Possibilities of the use of entomopathogenous viruses to control the multiplying of the nun moth (*Lymantria monacha L.*) and the pine looper (*Bupalus piniarius L.*) in the coniferous forests of Latvia

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Abstract

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Methods of rearing the larvae of the nun moth (*Lymantria monacha L.*) and the pine looper (*Bupalus piniarius L.*) on artificial media in the laboratory have been elaborated to obtain virus material. Nuclear polyhedrosis viruses (NPVs) have been isolated from natural populations of *Lymantria monacha* and *Bupalus piniarius.* Highly virulent experimental strains of the viruses suitable for producing virusinsecticides have been obtained in the laboratory. The activity of the isolated NPVs was tested in natural pests' populations and compared with the activity of bacterial biopreparations. NPVs proved to be much more active than bacterial biopreparations.

Key words: *Lymantria monacha, Bupalus piniarius,* nucleopolyhedrovirus, mass multiplying, virusinsecticides, biological control.

Introduction

In Latvia's climatic conditions, the larvae of the nun moth (*Lymantria monacha L.*) hatch at the end of April/beginning of May. They feed on the young, more rarely on the old needles of spruces and pines. The development of the larvae takes on the average 52 days. Pupation takes place behind the scales of pine bark, in the bark of spruces and pines, and at the base of forked branches. Developmental period of the pupae continues for 8-14 days. Imagoes fly out in July, August and live for 10-14 days. Eggs are laid on the trunks into bark cracks; there are 20-50 eggs per laying.

In Latvia, mass multiplying of the pest has been recorded in 1995 and 1996 - in the districts of Riga, Jelgava and Tukums; in 1997 and 1998 - in the districts of Tukums, Ventspils and Liepāja.

The pine looper *(Bupalus piniarius L.)* is an important pest of conifers in our geographical region; mass multiplying of it takes place periodically. From 1978 to 1980, mass multiplying was observed in several areas of the forestries of Jūrmala, Talsi and

Kuldīga; numbers of eggs reached on the average 8000-9000 per tree (age classes III and IV), what later caused almost 100 % defoliation of the trees. Significant damage to forestry was done by this pest also in 1982 and 1983 in the forests at Ventspils, Strenči, etc. High density of the pest was recorded in 1992-1995 in the forestries of Jūrmala, Talsi, Ventspils, Dundaga, Ugāle, etc. The area infested exceeded 40,000 ha. In Latvia, the outburst of the pest's multiplying usually continues at least 5 years. During the multiplication period, great damage is done also to spruce stands. At high densities of the pest, the trees wither on a mass scale (25-35 % under our conditions); increased multiplication of wood pests takes place in the weakened trees.

The growth of wood of the trees highly infested with *Bupalus piniarius* decreases by 40-50%. When 90 % defoliation occurs, the growth of wood on the 1st year is close to 0, but on the 2nd year it does not exceed 20 %. Partial recovering of needles is observable on the 2nd year to 65 % of the trees, which have suffered from 40-50 % defoliation. On the trees with comparably little loss of needles (10-15 %), normal growth of wood is usually observed only after 2 years. The loss of wood in 12 years has been estimated to reach 20 % in moderately infested forest stands, and up to 45 % - in highly infested ones (reports of the Ministry of Forestry).

Today we have synthetic, fast-acting, highly active preparations in sufficient quantity. Usually, they are of pyretroid-type with some modifications of the cyano-group; sometimes they contain Cr, Br or F. Unfortunately, these chemical insecticides are not selective, that is, they destroy together with pests all the beneficial entomofauna- predators and parasites, plant pollinators, and also make negative influence on birds and mammals. That drives to comparably quick recovering of the pest population. Therefore, wide use of the chemical preparations is limited under the conditions of Latvia. Chemicals must not be applied near natural water resources, populated areas, etc. (at least at the distance of 2 km).

An alternative would be in the use of biological plant protection means including microbial preparations, which are much more rational. These preparations are elaborated on the basis of *Bacillus thuringiensis*, different baculoviruses, etc., and their action is more or less selective- only those insect species become infected which feed on needles (the infection goes through the digestive tract). As a result, the preparations are not dangerous for the beneficial fauna.

In the present study, we set the main task in evaluating the possibilities of the use of several microbial preparations against *Lymantria monacha* and *Bupalus piniarius* under Latvia's conditions.

