Records of insect pests attacking *Salix* spp (willow) in the Spiti valley, Lahaul and Spiti, Himachal Pradesh

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ABSTRACT

The dry temperate and cold desert areas of Himachal Pradesh are considered to be the areas for production and utilization of willows, yet very little research work on the extent of distribution, the number of species and insect pest attacks on willows has been done which needs to be updated to subsequently boost the wood-based industry which has great scope for extended expansion in this region. During the present investigations, field surveys were conducted to monitor the insect pest infestation on *Salix* species at six sites viz Lalung, Giu, Guling, Mud, Losar and Chichumarea of the Spiti valley, Himachal Pradesh. Specimens of insect species were collected from *Salix* dominant areas of Spiti valley and were preserved for further identification and taxonomic characterization. The study led to identification of 9 insect species with their extent of damage and occurrence in the field. Nine species of insects belonging to the order Coleoptera, Lepidoptera, Hymenoptera and Diptera were identified. Two insect species viz *Tuberolachnus salignus* and *Nematus pavidus* were found causing serious damage to willow trees in Spiti valley, Lahaul and Spiti, Himachal Pradesh.

Keywords: Cold desert; willow; insect pests; *Tuberolachnus salignus*; *Nematus pavidus*; Spiti valley

INTRODUCTION

Insects are most diverse class of phylum Arthropoda. They have adapted to a wide range of environments, including the Arctic tundra, Alpine mountain peaks, tropical rainforests and coastal mangrove swamps and are able to withstand temperature and other climatic extremes. As willows (*Salix* spp) constitute the major vegetation component of the vegetation structure of the cold deserts, few workers have reported insect pest attacks on willow, prevailing in the cold deserts of Spiti valley. Many species of animals are known to show seasonal fluctuations in their numbers and densities (Young 1997, Davidson and Andrewartha 1948). This makes some species common during some parts of the year and less common at other times. These seasonal variations in population sizes might be due to several natural factors like their breeding cycles, seasonal movements across habitats, availability of food etc (Ehrlich 1986). Understanding such fluctuations in animal populations, can help in their management and conservation.

Tuberolachnus salignus was found to reduce not only the above- and below-ground growth of trees made during and subsequent to infestation, but also altered the mass of previously developed woody tissue. The negative effects of *T salignus* on the shoots and roots of established and establishing trees were drastic and were both quantitative and qualitative. They were also observed to reduce the survival of infested trees (Collins et al 2001b). It is calculated that a single *T salignus* ingests the photosynthetic product of 5-20 cm^2 of willow leaf per day (Mittler 1958). Collins et al (2001b) studied qualitative and quantitative features of shoots and reduced survival of infested trees. Collins et al (2001a) opined that introduction of relatively resistant clones in a mixed planting scheme has the potential to reduce the impact of *T salignus* on the host plant by means of reduced growth rate and reduced fecundity. Studies on Baspa and Beas basins by SASE and ISRO, on the environmental change at the higher altitude, indicates that the average temperature has increased from 6.2 to 8.4°C during 1977-2001. At the same time melting of glaciers and

run-off of the river water have increased (Kulkarni et al 2002).

Sharma and Sharma (2022) reported that willow trees were drying in the Lahaul region; above 80 per cent mortality was recorded which was continuously increasing. Sharma et al (2011) reported large scale willow mortality ranging from 2 to 93.8 per cent in Lahaul sub-division of Himachal Pradesh. Chakrabarti et al (2005) recorded the outbreak of giant willow aphid *T salignus* in the Lahaul valley and observed that aphid infestation varied from 40-100 per cent in four out of twelve villages where willow mortality was high.

Rawat et al (2006) studied detailed profile of willow plantation in Khoksar, Jahlma and Hinsa villages of Lahaul and Spiti. A striking observation was that only 30.0 ± 20.1 per cent trees were healthy; 55.2 ± 16.1 per cent had dried up and 14.8 ± 6.1 per cent were in drying condition due to a combination of pest infestation and infection. The use of willows to mitigate atmospheric CO_2 concentration is gaining popularity around the world (Riccioli et al 2020).

