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# Distribution of *Rhagoletis Batava* on Cultivated Sea Buckthorn and the Effects of Bio-Preparations

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***Abstract*** **– Sea buckthorn fly (Rhagoletis batava Hering, 1958) constitutes the primary pest affecting cultivated sea buckthorn in the western region of Mongolia, with its destructive impact escalating annually and causing significant losses in yield. This study aims to assess the distribution of sea buckthorn flies, well-known for their harm to cultivated sea buckthorn, and to evaluate the effectiveness of biological preparation and entomopathogenic nematode against these flies. From 2020 to 2022, the investigation into the distribution of sea buckthorn flies was conducted in regions where sea buckthorn cultivation is prevalent, selecting provinces within the central and western agricultural regions. This research has revealed the presence of the Sea buckthorn fly in Ulaangom and Tarialan sums of Uvs province, Jargalant of Khovd province, Khaliun sum of Gobi-Altai province, Uliastai, and Songino sums of Zavkhan province, respectively. In the years 2021-2022, a research study was carried out to assess the effectiveness of bio-preparations against sea buckthorn flies specifically in Ulaangom sum of Uvs province and Jargalant sum of Khovd province. The results indicated that the bio-preparation Aversectin C (Fitoverm), derived from entomopathogenic fungi, exhibited a notable effectiveness range of 75.8-93.8% against sea buckthorn fly larvae. Furthermore, the preparation containing Steinernema feltiae entomopathogenic nematode demonstrated a substantial reduction in the fly population by 2.3-3.6 times. These findings provide valuable insights into the potential utilization of these biological preparations for effective pest management in cultivated sea buckthorn ecosystems.**

***Keywords*** **– Aversectin C, Steinernema Feltiae, Effectiveness, Fungi, Parasitic Nematode.**

## I. INTRODUCTION

Sea buckthorn, a native plant of Mongolia, has been under cultivation since the 1960s. The "Fruits" national program, was initiated to enhance fruit and vegetable variety and production, provide the population with ecologically clean and nutritious produce, and boost export income through improved competitiveness implemented between 2010 and 1016 [7]. Consequently, sea buckthorn cultivation has expanded to encompass approximately 3100 hectares of land in the country [2]. The increasing cultivation of sea buckthorn each year has led to a rise in the prevalence and impact of certain specialized pests. Notably, the sea buckthorn fly, for instance, resulted in a 70-90 percent reduction in fruit yield between 2008 and 2011 in sea buckthorn cultivated in the western region of Mongolia [8].

Very limited research has been conducted on the fruit flies (Family: Tephritidae) in Mongolia. The sea buckthorn fly was initially discovered and documented in Bulgan Sum of Khovd Province and Ulaangom Sum of Uvs Province between 1971 and 1976 by researchers from the Plant Protection and Quarantine Service [5].

Seabuckthorn fly is are observed in cultivated sea buckthorn areas near Jargalant Sum of Khovd Province, Ulaangom Sum of Uvs Province, and wild sea buckthorn areas around Tes Sum of Uvs Province and Durvuljin Sum of Zavkhan Province, starting from the 3rdset of 10 days in June annually. Female flies lay 1-2 eggs in a single fruit during the 1stand 2ndsets of 10 days in July [8, 9].

The sea buckthorn fly has been documented in various ecological regions of Mongolia, including the Gobi and forest steppes of the Great Lakes Depressions, Ulaangom in Uvs province, around Uvs Lake, Kharhiraa, the Turgani River basin, sea buckthorn along the Tes River, near the Khovd River in Khovd province, around the Bulgan River in Bulgan Sum, the area along the Khovd River basin in Bayan-Ulgii province, Khaliun of Gobi-Altai province, Biger, Aldarkhaan of Zavkhan province, on wild sea buckthorn in Durvuljin Sum, Ulaangom in Uvs province, Jargalant in Khovd province, and cultivated sea buckthorn in the Uliastai region of Zavkhan province [9]. This comprehensive distribution data provides valuable insights into the geographical prevalence of the Sea buckthorn fly across diverse ecosystems in Mongolia.

Currently, in the environmental conditions of Mongolia, pyrethroid insecticides, specifically lambda-cyhalothrin, are employed against harmful flies affecting cultivated sea buckthorn. However, these interventions have demonstrated suboptimal efficacy, and the associated use poses a risk of pesticide residues in sea buckthorn fruits. Consequently, there is an imperative need to assess the distribution of the sea buckthorn fly and conduct research on control methods that prioritize both human health and environmental safety. Thus, the primary objective of this study is to ascertain the distribution of sea buckthorn flies on cultivated sea buckthorn, implement control measures utilizing biological preparations and parasitic nematodes, and subsequently assess the outcomes of these interventions. The study aims to contribute valuable insights towards the development of effective and environmentally sustainable strategies for managing sea buckthorn fly populations in Mongolia.