Several microbiopreparations have been elaborated on the basis of selected entomopathogenous bacteria: gomelin, lepidocide, bitoxibacilline (BTB), etc. At the same time there is very scanty information about the existence of entomopathogenous viruses in the local populations of *Lymantria monacha* and *Bupalus piniarius*. For that reason we made studies to ascertain the presence of such viruses in the populations of both species.

Material and methods

The entomological material- larvae of *Lymantria monacha* and *Bupalus piniarius* were collected in different forest sites of Latvia. The insects at all developmental stages were

reared in the laboratory- in isolators feeding on fresh natural food (branches of conifers) and on artificial semi-synthetic media (different modifications). The capacity of the isolators was 250 cm^3; 50-200 larvae were placed in each isolator depending on the stage of their development. 18-h daylight was maintained, the average temperature was 15-20^0 C for the 1st and 2nd instar larvae, and 23-25^0 C for instars 3rd to 6th.

The pupae and imagoes were reared in similar conditions with slightly higher relative air humidity (70-85 %).

The imagoes were held in 250 cm^3 isolators, 20-30 imagoes in each isolator, maintaining the sexual ratio of 1:1.

All necessary conditions were provided for laying eggs; fresh pine bark was used with appropriate surface structure. To re-activate the eggs, they were treated with changeable air temperature, increasing it gradually from +10% to +17%. The eggs in diapause, which were located in bark cracks, were stored in capron boxes at a low temperature (+4 - +10^0 C) and relative air humidity of 75-85 %.

The composition of the semi-synthetic medium for rearing *Lymantria monacha* in the laboratory:

beer yeast	5.0 g	ascorbic acid	0.8 g
flour of kidney beans	15.0 g	metaben	0.5 g
cuttings of sunflower seeds	15.0 g	agar agar	4.0 g
fish meal	1.5 g	formaldehyde (40 %)	0.5 g
sprouts of barley	20.0 g	ethanol	5.0 ml
sucrose	4.0 g	distilled water	250 ml

The composition of the semi-synthetic medium for rearing *Bupalus piniarius* in the laboratory:

Modification I

swollen flour of kidney beans	200.0 g	formaldehyde (40 %)	4.5 ml
agar-agar	15.0 g	metaben	3.0 g
fodder yeast	15.0 g	KOH (4 mol)	13.7 ml
sucrose	12.0 g	phosphorous acidic potassium (II)	4.0 g
lignin (powdered)	8.0 g	distilled water	250 ml
ascorbic acid	4.0 g		

Modification II

cuttings of sugar-beets	36.0 g	ascorbic acid	4.2 mg
beer yeast	20.0 g	linseed oil	1.5 ml
sucrose	9.0 g	folic acid	10.0 mg
agar-agar	8.0 g	choline-chloride	1.5 ml
flour of kidney beans	5.5 g	metaben	2.0 g
casein	14.0 g	phosphorous acidic potassium (II)	2.0 g
extract of sprouts of barley	14.0 g	distilled water	250 ml

When virus material was being obtained, no disinfectant ingredients of the medium (formaldehyde, metaben, KOH, phosphorous acidic potassium (II), ethanol) were added.

Before incubation, the eggs were protected from possible sources of infections by treating them with 1 % solution of NaOH for 1-2 min, then followed by rinsing in water for 10-15 min.

To activate latent virus infection, we subjected the larvae of *Lymantria monacha* and *Bupalus piniarius* to following stress-factors:

- biological - by contaminating the larvae with non-specific viruses (NPVs of *Operophthera brumata* L., *Orgyia antiqua* L., *Neodiprion sertifer* Geoffr.) or by feeding the larvae during all their developmental cycle on inadequate food (dried-off needles of pines and spruces, needles of junipers);
- physical - by subjecting the larvae to extreme temperatures (16-24 hours at +4 - +6^{0}C, then at +28 - +35^{0}C);
- chemical - the food (natural and semi-synthetic) was treated with 0.5 % $ZnSO_4$, 1.0 % H_3BO_3, and 0.3 % $NaNO_2$.

To identify viral inclusion bodies, a MBI-11 light microscope and a Tesla BS-242 electron microscope were used. To isolate viruses from the larvae, methods of fermenting, filtering, and centrifuging (20-30 min at 5500 r.p.m.) were applied. The isolated virus material was repeatedly subjected to a passage through host organism under environmental conditions, which were close to extreme. As a result, after 4-7 generations we obtained new experimental virus strains with increased virulence.