As per an estimate, willow growers experience about 50 per cent losses frequently due to insect pests (Hutchinson and Kearns 1930). It has been predicted that the severity of insect attack and productivity loss will further increase with global temperature rise and climate change (Klapwijk et al 2013, Skendžic et al 2021). Most of the researchers are of the opinion that environmental damage and pest-pathogen damage in the forest are quite different things. It has been suggested that mortality in different types of forests is due to various stress factors and no single factor is killing the tree but it is the total effect of several stresses. During the present investigations, field surveys were conducted to monitor the insect pest infestation on *Salix* species at six sites viz Lalung, Giu, Guling, Mud, Losar and Chichum in Spiti valley, Himachal Pradesh. Specimens of insect species were collected from *Salix* dominant areas of Spiti valley and preserved for further identification and taxonomic characterization. The study led to identification of 9 insect species with their extent of damage and occurrence in the field. Nine species of insects belonging to the orders Coleoptera, Lepidoptera, Hymenoptera and Diptera were identified. Two insect species viz *T salignus* and *Nematus pavidus* were found causing serious damage to willow trees in Spiti valley, Lahaul and Spiti, Himachal Pradesh.

MATERIAL and METHODS

Study area and climate

The Spiti valley, with a total area of 7,280 km^2 (31°35' to 33°0' N and 77°37' to 78°35' E) is a hyper-arid cold desert area with altitudes ranging from 3,350 to 6,700 m in the Indian trans-Himalayas of Himachal Pradesh. The region is characterized by extreme cold and xeric conditions, with low plant productivity in most parts of the landscape. Here the temperature ranges from –40° C in winters to 30° C in summer. Being a rain shadow region, the landscape is dry and the precipitation happens in the form of snow in winter. The vegetation is dominated by dry alpine steppe with gentle-rolling uplands interspersed with steep cliffs and rocky outcrops.

Sampling design

Sites in the moist and dry temperate and sub-alpine forest zones with willow inhabited forests were selected across the Spiti valley (Fig 1) and sampling surveys were carried out at these sites to assess the infestation of pests during pre-monsoon, monsoon and post-monsoon using an appropriate design. Insects were collected in the field and site details were recorded along with the life history of pests in the laboratory and in the field.

Surveys were conducted for the selection of suitable sites of willow populations prevailing in the Spiti valley. Study on the effect of pest incidences was carried out by assessing and monitoring the different affected plant parts. The life cycle and complete biology of the insect pests were studied.

Regular marked trials in all habitats of *Salix* were made during the night time, once every month (May to October). All moth species sighted were collected, identified and recorded. Identifications were confirmed using resources from various national museums and relevant literature. Since sampling efforts were unequal and all moths collected during each month were pooled together for analysis; only relative estimates of abundance were possible. Based on the relative abundance estimates, the collected moths were classified according to Rajasekhar (1992a, 1992b, 1995) as abundant: >30 per cent, very common: 20-30 per cent, common: 10-20 per cent, frequent: 5-10 per cent, occasional: 1-5 per cent and rare: <1 per cent.

The mean relative abundance values of all the counts in each habitat were calculated for the different

