difficult for animals. It should be noted that for the 2018 field work, the number of traps used was not adjusted based on the size of the pastures. Rather, traps were placed near animal resting areas and rock salt. Therefore, the catch results of traps may not necessarily indicate that there are fewer insects in the immediate vicinity of animals in extensive areas. In extensively grazed pastures, animals likely spent less time near traps than in small paddocks in intensively grazed pastures. However, there was no evidence that members of certain blood-sucking insect families were collected more by the traps on one type of pasture than the other, meaning there was no interaction between the abundance of different insect families and which type of pastures the traps were used on. Additionally, the study showed that the use of insect traps was significantly more effective in pastures with intensive grazing compared to extensive grazing, possibly due to animals spending more time around the traps in the first case.

## Testing spray gates and cattle activity monitors

The activity monitors attached to the cattle's collars functioned relatively well and did not seem to cause any discomfort or disruption to the animals' routine. However, the analysis of the data collected did not reveal a statistically significant difference in the activity levels of the experimental group and the control group in the days after the natural repellent was administered. However, a comparison of the graphs indicated some variation in the activity levels of both groups on the day following the application of the repellent. On that day, the experimental group was marginally less active compared to the control group. It is possible that releasing the animals into the adjacent paddock on the day the repellent was administered might have influenced their movements for some time. Nevertheless, it is noteworthy that the activity of the experimental group showed signs of decreased activity, which was unexpected according to the theory. Typically, animals under insect attack gather in a dense group and stop eating, resulting in reduced activity levels (Torr et al. 2007). Hence, it was anticipated that less stressed animals would move around more freely. However, it is currently uncertain whether the activity monitors were capable of differentiating between the animal's walking and other movements such as head shaking.

The cattle successfully adapted to the spray gates in 2022, and any remaining technical problems will likely be resolved in future experiments. Despite some malfunctions and inaccuracies in the activity monitors, their general reliability was good. However, it is unclear how accurately these devices distinguish animal steps from other movements, leading to some uncertainty in the data at the moment. However, developments in this field are rapidly advancing, and future assessments of cattle's physiological state will likely become more accurate. Estonian entrepreneurs are also working on developing solutions in this direction.

There is potential for promising advancements in the development of spray gates, activity monitors, and blood-sucking insect repellants. The implementation of activity monitors, and even implants, could provide animal breeders with more comprehensive insights into animal health, resulting in better herd health management. Additionally, the wider range of applications for natural hydrosols used in insect repellants could increase profitability in the cultivation and processing of these plants.



# Prototype: automatic insect repellent sprayer for cattle

Liiivimaa Lihaveis

# Contents

## Specifications

Dimensions: 2700x1240x2400

Water tank: 100l

Water pump: 12V 18A 9400l/h lifting height

3.5m Battery: 35Ah 12V

Charge controller: 20A 12V MPPT

Solar panel: 100w

Max trailer speed: 10 km/h

## Product description

The automatic insecticide sprayer is an easily portable device that applies insecticide to livestock and automatically sprays the animal when the animal passes through the device's sensors. The passage of the animal is detected by an infrared sensor, which sends a signal to the pump, after which the device sprays the animal for three seconds, both on the sides and on the back. The sprayer is powered by a battery that is charged by a solar panel attached to the device, making the device autonomous. The sprayer has a 100 l tank, in which it is possible to store various insect repellents. Three insulators are attached to both sides of the device, to which an electric herder can be attached to guide animals. A counter is also added to the device, which records the passability of animals.

To move the device, a trailer hook and a hydraulic jack are added, which allows the device to be lifted into the transport position. To use the device, the frame is lowered to the ground, which raises the wheels of the transport. Thanks to this, the device is easier for animals to pass through.