In the laboratory, virulent properties were ascertained of both the viruses isolated from natural insect populations and the obtained "experimental" virus strains. The activity of the viral preparations elaborated was compared with that of commercial bacteriological preparations - dry powders of gomelin 90SP, lepidocide 100, bitoxibacilline (BTB) 45. Preliminary research has been done also with the liquid bacterial preparation Forei 48V (made by the Danish firm "Novo-Nordisk"), which acts hormonally and inhibits the formation of insect chitin. All the mentioned biopreparations act through the digestive tract, are selective and therefore practically harmless to the environment. The bacterial preparations used in the experiments were received from the Byelorussian Research Institute of Forestry.

In field tests, each experimental variant consisted of 3-4 replicas and a control. The area covered by each replica was 250 m^2 (25x10 m). A backpack air-blast sprayer (Yanmar, Japan) was used to treat tree stands; expenditure of the working suspension was on the average 50 l/ha. All dead and alive larvae were counted visually on model-trees every third day after the treatment. Causes of the death of the larvae were ascertained in the laboratory. The larvae were gathered by shaking trees; the larvae fell on polyethylene sheets spread out under the trees. The influence of the virus and bacterial preparations was investigated simultaneously also in the laboratory.

The whole experimental work was performed from 1992 to 1997.

Results and discussion

Methods of growing the larvae of *Lymantria monacha* and *Bupalus piniarius* on the artificial semi-synthetic media had to be elaborated to make laboratory researches on them. Several modifications of the media have been tested, the best ones being those described in the "material and methods" chapter. The best development of the 1st and 2nd instar larvae of *Bupalus piniarius* was observed on the medium of modification I, but, beginning with the 3rd instar, the best feeding of the larvae was observed on the medium of modification II. Survival rate of the larvae reached usually 72-75 %, their development continued for 56-68 days, but the number of eggs per laying varied from 20 to 38. As regards the larvae reared under similar conditions on natural food, their recorded survival rate was about 5 % lower, but the number of laid eggs slightly (for about 30) higher, and the physiological condition of the eggs was also better (tab. 1).

Table 1
Survival and fecundity of *Lymantria monacha* and *Bupalus piniarius* reared on natural and semi-synthetic media

Insect species	Food	Survival rate of larvae, %	Length of development, days	Weight of pupae, mg		Mean number of eggs per laying
				♀	♂	
Lymantria monacha	natural food - fresh branches of conifers	68.8± 1.75	51-54	-	-	43-51
-"-	artificial medium, modification I	75.3± 2.20	56-60	-	-	30-38
- "-	artificial medium, modification II	72.7± 2.35	59-68	-	-	20-29
Bupalus piniarius	natural food - fresh branches of conifers	71.3± 1.50	55-65	1225.3 ± 10.80	467.0 ± 7.05	200-220
-"-	artificial medium	78.8± 1.85	63-72	1060.5 ± 8.35	516.5 ± 9.15	170-190

The survival rate of the larvae of *Lymantria monacha* reared on the semi-synthetic medium reached 78.8 %, the mean number of eggs obtained from each female was 180. The survival rate of the larvae reared on natural food was lower for 7-8 %, but the number of eggs obtained - higher for about 30 (tab. 1).

The fact that the number of the larvae reared on artificial media is slightly higher than that of using natural food may be explainable by insufficient sterility of the natural food leading to the occurrence of different infestations (fungal, etc.) despite of immediate isolation of infested specimens. Fecundity of the butterflies reared on the natural food was somewhat higher.

In natural populations of both pests of conifers, dying of some larvae as a result of virus infection can be observed quite often. Investigations of several researchers testify that in such cases the population contains the virus infection in latent form, which can activate under appropriate conditions, unfavorable to pest development, and cause the dying of larvae (Krieg, 1973, Lautenschlager, Podgwaite, 1997). Considering this, we tried to activate experimentally the latent virus infection within the larvae investigated by using the stressing factors mentioned in methods. Table 2 shows the results obtained. Apparently, to isolate a NPV virus, the most effective was the adding of boric acid to the food, as well as thermal treatment of the larvae and the use of partially inadequate food.