## II. METHODOLOGY

*Route Survey*

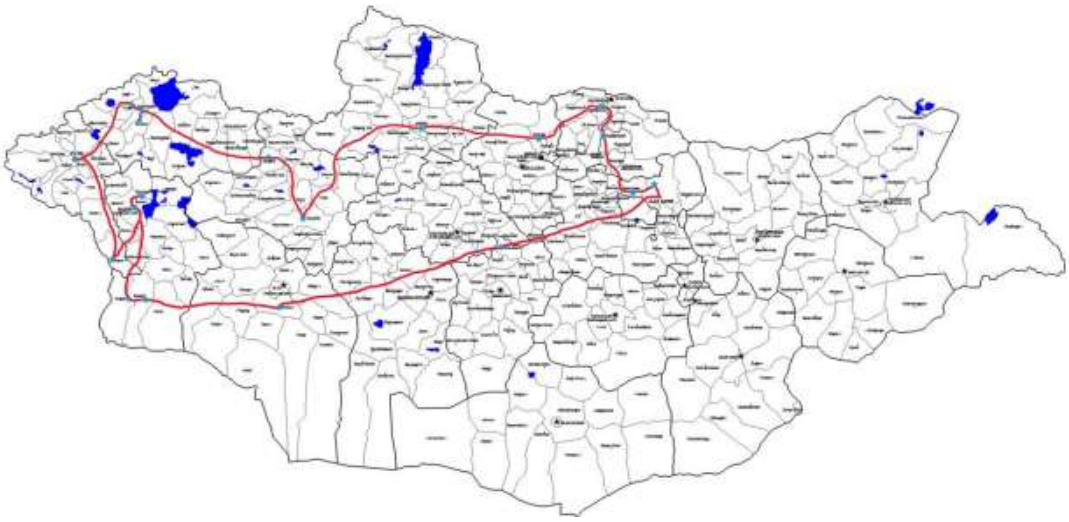

Fig. 1. The research route for detecting and identifying the distribution of sea buckthorn flies (Red line - survey route, blue dots - survey locations).

A comprehensive survey was undertaken to assess the distribution of sea buckthorn flies within cultivated sea buckthorn fields across selected sums in Tuv, Selenge, Khuvsgul, Bulgan, Uvs, Khovd, Zavkhan, Gobi-Altai, and Uvurkhangai provinces, representative of the central and western agricultural regions of Mongolia (Figure 1). The research was conducted during the plant growth periods of 2020 and 2021 to detect sea buckthorn fly larvae in the fruit at the time of ripening and maturation. Additionally, the study aimed to identify larvae in the soil, particularly those that migrated during the winter period.

Observations were systematically conducted on fruiting trees and the soil beneath the crown of trees exhibiting signs of fly larvae infestation. These observations were strategically performed by traversing the field along the two diagonals or adopting a chessboard-like pattern, depending on the positional arrangement of sea buckthorn trees within the field.

### *Field Survey*

A research investigation was carried out in 2021 and 2022 to assess the efficacy of parasitic nematodes and bio-preparation against sea buckthorn flies in Ulaangom (N49059"53/E92002"53., elevation: 972m) and Jargalant Sum (N48000"01/ E91035", elevation: 1410m) in Khovd Province. The study targeted a sea buckthorn field where the sea buckthorn fly had shown a spread of 70-100% in previous years. The active ingredient employed in this investigation was Aversectin C (2g/l), a product of microbial synthesis utilizing a culture of Streptomyces avermitilis, specifically chosen for its effectiveness against sea buckthorn flies.

### *Application of Entomopathogenic Nematodes to Insects*

The optimal developmental stage for the parasitic nematode Steinernema feltiae to target the fly is the diapausing pupa, which undergoes wintering within a false envelope at depths of up to 10 cm in the soil. To effectively address this stage, an aqueous suspension containing 125,000 larvae of the nematode population (equivalent to 10 liters of solution) was calculated and applied to 1 m² of soil. This solution was used to irrigate the soil surrounding the main stem under the crown of the tree during the third set of ten days in May, approximately two weeks before the emergence of flies from wintering. In the control scenario, the soil around the main stem of the sampled tree received irrigation with water. Each experiment comprised four replicates. The results were assessed by counting the adult flies attached to the trees in both treated and untreated control plots using yellow paper traps. A rectangular yellow sticky trap (25x20 cm, made in Mongolia) with glue on both surfaces to capture insects was employed. The traps were suspended in female trees at a height of 1.5-2 meters from the ground and at a distance of approximately 20 meters. The entomopathogenic nematode species Steinernema feltiae represents an environmentally friendly biological preparation employed for the control of soil-borne pests. Widely distributed in nature, this nematode can persist in soil devoid of host insects for an extended period, exceeding 2 years. Its impact is selectively targeted towards insects, ensuring safety for humans, animals, and beneficial arthropods.