The purpose of the device is to facilitate the application of insect repellents to cattle, which would reduce animal stress and health problems during the insect season and reduce the need for human resources

## Product overview

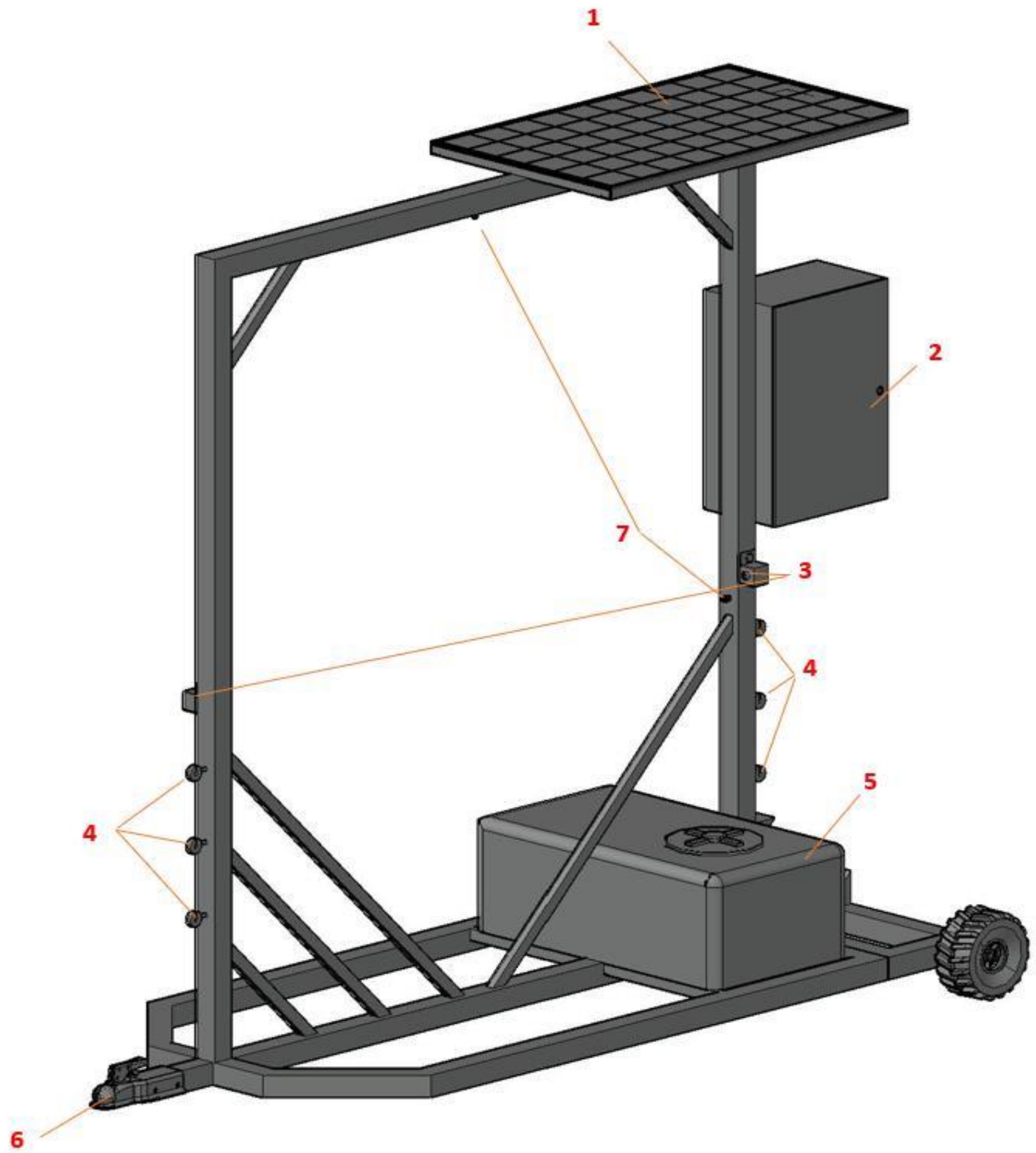



*Figure 1. Product diagram from the 1. side*

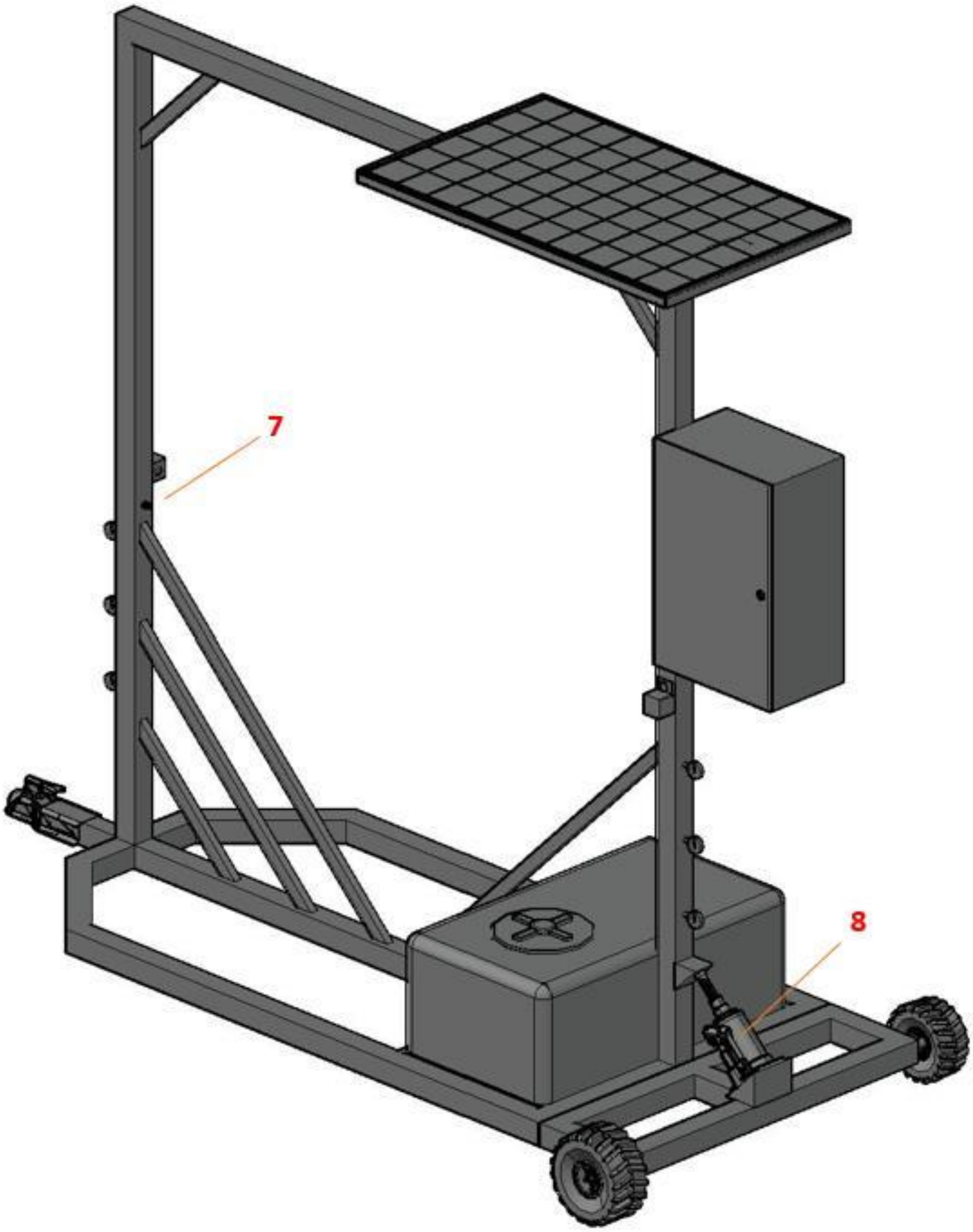



*Figure 2.Product diagram from the 2. side*