To improve virulent properties of the isolates of NPV viruses obtained, several passages of the viruses through the insects of the laboratory populations of both pests were performed under appropriate extreme conditions. It resulted in obtaining "experimental" virus strains with increased virulence. Samples of virus preparations were made on the basis of these new virus strains. The activity of the preparations was at first estimated in the laboratory on the semi-synthetic media, simultaneously determining the mortality of the larvae (and also pupae) at different stages of their development. As table 3 shows, the lethality of *Lymantria monacha* reaches 80-92 %, while that of *Bupalus piniarius*- 68 %. It must be noted that NPVs of *Lymantria monacha* and *Bupalus piniarius* have been isolated for the first time from the populations found in Latvia, and "experimental" virus strains have also been obtained suitable for the production of virus preparations.

It is important to estimate the "right' moment of transferring entomopathogenous viruses into a pest population to reach the maximal efficiency and stimulate the spreading and remaining of the viruses in a biocenosis. The remaining of the virus causing an infection in the pest population regulates the multiplication rate of the pest also in subsequent (at least 3) generations. That is a difference between biological and chemical treatments. To check this, we have made researches for several years in the forest stands at Dundaga, Ugāle, Talsi, Liepāja, Riga. Entomopathogenous viruses were transferred into pest populations at the pre-phase of their mass multiplying, at the "eruptive" phase (when density of the pest reaches maximum), at the "weakening" phase, and the phase of minimal pest density. The results obtained are summarized in table 4. Evidently, the pests have been most susceptible to the virus infection at the "eruptive" phase- at the beginning of mass multiplying, and partially at the phase of depression, when the density was low. At the last phase, the virus infection turns to latent form without causing mass scale mortality of the pests. Viruses transferred artificially into populations of *Lymantria monacha* can cause an epizooty and the mortality of the pest's larvae can reach 83 %, but in populations of *Bupalus piniarius*- up to 64 %. The mortality of the pest's pupae varies between 27-45 %.

It must be noted that at the phase of pest's mass multiplying other entomopathogens and entomophagues also activate significantly (the fungus *Beauveria bassiana*- mainly on the pupae).

Table 2
Activation of the latent virus infections of *Lymantria monacha* and *Bupalus piniarius* using different stress-factors

Insect species	Stress-factor	Instar of larvae	Lethality of larvae, %	Amount of contaminated larvae, %	Amount of pupated larvae, %
Lymantria	Viruses from:				
monacha	*Orgyia antiqua*	I-II	61.0±2.20	32.7±1.28	39.0±3.87
	-"-	III-IV	42.5±3.00	40.0±4.02	57.5±3.60
-"-	*Neodiprion sertifer*	I-II	50.8±3.27	22.7±0.20	49.2±3.27
-"-	-"-	III-IV	38.5±2.30	32.2±1.35	61.5±2.20
-"-	*Operophthera brumata*	II-III	39.7±4.02	28.5±1.29	60.3±2.20
-"-	Inadequate food	II-V	44.5±3.90	40.0±4.00	55.5±3.47
-"-	Extreme temperatures:	II-III	73.2±2.15	65.7±1.50	34.3±1.35
-"-	+4+35°C	III-IV	67.3±1.80	51.2±2.23	32.7±1.75
	Chemical additives to food:				
-"-	0.5 % $ZnSO_4$	II-V	60.8±1.86	37.2±1.50	39.2±1.45
-"-	1.0 % H_3BO_3	II-V	67.4±1.75	60.8±1.87	32.6±1.29
-"-	0.3 % $NaNO_2$	II-V	54.3±3.20	42.2±1.60	45.7±2.25
-"-	Controls	I-V	12.3±0.63	1.5±0.02	87.7±5.30
Bupalus	Viruses from:				
piniarius	*Lymantria monacha*	I-II	37.7±1.45	30.0±1.28	62.3±2.20
-"-	-"-	III-IV	29.3±1.20	21.7±0.75	70.0±2.10
-"-	*Orgyia antiqua*	I-II	44.2±1.75	29.8±1.30	55.8±3.10
-"-	-"-	III-IV	35.3±1.35	27.9±1.46	64.7±1.62
-"-	*Neodiprion sertifer*	I-II	43.2±1.75	32.3±1.29	56.8±3.12
-"-	-"-	III-IV	30.0±1.25	12.5±1.20	70.0±2.10
-"-	Inadequate food	II-V	45.3±3.29	23.7±1.20	76.3±4.00
-"-	Extreme temperatures:	II-III	74.2±2.15	38.8±1.50	25.8±1.20
-"-	+4+35°C	III-IV	51.5±3.27	44.2±1.80	48.5±3.27
	Chemical additives to food:				
-"-	0.5 % $ZnSO_4$	II-V	54.8±2.25	30.2±1.25	45.2±4.01
-"-	1.0 % H_3BO_3	II-V	51.7±3.27	27.7±1.35	48.3±2.35
-"-	0.3 % $NaNO_2$	II-V	63.4±2.62	45.5±2.00	36.6±1.20
-"-	Controls	I-V	17.0±0.70	2.3±0.03	83.0±5.02