### *Application of Bio-preparation Fitoverm CE to Insects*

In 2021, a field research study was conducted in sea buckthorn fields to assess the efficacy of Fitoverm CE preparation containing Aversectin C against the sea buckthorn fly. Fruiting trees hosting fly larvae were selected for the study, incorporating two versions and four repetitions. The Fitoverm preparation was applied at a rate of 3 l/ha on July 18 in the targeted field of Jargalant Sum, Khovd province and on July 20 in the Ulaangom Sum of Uvs province. Seven days post-application, the biological effects of the preparation were evaluated by assessing the mortality percentage of fly larvae. This assessment was based on 100 fruits from each repetition (25 per tree, totaling 4 trees) to calculate the percentage of fly larval mortality.

Aversectin C enters the insect's body through either spraying or ingestion of plant parts, impacting the nervous system, and leading to paralysis and eventual death. Insects cease feeding 8-10 hours post-spraying and succumb within 3-6 days. Importantly, Aversectin C does not accumulate in plants during fruit ripening. Its

application is versatile, and effective at any stage of plant development when pests emerge. Preparations containing Aversectin C lack resistance to harmful insects, allowing for consecutive use over several years. These preparations find application against a spectrum of pests affecting various vegetables, fruits, berries, and grains. Notably, Aversectin C exhibits low toxicity in humans and warm-blooded animals.

Statistical Analysis: The effects of biopreparation usage were analyzed using Analysis of Variance (ANOVA). Interactions were assessed by aggregating data from replicate trials.

## III. Results

### *Distribution of Sea Buckthorn Fly*

This study aimed to assess the distribution of the sea buckthorn fly, a specialized pest affecting cultivated sea buckthorn. The investigation covered a total of 18 districts in, Tuv, Uvs, ovd, Zavkhan, and Govi-Altai provinces, including Songino Khairkhan district of Ulaanbaatar city. These regions, located in the central and western parts of Mongolia, are known for cultivating sea buckthorn.

Within the surveyed districts, adult flies were observed on the leaves of cultivated sea buckthorn in Uliastai, Songino, Uvs provinces, Ulaangom, Jargalant in Khovd, and Govi-Altai provinces. Additionally, fly larvae were found in the fruit, while overwintering fly larvae were identified in the soil beneath the crown of the tree (refer to Fig. 2 and 3).

Fig. 2. Distribution of sea buckthorn flies on cultivated sea buckthorn (-fly distribution arrows).


Fig. 3. Sea buckthorn fly: a-adult fly on sea buckthorn leaf, b-larvae in fruit, c-larvae overwintering in soil. (Photo by T. Dejidmaa, B. Munkhtsetseg).

*Effectiveness of Entomopathogenic Nematode against the Sea Buckthorn Fly*

In the sea buckthorn field under investigation, the emergence of flies commenced towards the conclusion of the initial ten days of June, reaching its peak during the final ten days of the month. During this period, an average of 0-13 flies were documented per day in the treated area. In contrast, in the untreated field, where no preparation was applied, 5-42 flies were counted on a single sticky trap.

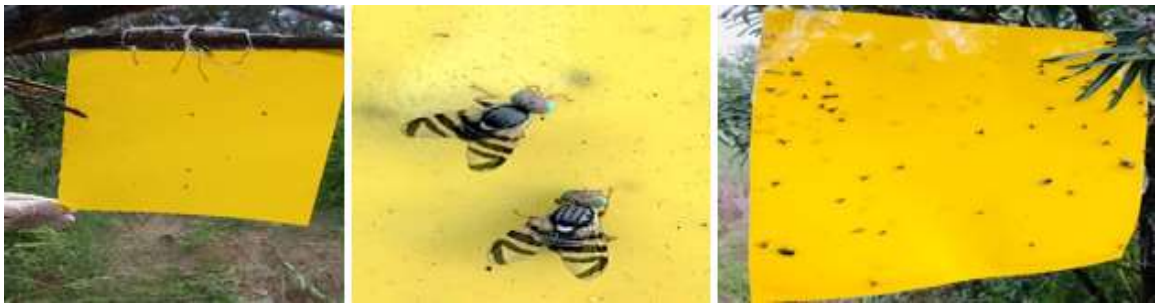

Fig. 4. Adult Sea Buckthorn Flies on a Stick Trap (Photograph by T. Dejidmaa, N. Batbayar).

