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FOREST REVIEW

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THE HEALTH CONDITION OF CONIFEROUS FORESTS AND CULTURES IN R. MACEDONIA WITH A SPECIAL FOCUS ON INSECT PESTS

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ABSTRACT: In the conifer stands in the Republic of Macedonia the most damaging insects are detected in the pine stands. From the large number of identified pests in the last three decades, the most significant damages were done by the following species: *Thaumetopoea pityocampa* Den. et Schiff., *Neodiprion sertifer* Geoff., *Diprion pini* L., *Rhyacionia buoliana* Den. et Schiff., *Pissodes notatus* F., *Monochamus galloprovincialis* Ol. and the bark beetles (*Hylastes linearis* Erich., *Hylastes ater* Paik., *Tomicus minor* Hart., *Tomicus piniperda* L., *Pityogenes bidentatus* Hrbst. *Pityogenes bistridentatus* Eich., *Pityogenes quadridens* Hart., *Ips sexdentatus* Boern., *Ips acuminatus* Gyll., *Ips mansfeldi* Wach. and *Ortothomicus erosus* Boern.). The pine processionary moth in the pine stands in the R. of Macedonia has been in overpopulation on a regular intervals of 4 or 5 years. Such gradation of these species were registered in 1990, 1995, 2001 and 2010, when more than 20.000 ha of pine stands were attacked. In 2009 nearly 15.000 ha and 2010 - 19.100 ha showed very high population density, with serious threats for total defoliation and possibly destruction. According to our data, the number of caterpillar nests from the generation 2015/16 ranged from 700 in the locality Kalaslari-near Veles to 22.000 per 1ha in locality Crnilishki Rid- near Sveti Nikole. From 11 bark beetle species, *Ips sexdentatus* Boern. and *Ips acuminatus* Gyll. had the highest populations in the regions near Berovo, Strumica, Kavadarci, Kochani, Delchevo, and in the regions near Sveti Nikole - *Pityogenes bistridentatus* Eich. and Bitola- *Ips sexdentatus* Boern. *Ips acuminatus* Gyll. and *Tomicus minor* Hart. The abundance of the other pest insects: *Neodiprion sertifer* Geoff., *Diprion pini* L., *Rhyacionia buoliana* Den. et Schiff., *Pissodes notatus* F., *Monochamus galloprovincialis* Ol. and *Coleophora laricella* Hb. in natural and newly planted coniferous stands in the R. of Macedonia is low.
Keywords: insects, pine processionary moth, bark beetles, larch casebearer, defoliator, population dynamics.

1 INTRODUCTION

Conifer forests in the R. Macedonia are covering an area of 791162,89 ha, of which 70812,33 ha are pure and 8350,56 ha are mixed conifer forests. Also, there are 4175,30 ha of mixed conifer–broadleaved forests (Monograph of Macedonian Forests, 2008).

Since the fifties of the last century, when the intensive afforestation of bare land began, according to Dimitrov, until 1970 there were about 60,000 ha afforested through systematic permanent programes and in the period from 1971 to 1985 another 100,000 ha were afforested. *Pinus* spp. were the most frequently used species in these afforestation projects (accounting for 95% of seedlings planted) and *Pinus nigra* Arn. as a dominant species, often in monocultures. In that period, also were used other coniferous species on the individual sites but with much smaller percentage (*Pinus silvestris* L., *Larix europea* DC, *Picea abies* (L.) H. Karst., *Pinus strobus* L., *Pseudotsuga menziesii* (Mirb.) Franco and *Chamaecyparis lawsoniana* Parl).

Natural coniferous forests as stable ecosystems are less threatened by insect pests. However, due to certain disorders of abiotic nature as uprooting by wind (windthrow, windsnap) or snow, forest fires, conifer forests become more susceptible to bark beetles and in certain regions of the Republic Macedonia they are a serious threat to the coniferous stands [1,2,3,4,10,11,12,14,18].

As opposed to them, the newly created monocultures represent poor ecosystem that still has not established a biological balance, in which we have registered the appearance of many pests and plant diseases. The most commonly recorded species are *Thaumetopoea pityocampa* Den. et Schiff., *Neodiprion sertifer* Geoff., *Diprion pini* L., *Rhyacionia buoliana* Den. et Schiff., *Pissodes notatus* F., *Monochamus galloprovincialis* Ol. and the bark beetles (Curculionidae: *Solytinae*) [5,6,7,8,15,16,17].