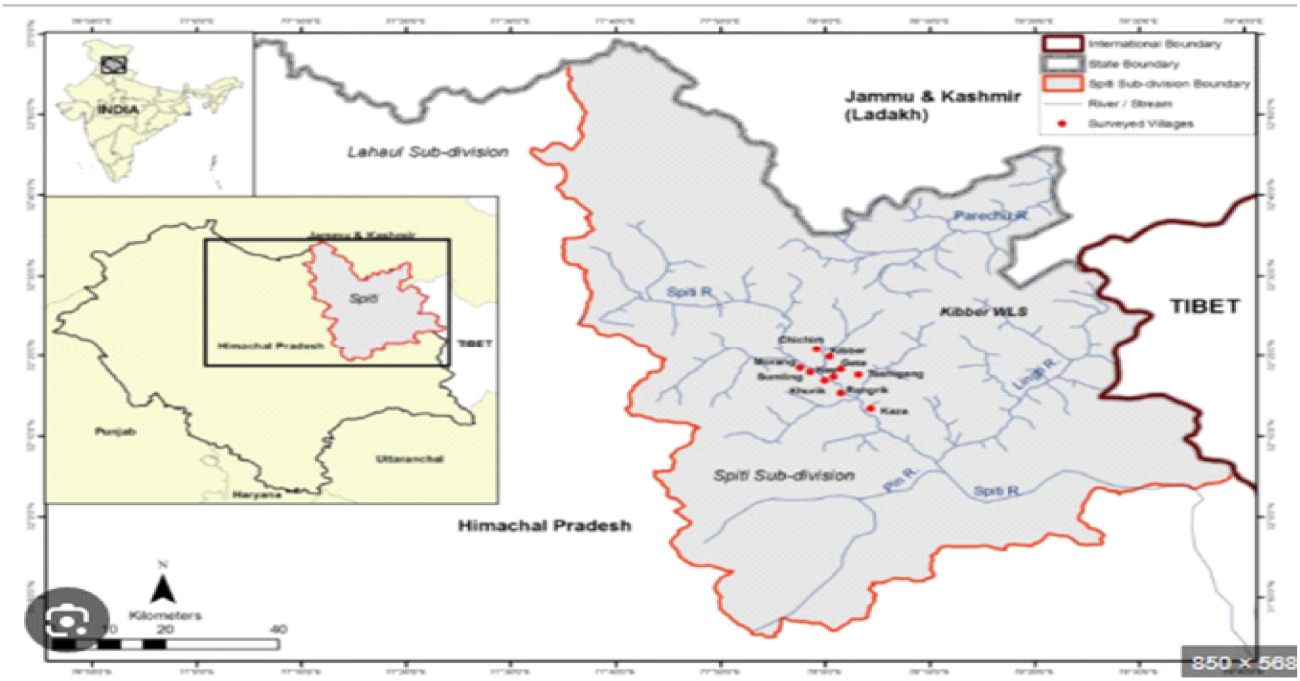

Fig 1. Study area

species in the four seasons. Differences between the means across the habitats were tested to determine any habitat preference by the moths.

Trap counts were made to monitor moth populations during May to October. Two sites were selected at each habitat. Each of the sites was visited at least once per month and all the moths observed were recorded site-wise. Moths were also collected for identification.

Chi-square analysis was carried out to assess the variation in the abundance of moths by taking the cumulative number of each species in each habitat. The beta diversity was estimated using similarity coefficients as a measure of how different or similar a range of habitats or samples were in terms of the variety of species found in them. Though several indices existed, the Jaccard index (Jaccard 1901) was used for the present study as follows:

$$Cj = j/(a + b - j)$$

where J = Number of species found at both the sites, a = Number of species at site a, b = Number of species at site b

This analysis answered two fundamental questions: what was the true species richness for the taxonomic group at the study site and what extra effort was required to bring the survey to some specified level of completeness. By applying the diversity index, species richness, species abundance and seasonal distribution were evaluated and the diversity index with progressive sampling was considered worth investigating to determine after what period diversity stabilized (Robinson and Tuck 1993).

RESULTS and DISCUSSION

The present investigations were conducted for five years from April 2019 to March 2024. Recently heavy buildup of different insect pests such as defoliators, sap suckers, stem borers etc has been noticed attacking and heavily infesting the plantations of *Salix* throughout the cold deserts of Indian Himalaya. Widespread mortality in willow in the cold deserts is matter of great concern, which had caused a lot of damage to ecology of the unique ecosystem and adversely affected the socio-economic status of local population in particular.

At each site, the infestation of different species of insect pests was observed on *Salix*. Study revealed that *Salix* trees were heavily infested by insects of the order Lepidoptera followed by Coleoptera, Hymenoptera, Hemiptera, Dermaptera and Orthoptera. Two insect species viz *T salignus* and *N pavidus* (Plates 1, 2) were identified causing serious damage to willow trees in the Spiti valley, Lahaul and Spiti, Himachal Pradesh.