Biological preparations of entomopathogenic nematode (*Steinernema feltiae*), when applied to the pupal stage of Sea buckthorn flies, reduced the number of flies by 2.3-3.6 times (result shown in Table 1).

Table 1. Effectiveness of bio-preparation containing entomopathogenic nematodes.

| Variation | Jargalant, Khovd Province 28 June, 2022 | | Ulaangom, Uvs province 30 June, 2022 | |
|---|---|---|---|---|
| | Number of Flies in the Trap | Reduction in Fly Population | Number of Flies in the Ttrap | Reduction in fly population |
| *Steinernema feltiae* (125.000/1м$^2$) | 5,0 | 3,6 times | 7,8 | 2,3 times |
| Control (water) | 17,8 | - | 18,3 | - |
| Minimum mean difference | 4,2 | - | 1,5 | - |

Fly larvae that enter the soil for pupation in the second half of summer are susceptible to nematodes, thereby contributing to a reduction in the number of flies during the growing season.

*Effectiveness of Fitoverm EC against the Sea Buckthorn Fly*

The study evaluating the efficacy of the Fitoverm EC preparation was conducted under hot and dry weather conditions. Seven days after spraying, the percentage of fly larval mortality ranged from 75.8% to 93.8% (see Table 2).

Table 2. Effectiveness of bio-preparation containing Aversectin C.

| Variation | Mortality rate of larvae, % | |
|---|---|---|
| | Jargalant, Khovd province 25 July, 2021 | Ulaangom, Uvs province 27 July, 2021 |
| Control, (non-treated) | 7.5 | 10,3 |
| Aversectin C -2g/l, (3l/ha) | 75,8 | 93,8 |
| Minimum mean difference | $F_{0.05}>F_{crit}$ | |

Given the effectiveness of bio-preparation in safeguarding against sea buckthorn flies, it suggests its potential widespread utilization in the future to mitigate the harm inflicted by these flies.

## IV. Discussion

The investigation into the distribution of the sea buckthorn fly in cultivated sea buckthorn and methods of its control represents the inaugural study of its kind in Mongolia. While the sea buckthorn fly is prevalent in Russia, European countries, and China, its distribution varies, being classified as a foreign species (Alien pest) in Europe, including Belarus, Estonia, Latvia, Lithuania, Finland, and the European part of the Russian Federation, and as a native species in Belgium, Germany, Hungary, Italy, Poland, Spain, Sweden, Switzerland, and The Netherlands [1]. Notably, it has been observed to be widespread in cultivated sea buckthorn in Western Siberia, Russia. In China, it is distributed in Heilongjiang, Liaoning, Neimenggu, Shaanxi, and Xinjiang provinces [6]. The likelihood exists that this fly was introduced through wild buckthorn, given its status as a native insect, and subsequently spread to cultivated sea buckthorn in four provinces of the western region of Mongolia, encompassing six sum locations.

For the control of Rhagoletis batava, recommendations include the utilization of insect traps, cultivating varieties resistant to the sea buckthorn fly, and deploying pathogenic fungi and parasites [3]. In the current study, fungal bio-preparation and parasitoids were employed in combating the sea buckthorn fly. The Aversectin C preparation (Fitoverm, 3l/ha) with a concentration of 2g/l, derived from fungus, demonstrated a significant efficacy of 75.8-93.8% against fly larvae. In the Altai region of Russia, similar preparations exhibited results ranging from 84.7% to 100% [8]. Additionally, a preparation containing Steinernema feltiaeparasitic nematode (5 million/1g) achieved a substantial reduction in the number of flies by 2.3-3.6 times, showing the effectiveness of 60-98% against the sea buckthorn fly and certain crop insects in Russia [4].

## V. Conclusion

The sea buckthorn fly (Rhagoletis batava) inflicted damage on cultivated sea buckthorn in the western region of Mongolia, spreading to Ulaangom and Tarialan in Uvs province, Jargalant in Khovd province, Khaliun in Gobi-Altai province, and Uliastai and Songino in Zavkhan province.

The utilization of a bio-preparation containing Steinernema feltiaeentomopathogenic nematode against sea buckthorn fly pupae resulted in a reduction of fly numbers by 2.3-3.6 times. Moreover, a bio-preparation containing Aversectin C (Fitoverm, 3l/ha) demonstrated notable efficacy, achieving results of 75.8-93.8% against sea buckthorn fly larvae.