2 MATERIAL AND METHODS

For the realization of this research we have used standard and adapted methods for the determination of the abundance of pine processionary moth, european pine sawfly, pine bark beetles, larch casebearer, also the intensity of the attack and the degree of the damage of the needles were assessed. This investigations were performed on the stationary experimental plots in natural and newly planted coniferous stands and also in the entomological laboratory of the Faculty of Forestry in Skopje.

For this reason we have selected stationary experimental plots with dimensions of 25x25m (625m^2) in which the elements mentioned above were monitored.

- On this test surface occurrence and density of the populations of the harmful insects are monitored.
- Abundance was determined by the number of nests per pine for the *Th. pityocampa,* number of larval colonies for the *N. sertifer*, and the registration of certain stages of the development for the bark beetles.
- The intensity of the attack and the degree of development of the larvae of *Th. pityocampa* and *N. sertifer* were also determined. Eggs of pine processionary moth were collected and brought to the entomological laboratory, at the Faculty of Forestry in Skopje, to determine the percentage of parasitization.

On the locations where was observed bark beetle attacks three trees were analyzed. Also, during the research we have conducted registration of the shoots damaged due to larval feeding (folded and dried shoots) from the caterpillars of *Rh. buoliana* damaged stems from *Pissodes notatus* and defoliation from the larch moth.

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3 RESULTS AND DISCUSSION

3.1 *Thaumetopoea pitiycampa* Den. et Schiff.– The pine processionary moth

Pine processionary was already recorded 50 years ago in nearly all the natural black pine stands of the Republic of Macedonia [19, 9].It was observed in the southern part of the country (Gevgelija at an elevation of 535 m a.s.l to Visoka Čuka at 1.200 m; Mariovski basen, where the main focus of infestation, to Ligurasa – Tribot Karavastina at 1200 m a.s.l) as well as in the north (from Pusta Breznica to Skopje) the Central part (it can occasionally be found near Krusevo on 1300 m a.s.l) in the east along the border (Malesevski Mountains, Golak , Plačkovica, Ograzden), and in the west to Bitola, Resen and Ohrid Region. In these natural stands, the processionary moth did not constitute particular threat because of the natural regulation of its populations, and the resulting damage is thus reduced to minimum.

But the pine processionary moth has extended to the man-made pine plantations which cover 160,000 ha, 95 % from them being black pine monocultures. At present it can be found nearly everywhere, from Gevgelija on south through the whole flow of Vardar River to Skopje; in the east at Kriva Palanka, Kratovo, Golak, Malesevski Mountains, Plackovica, and Sveti Nikole; in the west at Prilep, Resen, Ohrid, Struga occasionally in Krusevo and Brod; and a single presence is register in Demir Hisar and Kičevo Region. Presently, the most jeopardized black pine cultures are those in the regions near Vinica, Delcevo, Radoviš, Kočani, Štip, Veles, Negotino, Sveti Nikole, Bitola and Prilep [3].

Population Dynamics and Outbraking Periods in the Past. Pine proccesionary moth showed gradations in the pine stands of the Republic of Macedonia at regular intervals of 4-5 years. Thus, moth outbreaks were registered in 1990, 1995 and 1996, when more than 20,000 ha of pine stands were attacked.

The first outbreak on the large area was noticed in 1986, when 3,000 ha of pine forests were damaged in the region of Bitola. Since then, cyclical heavy infestations occurred, increasing in intensity with changes in climatic conditions. In 1992, 4500 ha became infested whilst the damaged area reached 20,000 ha in 1994. Control measures resulted in population collapse in the following years. However, in 1999, the level of infestation increased, and 26,500 ha subsequently became infested (Fig. 2).