Plate 1. *Nematus pavidus* resistant trial on willow in field

Plate 2. *Nematus pavidus* larvae attack on willow

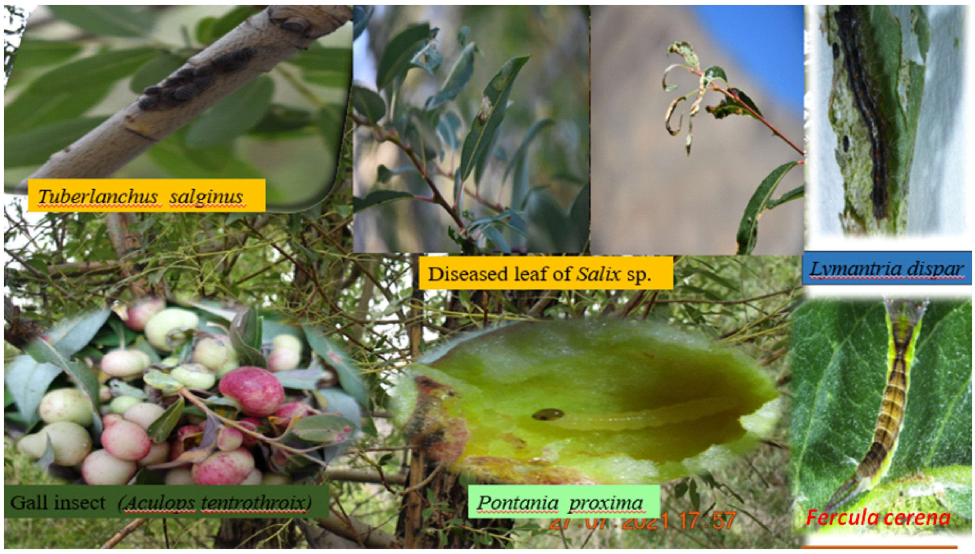

Plate 3. Invasion of insect pests on *Salix* sp

The field survey was conducted to monitor the insect pest infestation on *Salix* at different sites (Modh, Chichum, Lalung, Pohnallah, Tailing, Guiling and Rangreek) in Spiti valley, Himachal Pradesh. Attack of defoliators, sap suckers and gall forming insects was observed at the surveyed sites (Plate 3). The identified defoliators represented three orders viz Lepidoptera, (butterflies and moths), Coleoptera (leaf beetles) and Diptera (leaf miners). Attack of coleopteran *Aromia moschata, Lamia textor* and *Chrysomela populi* belonging to the families Chrysomelidae and Cerambycidae was very pronounced causing considerable damage to the tree. Among Lepidoptera, four species viz *Lymantria dispar* (Erebidae), *Cerura vinula* (Notodontidae), *Furcula cinerea* (Notodontidae) and *Lecoma salicis* (Erebidae) were the prominent defoliators. Their caterpillars were found feeding extensibly on catkin and leaves of *Salix*. It was found that leaf defoliators, gall insects and sap-sucking insects caused considerable damage to the *Salix* plants during different seasons and it needed to develop effective control plan against all these pests. Kumar et al (2022) recorded similar pattern of insect pest diversity in high-altitudinal transitional zones of the northwestern Himalayas, recording 32 species across six insect orders. Climate change and host shifts influenced pest diversity, with Coleoptera being the most dominant followed by Lepidoptera and Hemiptera.

Insect species were also collected from *Salix* inhabiting areas of Spiti and were preserved for further

identification and taxonomic characterization. Nine species of insects, belonging to the order Coleoptera, Lepidoptera, Hymenoptera and Diptera, were identified.

Heavy attack of saw fly, *N pavidus* (family Tenthredinidae) defoliating the willow was recorded at Giu (Spiti valley). Large number of larvae of the sawfly were found on fresh as well as old leaves, completely denuding the branches of trees and adversely affecting the growth of trees. The field survey was conducted to monitor the insect pest infestation on *Salix* at different sites (Modh, Chichum, Lalung, Pohnallah, Tailing, Guiling and Rangreek) in Spiti valley, Himachal Pradesh.