Table 3
Activity of the experimental strains of NPVs of *Lymantria monacha* and *Bupalus piniarius* (laboratory tests on artificial media)

Insect species	Variants	Lethality of larvae caused by virus infection at different stages of larval development, %					Total lethality of larvae caused by virus infection, %	Lethality of pupae caused by virus infection , %	Total lethality of insects caused by virus infection, %
		I	II	III	IV	V			
Lymantria monacha	Artificial media: modification I	3.5	9.2	16.6	26.2	20.3	75.8 ± 2.45	16.5 ± 1.52	92.3 ± 4.80
-"-	modification II	2.8	8.3	23.5	19.2	14.0	67.8 ± 2.32	12.7 ± 0.45	80.5 ± 5.20
	virus-free controls	-	-	1.0	2.1	-	3.1 ± 0.20	5.3 ± 0.08	8.4 ± 0.47
Bupalus piniarius	Artificial medium	-	4.5	12.8	18.7	13.6	49.6 ± 3.56	18.7 ± 1.25	68.3 ± 2.65
	virus-free controls	-	-	2.5	5.0	-	7.5 ± 0.38	4.5 ± 0.12	11.5 ± 0.78

Field trials were carried out to compare the activity of the newly elaborated virus insecticides with that of some other biological preparations used against *Lymantria monacha* and *Bupalus piniarius* in Latvia.

Bacterial preparations lepidocide and bitoxibacilline (BTB) are more universal in use- they can be applied against different nibbling agricultural pests. Nevertheless, their action is based on endotoxins, therefore they may be classified also as insecticides of somewhat chemical nature. Gomelin is a perspective preparation in forest protection. It contains selected strains of bacteria and is hardy to phytoncids excreted by conifers.

The results of the trials in Table 5 show that the efficiency of the virus insecticides in both variants is somewhat higher than that of using other biopreparations. The NPV of *Lymantria monacha* turned out to be more active for about 15 % than the virus of *Bupalus piniarius*. The least activity was recorded for lepidocide, BTB and Forei. It is possible that these preparations, especially Forei, can be used successfully together with virus insecticides, thus increasing their efficiency and shortening the time of action. To examine this, researches have to be made.

The development of virus infections continues 6-9 days depending on environmental conditions (air temperature, developmental stage of the larvae, etc.); bacterial infections develop in 4-8 days. Maximum mortality of the larvae is observable on the 12^{th}-18^{th} day after the beginning of the infection. These results of the struggle against *Lymantria monacha* using entomopathogenous viruses are similar with the efficiency of the viruses presented by B.Clowacka-Pilot (1983).

The influence of virus infections is expressed at all developmental stages of insects, and the infection can also pass to subsequent generations through eggs, thus limiting the multiplying of pests (Table 3).

Table 4

Mortality of *Lymantria monacha* and *Bupalus piniarius* in natural populations after the application of NPVs at different phases of the pests' multiplication