In 2009, there was another outbreak and by May 2010 significant damage was reported. Moth monitoring using the number of larval tents revealed a critical population density in the country although annual and regional fluctuations were noticed. Moth presence was ascertained in 27 regions. During 2003-2010, the number of larval tents ranged 400-20,400 in Bitola region whilst these values varied between 460 and 19,000 in Kočani region. In 2011, nearly 8000 ha showed very high population density, with serious threats for total defoliation and possibly destruction. In this year, the number of larval tents varied from 3,400 per ha at Mirjanina crkva-Štip to 8,600 at Goceva Gora – near Negotino (Fig. 1).

Around 14,000 hectares of pine cultures were attacked from the caterpillars of pine processionary moth in 2015, from which 75.1% (10315,8 ha) were with medium to strong intensity of the attack.

Particular Biological Features Observed in the Country. Swarming and egg-laying of pine processionary moth starts by late July and lasts until the beginning of August in sites located at high elevation (700-900 m), in the Republic of Macedonia. However, these processes start 7-10 days later in sites at lower elevation (200-500m) larval development depends on the climatic conditions. In a year with mild winter (such as years 2001/2002), larval development is completed by mid-February when the larvae begin to process. By contrast, in years with cold and long winters (such as years 2011/2012) the development is delayed and only completed by mid- or late May.

Several species of egg parasitoids have been identified in Macedonia: *Ooencyrtus pityocampae, Tetrasitchus tibialis, Trichogramma semblidis* and *Trichgramma embryophagum.* Natural parasitization by these egg parasitoids only reached 13.5 % which is not enough to induce a natural regulation of moth populations in the pine plantations.

Hosts. Predominantly on *Pinus nigra*, but occasionally on *P.sylvestris, P.peuce, P. brutia, P.pinaster*, and *Pseuodotsuga menziensii.*

Expansion with Global Warming. As likely result of global warming, larval colonies were registered in 2009 for the first time at Zmiski Rid near Kumanovo as the most northern location in the country. High densities of larval tents were also observed on the 500 ha of this area in 2010.

3.2 Bark beetles (Fam. *Scolytidae /Ipidae/*)

In the last twenty years the negative influence of the bark beetles in the natural and artificial pine stands is becoming bigger [4,10,11].

The insects of the *Scolytinae* subfamily are secondary pests on the pine, but under certain favourable conditions in the forests, like for example in Berovo region in 1993, these insects may become primary. Except in Berovo, these insects were registered with overpopulation in the regions near Pehchevo, Delchevo, Kamenica, Kochani, Svetinikole, Kriva Palanka, (Novo Selo) Strumica, Prilep, Bitola and Kavadarci.

During this research 11 species of *Scolytinae* subfamily were registered (*Hylastes linearis* Erich., *Hylastes ater* Paik., *Tomicus minor* Hart., *Tomicus piniperda* L., *Pityogenes bidentatus* Hrbst. *Pityogenes bistridentatus* Eich., *Pityogenes quadridens* Hart., *Ips sexdentatus* Boern., *Ips acuminatus* Gyll., *Ips mansfeldi* Wach. and *Ortothomicus erosus* Boern.) with regular occurrence in the pine forests. From these species *I.acuminatus* and *I. sexdentatus*, had the highest populations in the regions near Berovo, Kamenica, Kochani, Kriva Palanka and Prilep, in the Sveti Nikole region – *P. bistridentatus* and *P. bidentatus*, in the Veles region – *P. bistridentatus* and *I. mansfeldi*, in the Bitola region – *T minor* and near Delchevo – *I. sexdentatus* Boern.

Over 3500 ha of white and black pine forests were attacked by the bark beetles in 2015 in the Republic of Macedonia (fig.3). Regions most affected by beetles in 2015 are: Kochani, Kamenica, Kriva Palanka, Kratovo, Bitola, Berovo, Pehcevo, Strumica and Prilep. Control measures are required to prevent their gradation in the spring 2016.

In the future investigation, bigger attention will be given to the biological and biotechnological means of the suppression.