It was found that a number of insect pest species were attacking different parts of the trees. Among these insects, defoliators and sap suckers were most prevalent feeding on *Salix*. The most prominent insect defoliators attacking the *Salix* were gall insect (*Pontania proxima* and *Aculops tetanothrix*). It was also found that sap-sucking insect species (*T salignus* and *Cavariella aegopodii*), belonging to the order Hemiptera, were causing considerable damage to the trees.

Attack of coleopterans, *Aromia moschata* (Cerambycidae), *Lamia textor* (Cerambycidae) and *Chrysomela populi* (Chrysomelidae) was also high. They are most prominent insect pests of *Salix* and also its defoliators.

The caterpillars of Lepidoptera, *Lymantria dispar* (Erebidae), *Cerura vinula* (Notodontidae), *Fercula cerena* (Notodontidae) and *Lecoma salicis* (Erebidae) fed on catkin and leaves of *Salix*.

Biological control of aphid (*T salignus)* was carried out under the laboratory conditions. Their eggs, nymphs and adults were reared. Lady bird beetles (*Coccinella undecimpunctata*) were predatory in behaviour. Their cultures were maintained in laboratory and their feeding behaviours were recorded. In their life cycles, 80-90 aphids were consumed by lady bird beetles.

Field investigation studies revealed that maximum population of gall insect build up was during the period from July to August with maximum temperature 17.2°C and minimum 15.5°C and maximum humidity 37.6 per cent and minimum 30.0 per cent.

At Giu, lepidopteran caterpillar infestation was maximum recorded from June to September with maximum temperature 19.4°C and minimum 12.3°C and maximum humidity 40.2 per cent and minimum 25.8 per cent.

Insect species *L dispar* (defoliator) and *F cerena* were found extensively feeding on the leaves of *Salix*. Immature stages like eggs, larvae and pupae and adults of these species were also collected. Other insect species like aphids, beetles and dipteran flies were also collected from *Salix* inhabiting areas of Spiti. These insects were noticed attacking different parts of the plant. These insects were preserved for taxonomic characterization and for their permanent storage.

Tailing and Lalung areas appeared to have consistently higher pest populations compared to others. Certain locations, such as Gulling and Chicham, showed relatively lower pest counts as shown in Fig 1.

Table 1 shows 9 insect species seriously damaging *Salix* viz *Aromia moschata, Lamia textor, Chrysomela populi, Lymantria dispar, Cerura vinula, Fercula cerena, Lecoma salicis, Tuberolachnus salignus* and *Nematus pavidus*. Out of these 9 insect species, 2 insect pests (*T salignus* and *N pavidus*) were found damaging *Salix* and they were collected and their cultures were maintained in the laboratory for further studies.

Yasaman et al (2017) studied pest species richness on *S alba* L var *alba* in five watersheds of West Azerbaijan, Iran and identified 21 pest species. Kirichenko et al (2018) also studied leaf-mining insects on *Salix* and *Populus* in Siberia, identifying 50 species (24 Lepidoptera, 15 Coleoptera, 6 Diptera and 5 Hymenoptera). Eight species could cause outbreaks in urban and natural areas. Most species overlapped with central and eastern Europe, highlighting faunal similarities and the value of integrative research.

According to Rawat et al (2006), *S fragilis*, a key agroforestry tree in Lahaul valley, is under severe pest attack, threatening its survival. To sustain cultivation, introducing resilient willow varieties from similar Himalayan regions is recommended.