Insect species	Phases of pests' multiplication	Moment of virus transfer into pest population (stage of pest's development)	Percentage of dead larvae, %	
			from virus infection	from other entomopathogens
Lymantria monacha	pre-phase of pest's mass multiplication (1-3 generations)	eggs larvae (II-III instar) controls	39.7 ±4.00 36.5 ± 2.30 0.5 ± 0.02	10.0 ±0.23 9.7 ± 0.34 16.3 ± 0.39
-"-	"eruptive" phase– maximal density of pests (1-2 generations)	eggs larvae (II-III instar) controls	82.7 ± 3.02 79.5 ± 5.20 7.5 ± 0.40	13.0 ± 0.90 9.5 ± 0.58 30.0 ± 1.28
-"-	"weakening" phase- (1-2 generations)	eggs larvae (II-III instar) controls	75.5 ± 2.20 69.9 ± 2.10 2.3 ± 0.09	13.3 ± 0.68 1.5 ± 0.76 25.2 ± 1.10
-"-	"depression" phase- minimal density of pests (2-4 generations)	eggs larvae (II-III instar) controls	70.3 ±2.14 62.5 ± 2.23 10.0 ± 0.15	15.2 ± 0.89 12.0 ± 0.72 27.4 ± 1.37
Bupalus piniarius	pre-phase of pest's mass multiplication (1-3 generations)	eggs larvae (I-III instar) controls	15.9 ± 1.02 21.5 ± 1.12 0.3 ± 0.02	14.0 ± 0.72 10.7 ± 0.35 17.6 ± 0.85
-"-	"eruptive" phase - maximal density of pests (1-2 generations)	eggs larvae (I-III instar) controls	45.8 ± 1.80 47.2 ± 3.20 2.7 ± 0.30	15.3 ± 0.94 13.7 ± 0.78 19.2 ± 1.21
-"-	"weakening" phase - (1-2 generations)	eggs larvae (I-III instar) controls	63.8 ± 2.21 58.4 ± 3.10 6.5 ± 0.32	12.0 ± 0.70 7.5 ± 0.46 25.0 ± 1.40
-"-	"depression" phase - minimal density of pests (3-5 generations)	eggs larvae (I-III instar) controls	59.3 ± 2.23 61.5 ± 2.18 9.0 ± 0.42	16.0 ± 0.67 19.0 ± 1.08 27.5 ± 1.37

Table 5
Comparison of the activity of NPVs and bacterial biopreparations used against *Lymantria monacha* and *Bupalus piniarius*

Insect species	Biopreparation	Titre of working solution	Technical efficiency, %
Lymantria monacha	Virus preparation ($1 \cdot 10^7$ pol/ml)	$2.0 \cdot 10^{11}$ pol/ha	86.8 ± 4.45
	Gomelin - 90SP	3.0 kg/ha	73.5 ± 5.00
	Lepidocide ($1 \cdot 10^{11}$ spores/g)	1.0 kg/ha	48.8 ±1.85
	Bitoxibacilline- BTB 45	2.0 kg/ha	59.3 ± 3.25
	Forei 48 V	3.0 kg/ha	45.8 ± 2.70
	Controls	-	5.7 ± 0.35
Bupalus piniarius	Virus preparation ($1 \cdot 10^7$ pol/ml)	$6.0 \cdot 10^{10}$ pol/ha	71.0 ± 3.47
	Gomelin - 90SP	2.5 kg/ha	67.4 ± 3.00
	Bitoxibacilline- BTB 45	2.0 kg/ha	51.3 ± 3.26
	Forei 48 V	3.0 kg/ha	45.3 ± 2.20
	Controls	-	11.3 ± 1.35

We consider virus preparations to be sufficiently effective and ecologically harmless means against mass multiplication of *Lymantria monacha* and *Bupalus piniarius* under the climatic conditions of Latvia; they can be used successfully instead of chemical insecticides.

Kopsavilkums

Latvijas Universitātes Bioloģijas institūta Eksperimentālās Entomoloģijas laboratorijā izstrādāta egļu mūķenes (*Lymantria monacha* L.) un priežu sprīžmeša (*Bupalus piniarius* L.) audzēšanas metodika laboratorijas apstākļos uz pussintētiskās barotnes vīrusu materiāla iegūšanai. No egļu mūķenes un priežu sprīžmeša vietējām populācijām izdalīti kodola poliedrozes vīrusi (KPV). Laboratorijas apstākļos iegūti to eksperimentālie celmi vīrusu insekticīdu izgatavošanai. Noteikta mākslīgi introducēto entomopatogēno vīrusu aktivitāte egļu mūķenes un priežu sprīžmeša populācijās atkarībā no kaitēkļu savairošanās fāzes; visaugstākā tā ir eruptīvajā fāzē. Salīdzināta vīrusu un baktēriju biopreparātu aktivitāte egļu mūķenes un priežu sprīžmeša apkarošanā Latvijas apstākļos. Egļu mūķenes kāpuru letalitāte sasniedz 87%, priežu sprīžmeša - 71%. Kaitēkļu bojāeja novērojama arī kūniņas fāzē. Bakterioloģisko preparātu aktivitāte ievērojami zemāka. Vīrusu infekciju attīstība ilgst 6-9, baktēriju- 4-8 dienas. Kāpuru mirstības maksimums novērojams no 12. līdz 18. dienai.

Vīrusu preparāti ir pietiekami efektīvi un ekoloģiski nekaitīgi cīņas līdzekļi egļu mūķenes un priežu sprīžmeša savairošanās regulēšanai Latvijas apstākļos.

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