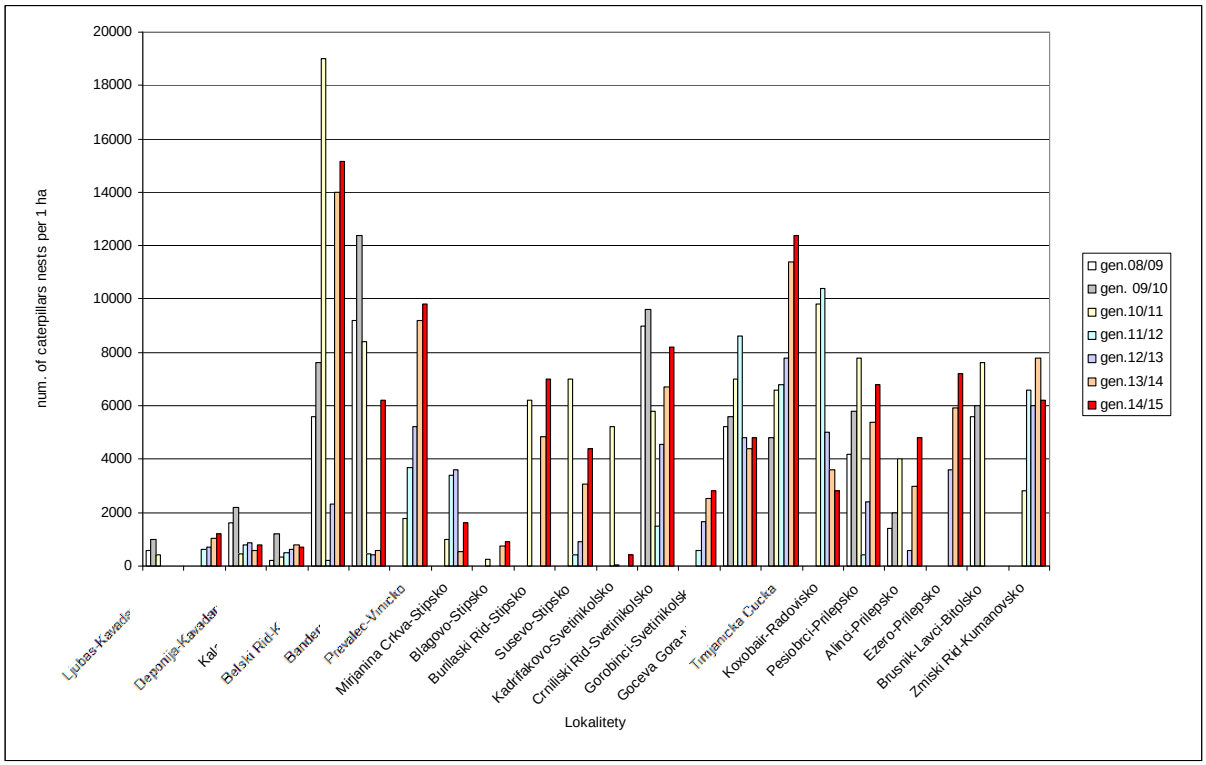

Figure 1: Abundance of the pine processionary moth from 2008-2015 in R. Macedonia (number of caterpillar nests per 1ha)