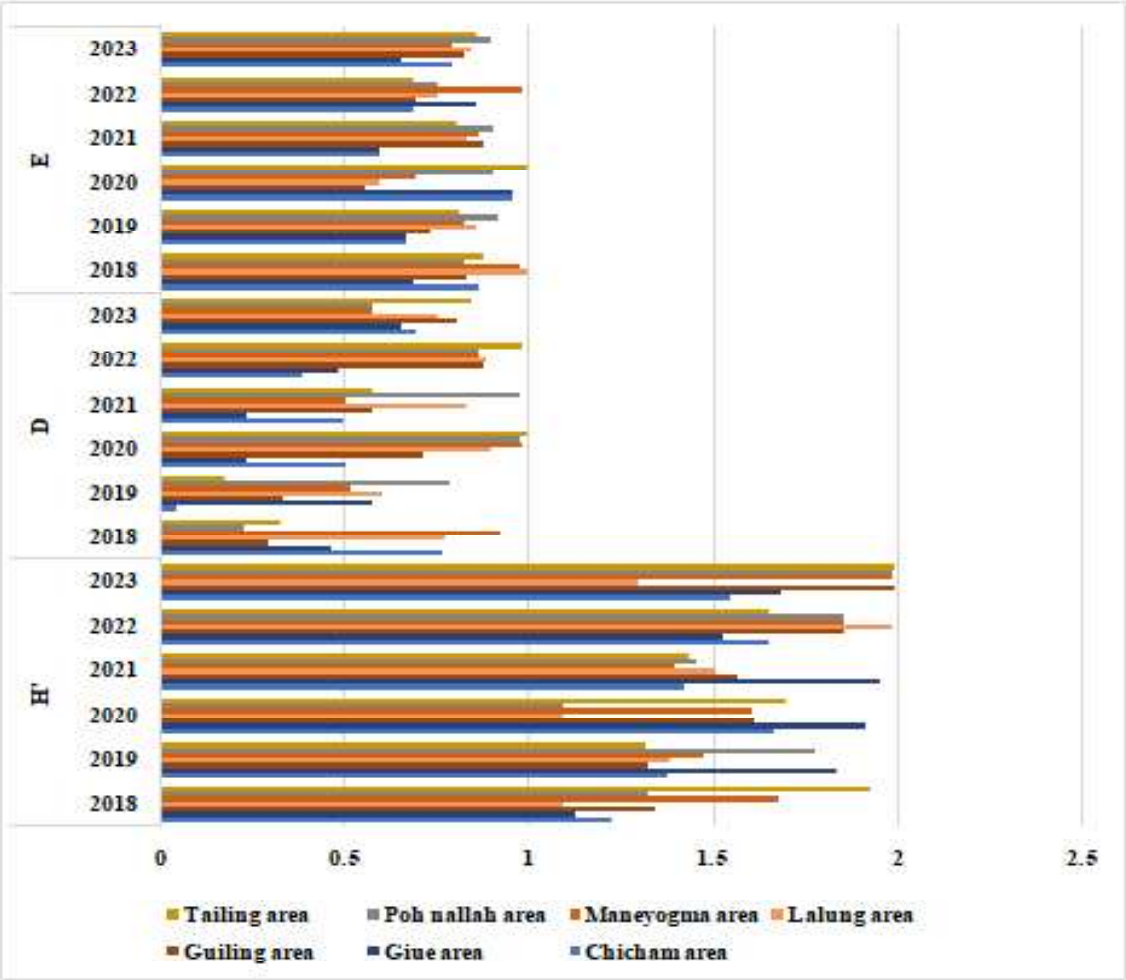

Fig 1. Population dynamics of insect pests of *Salix* sp at seven sites of Spiti valley (2018-2023)

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Table1. List of identified insects (2017-2023)