## Product overview

**Legend to Figures 1 and 2:**

1. Solar panel

2. Power panel

3. Infrared sensors

4. Insulators

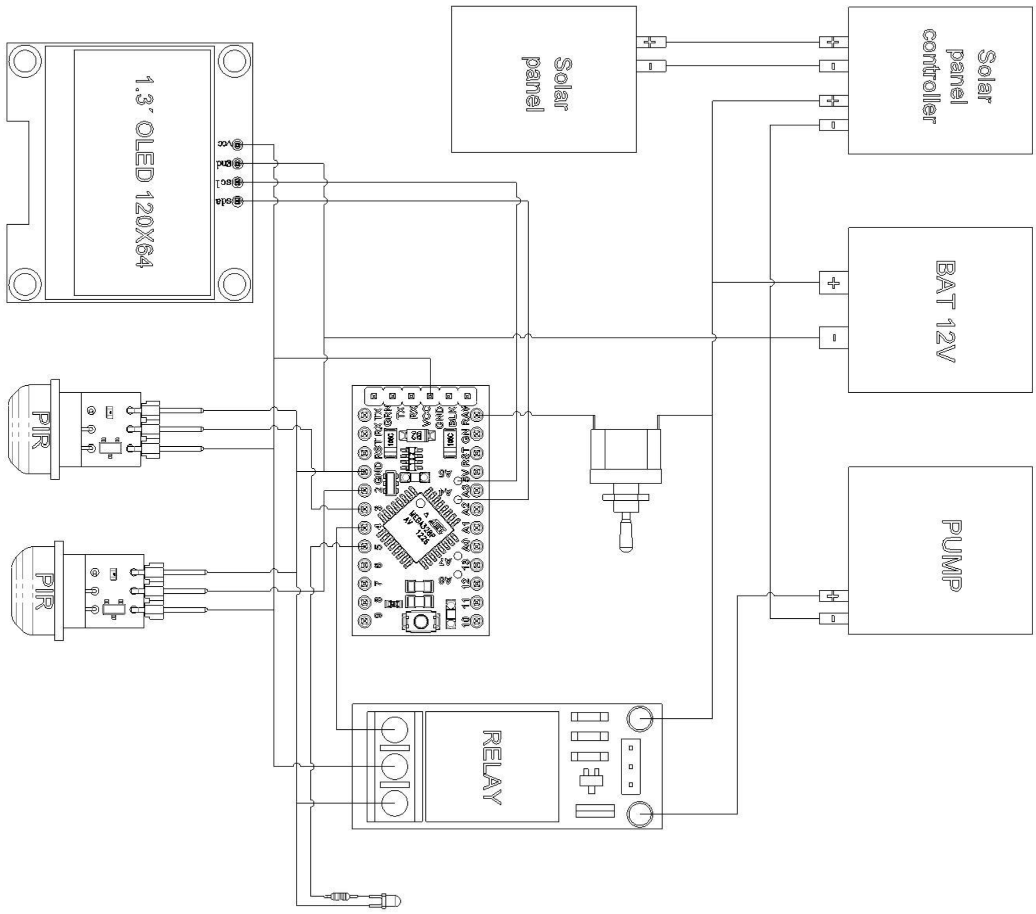
5. Tank

6. Hooklift

7. Injectors

8. Hydraulic jack

## Electrical diagram



## Creation process and problems to be solved

Creation process

- Sketching the product
- Welding the frame together
- Creating and designing the wheel lifting/lowering mechanism
- Compiling the
- electrical diagram Soldering the components of
- the electrical panel to the components
- Arduino mini pro programming and writing code
- electrical circuit Testing
- solar panel Testing
- different combinations of injection systems Testing
- the cooperation of the entire system

Problems that need to be solved

- Getting air into the pipeline
- Pressurizing the injectors
- Testing the counter