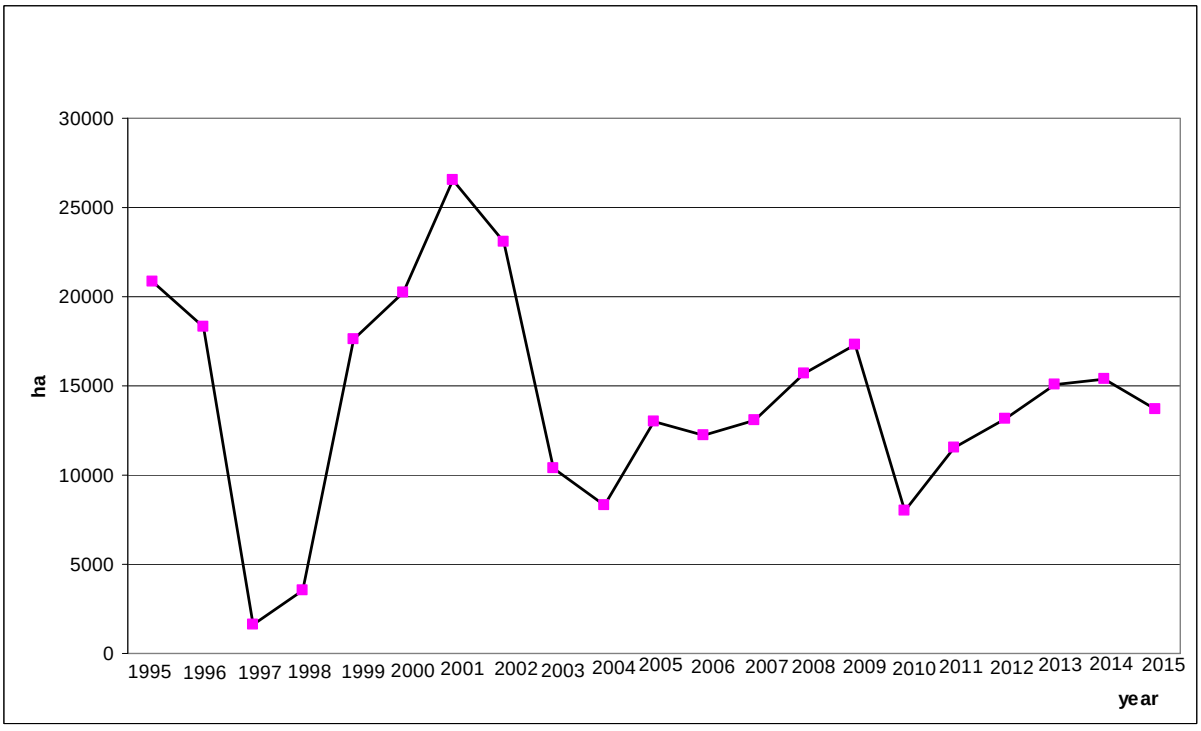

Figure 2: Surface area under attack of the pine processionary in R. Macedonia in the period from 1995-2015

We need detailed research of the ecological factors which have the most influence on the population abundance of these pests, in order to be used as a natural regulator of the abundance.

3.3 *Neodiprion sertifer* Geoffr.- The European pine sawfly

Neodiprion sertifer Geoffr. represents a harmful insect that is constantly present in cultures of black pine in the regions near Skopje, Kumano, Sveti Nikole, Veles, Negotino and Prilep.

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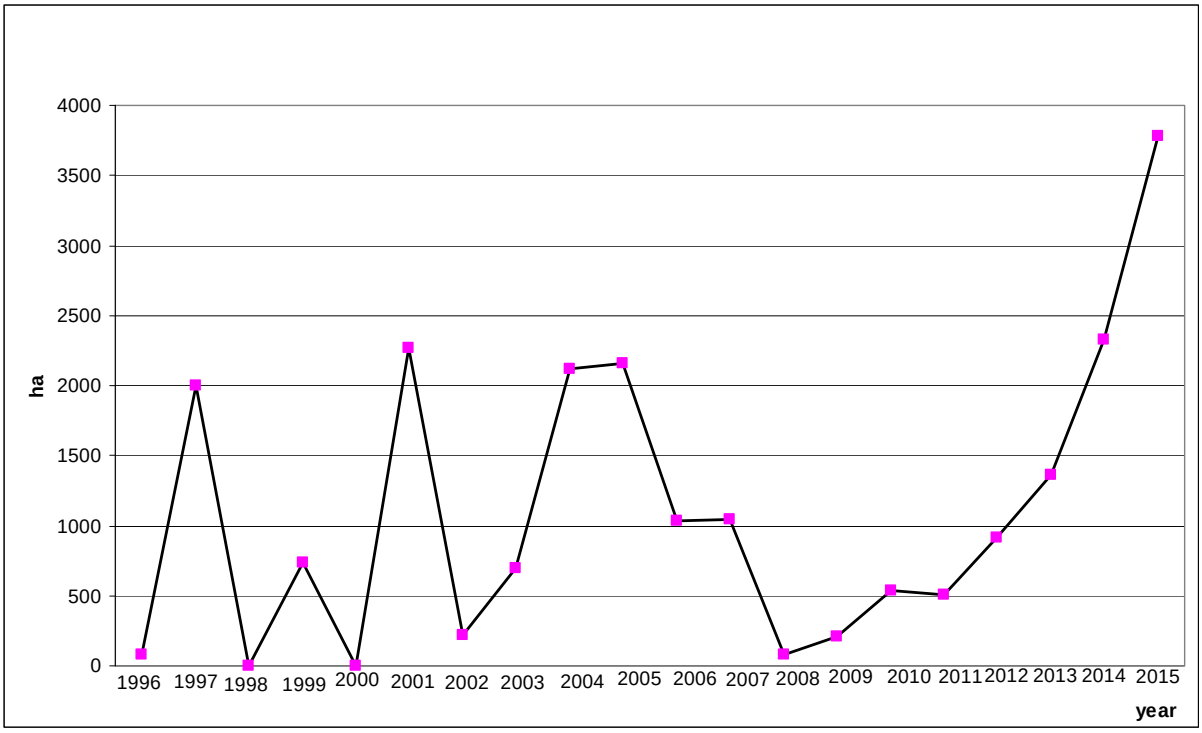