Order	Family	Insect pest	Pest status						
			Chichum	Giu	Guiling	Lalung	Maneyogma	Poh Nallah	Tailing
2017-2018									
Colepoptera	Cerambycidae	*Aromia moschata*	+	+	+	+	+	+	
Colepoptera	Cerambycidae	*Lamia textor*	+	+	+	+			+
Colepoptera	Chrysomelidae	*Chrysomela populi*	+		+	+	+		
Lepidoptera	Erebidae	*Lymantria dispar*	+	+	+		+	+	+
Lepidoptera	Notodontidae	*Cerura vinula*		+	+		+	+	+
Lepidoptera	Notodontidae	*Furcula cinerea*	+		+	+	+	+	+
Lepidoptera	Erebidae	*Lecoma salicis*		+	+	+	+		
Hemiptera	Aphididae	*Tuberolachnus salignus*	+	+	+		+	+	+
Hymenoptera	Tenthredinidae	*Nematus pavidus*	+	+	+	+	+	+	
2018-2019									
Colepoptera	Cerambycidae	*Aromia moschata*		+	+	+	+	+	
Colepoptera	Cerambycidae	*Lamia textor*	+	+	+	+		+	+
Colepoptera	Chrysomelidae	*Chrysomela populi*	+		+	+	+	+	
Lepidoptera	Erebidae	*Lymantria dispar*	+	+	+		+	+	+
Lepidoptera	Notodontidae	*Cerura vinula*		+	+		+	+	
Lepidoptera	Notodontidae	*Furcula cinerea*	+		+	+	+		+
Lepidoptera	Erebidae	*Lecoma salicis*		+	+	+			
Hemiptera	Aphididae	*Tuberolachnus salignus*	+	+	+		+	+	+
Hymenoptera	Tenthredinidae	*Nematus pavidus*	+	+	+	+	+	+	
2019-2020									
Colepoptera	Cerambycidae	*Aromia moschata*	+	+	+	+	+	+	
Colepoptera	Cerambycidae	*Lamia textor*	+	+	+	+		+	+
Colepoptera	Chrysomelidae	*Chrysomela populi*	+		+	+	+	+	
Lepidoptera	Erebidae	*Lymantria dispar*	+	+	+		+	+	+
Lepidoptera	Notodontidae	*Cerura vinula*		+	+		+	+	+
Lepidoptera	Notodontidae	*Furcula cinerea*	+		+	+	+	+	+
Lepidoptera	Erebidae	*Lecoma salicis*		+	+	+	+		
Hemiptera	Aphididae	*Tuberolachnus salignus*	+	+	+		+	+	+
Hymenoptera	Tenthredinidae	*Nematus pavidus*	+	+	+	+	+	+	
2020-2021									
Colepoptera	Cerambycidae	*Aromia moschata*		+	+	+	+	+	+
Colepoptera	Cerambycidae	*Lamia textor*	+	+	+	+		+	+
Colepoptera	Chrysomelidae	*Chrysomela populi*	+		+	+	+		
Lepidoptera	Erebidae	*Lymantria dispar*	+	+	+		+	+	+
Lepidoptera	Notodontidae	*Cerura vinula*		+	+		+	+	+
Lepidoptera	Notodontidae	*Furcula cinerea*	+		+	+	+		+
Lepidoptera	Erebidae	*Lecoma salicis*		+	+	+			
Hemiptera	Aphididae	*Tuberolachnus salignus*	+	+	+		+	+	+
Hymenoptera	Tenthredinidae	*Nematus pavidus*	+	+	+	+	+	+	
2021-2022									
Colepoptera	Cerambycidae	*Aromia moschata*		+	+	+	+	+	
Colepoptera	Cerambycidae	*Lamia textor*	+	+	+	+		+	+
Colepoptera	Chrysomelidae	*Chrysomela populi*	+		+	+	+	+	
Lepidoptera	Erebidae	*Lymantria dispar*	+	+	+		+	+	+
Lepidoptera	Notodontidae	*Cerura vinula*		+	+		+	+	+
Lepidoptera	Notodontidae	*Furcula cinerea*	+		+	+	+		+
Lepidoptera	Erebidae	*Lecoma salicis*	+	+	+	+			
Hemiptera	Aphididae	*Tuberolachnus salignus*	+	+	+		+	+	+
Hymenoptera	Tenthredinidae	*Nematus pavidus*	+	+	+	+	+	+	
2022-2023									
Colepoptera	Cerambycidae	*Aromia moschata*	+	+	+	+	+	+	
Colepoptera	Cerambycidae	*Lamia textor*	+	+	+	+	+	+	+
Colepoptera	Chrysomelidae	*Chrysomela populi*	+		+	+	+		
Lepidoptera	Erebidae	*Lymantria dispar*	+	+	+		+	+	+
Lepidoptera	Notodontidae	*Cerura vinula*		+	+		+	+	
Lepidoptera	Notodontidae	*Furcula cinerea*	+		+	+	+		+
Lepidoptera	Erebidae	*Lecoma salicis*		+	+	+	+		
Hemiptera	Aphididae	*Tuberolachnus salignus*	+	+	+		+	+	+
Hymenoptera	Tenthredinidae	*Nematus pavidus*	+	+	+	+	+	+	

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