## References

[1] Arturs Stalazs and maksims balalaikins. country checklist of rhagoletis loew (Diptera: Tephritidae) for Europe, with focus on R. Batavia and its recent range expansion. Proceedings of the Latvian Academy of Sciences. Section B, Vol. 71, No. 3 (708), pp. 103–110. DOI: 10.1515/prolas-2017-0018
[2] Areas of Fruits and Berries, by type, region, aimags and the Capital and Year. National Statistics Office. 2023-09-26https://1212.mn /mn/statistic/statcate/573069/table-view/DT_NSO_1002_009V1
[3] Claudia Daniel. Experiences of integrated management of European cherry fruit fly (*Rhagoletis cerasi*) and how to utilize this knowledge for Sea Buckthorn Fly (*Rhagoletis batava*). Proceedings to the 3rd European Workshop on Sea Buckthorn, Euro Works, Naantali, Finland, 14-16 October 2014.
[4] Danilov L.G. (2001).Biological basis for the use of entomopathogenic nematodes (*Rhabditida: Steinernematidae, Heterorhabditidae*) in plant protection: abstract diss.Doctor of Agricultural Sciences: 06.01.11 /All-Russian Research Institute of Plant Protection. -Saint Petersburg, 2001. -46c.
[5] Davaa M.(1999). Investigating and developing control methods for the primary pests of berry crops in Mongolia. The thesis for the degree of Doctor of Agricultural Sciences, Ulaanbaatar.
[6] EPPO Global Database, 2023 https://gd.eppo.int/taxon/RHAGBA/distribution/CN

[7] Government Resolution, March 10, 2010, No. 60.https://legalinfo.mn/mn/detail/5437/2/202603
[8] Munkhtsetseg B.,Turbat T. and Dorjderem B.(2021). The humid and thermal impact on distribution of Sea buckthorn fly (*Rhagolethis batava* Hering, 1958) in Mongolia. Proceedings of the Mongolian Academy of Sciences, Vol. 61 No 02(238). https://doi.org/10.5564/pmas.v61i02.1759
[9] Munkhtsetseg B., Chuluunjav Ch., Nasandulam D. and Turbat T. (2021). Sea Buckthorn Fly*Rhagoletis batava* (Hering, 1958), "Orgil chanar" Printing factory, Ulaanbaatar, ISBN -978-99978-784-6-5
[10] Shamanskay L.D.,Efficacy of Fitoverm against sea buckthorn phytophages, NTP: Agriculture and Cropping, UDC 632.951https: //cyberleninka.ru/article/n/effektivnost-fitoverma-protiv-fitofagov-oblepihi/viewer

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**Nasandulam Damdinpurev,** With a PhD in Agriculture, the researcher specializes in various fields including Entomology, Entomopathogenic control of plant protection, Integrated pest management, and Plant quarantine and food safety assessment. Currently, she holds a position as a teacher of plant protection and entomology at the School of Agroecology at the Mongolian University of Life Sciences. Furthermore, the researcher has contributed significantly to scientific literature. Notably, Nasandulam and other researchers assessed the environmental significance of heavy metal contamination in Tuul River sediments, Ulaanbaatar basin, Mongolia in 2015. Additionally, in 2019, she was involved in the geochemical evaluation of land use at a medieval harbor site in Masuda City, Chugoku region, Japan. Moreover, her work on the morphological and molecular identification of Beauveria bassiana from agricultural soils in Mongolia has been published.
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**Fourth Author**

**Dejidmaa Turmunkh,** With a PhD in Agriculture and membership in the Plant Protection Association of Mongolia, she is actively engaged as a researcher in the Laboratory of Plant Pathology at the Institute of Plant Protection Research in Mongolia. Her research interests encompass a wide array of topics including Integrated Crop Pest Control, Sustainable Irrigation Management, and Organic Buckthorn Project in Mongolia/ AFACI. Throughout her career, she has been involved in several significant projects, including the Integrated Crop Pest Control Science and Technology Project from 2009 to 2011, the Sustainable Irrigation Management Project TCP/MON/3203 from 2010 to 2012, and the Organic Buck--thorn Project in Mongolia/ AFACI from 2012 to 2015. Dejidmaa, alongside other esteemed researchers, has made noteworthy contributions to the field, with publications such as "Geographical distribution patterns of Geastrum melanocephalum (Geastraceae, Basidiomycota) in Siberia in present and under conditions of climate change" and "Distribution and ecological niche modelling of a rare species Poronia punctata in Asia" which have garnered international recognition. email id: chag_dejidmaa@yahoo.com