Figure 3: Surface area under attack of the bark beetles (subfam. *Scolytinae*) in R. Macedonia in the period from 1995-2015

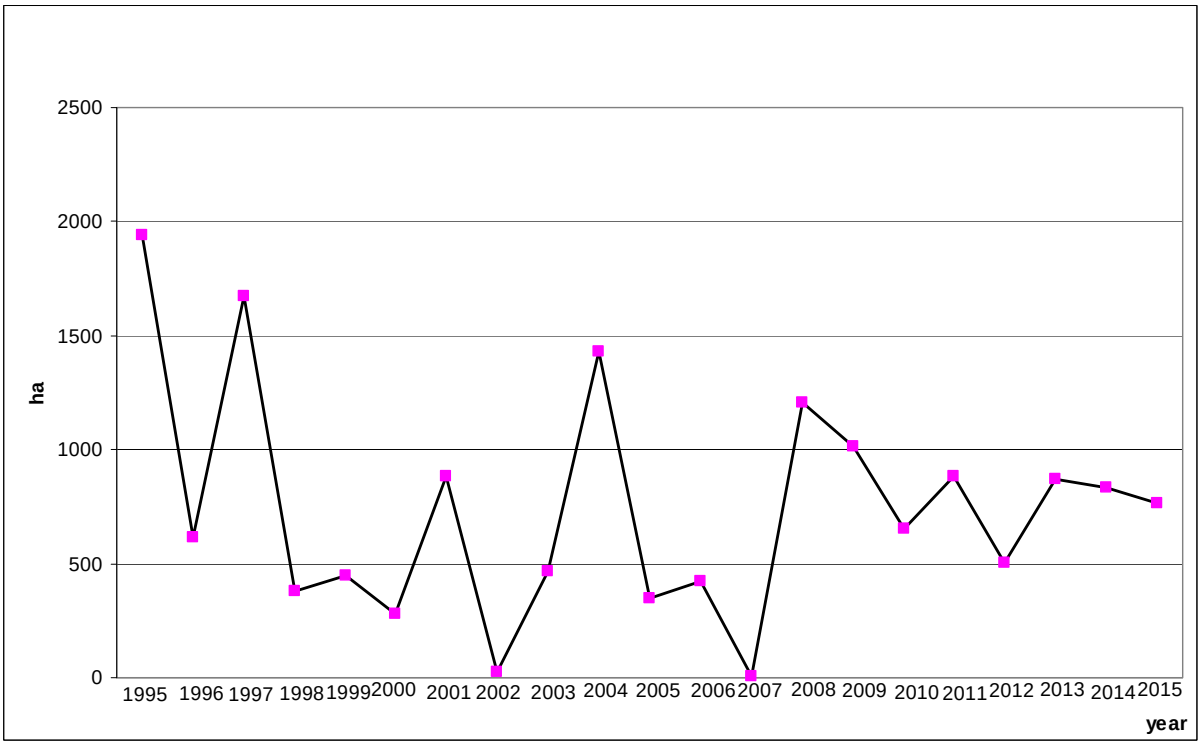

Figure 4: Surface area under attack of *Neodiprion sertifer* in R. Macedonia in the period from 1995-2015

Its last gradation was registered in 2005 when aviosuppression were performed on 500 ha of black pine cultures in Miladinovci – near Skopje and Pchinja and Vakav - near Kumanovo, whith good results.

In untreated pine cultures in 2006 abundance of *N. sertifer* continued to grow (also in other cultures such as in Veles and Kumanovo regions, where attack was rated with high intensity, which had total defoliation).

During the year 2008 attacked area of pine stands by *N. sertifer* was 1205 ha. In the next years the attacked area by *N. sertifer* was 1014 ha in 2009; 656 ha in 2010, 886 ha in 2011, 501 ha in 2012, 870 ha in 2013, 832 ha in 2014 ha and 767.5 ha in 2015. In some microlocalities we have observed progradation, which in 2015 had the retrogradation trend (Fig. 4).

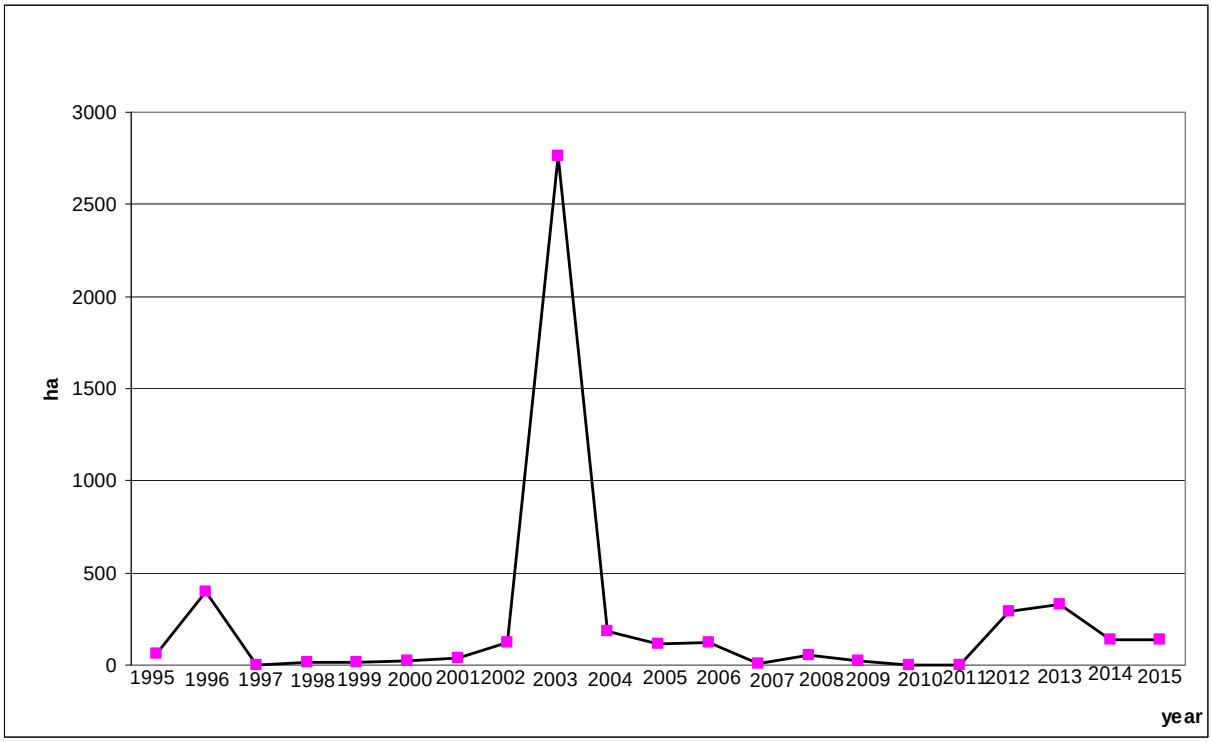

Figure 5: Surface area under attack of *Rhyacionia (Evetria) buoliana* in R. Macedonia in the period from 1995-2015

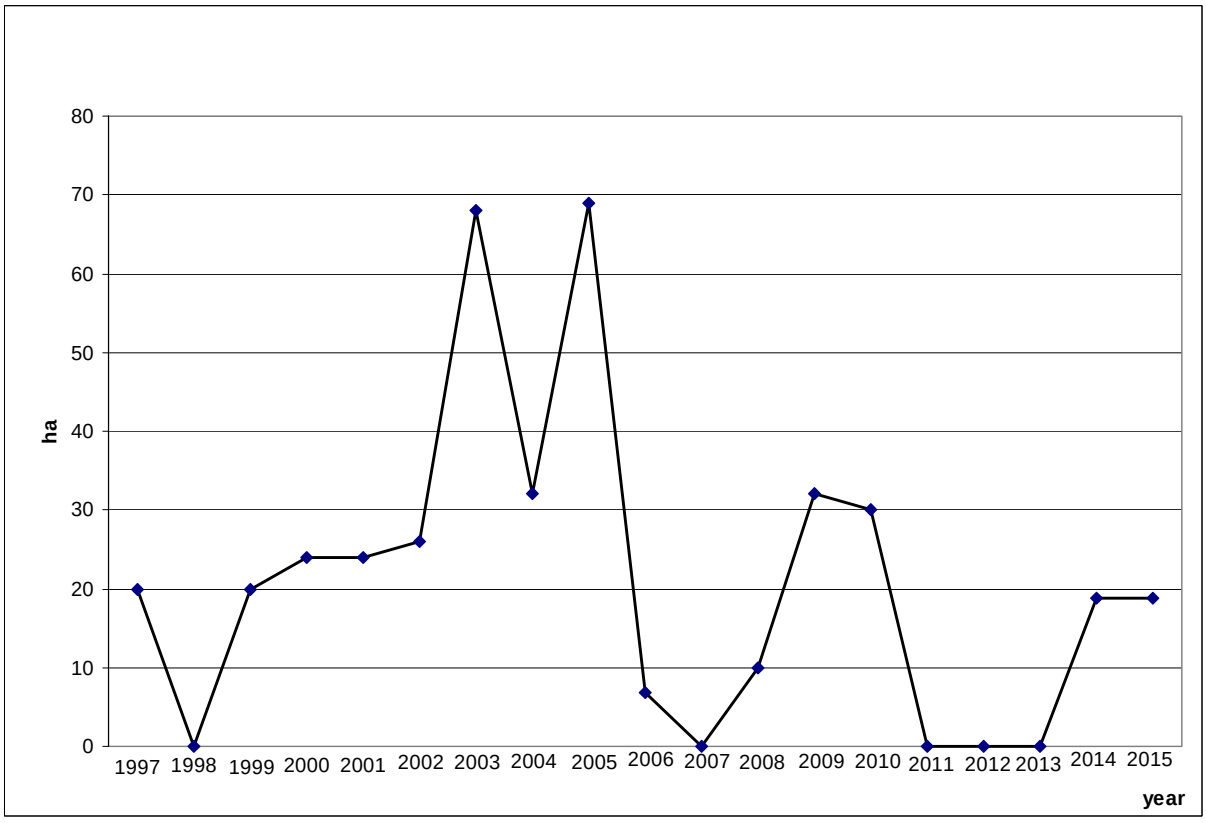

Figure 6: Surface area under attack of *Coleophora laricella* in the R. Macedonia in the period from 1997-2015

According to our field observations and registrations we can conclude that the larvae of this insect are present in almost all black pine cultures in the Republic of Macedonia, with populations which are currently in latency, so the hazard is very low on the most of attacked area. Intensity of attack by *N. sertifer* is medium on 54.7% of the total area or 420 hectares, and 37% or 287,5 ha low to medium, while the 7.8% or 60 ha are attacked with very low to low intensity. These data once again confirms the conclusion that this species is not a threat to

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the black pine stands in the year of 2016.

3.4 *Rhyacionia buoliana* Den. et Schiff.- Pine shoot moth

Pine shoot moth is one of the most important pests, with particulary distinct negative impact in the beginning period of the formation of pine ultures in R. Macedonia.

Low attack by *Rh. buoliana* is due primarily to the small number of newly afforested areas with black pine during the last ten years (Fig. 5).

3.5 *Coleophora laricella* Hb.- Larch casebearer

In the period of 1971-1985 on some localities in the regions near Bitola, Resen, Ohrid, Krushevo, Kochani and Skopje larch seedlings were introduced (*Larix europea*) wich were brought from the Republic of Slovenia. With this seedling larch casebeaerer was introduced in the R. Macedonia whose increasing abundance was observed in 1997 [2].

The aim of this study is to give information about the abundance and defoliations made by this invasive species in the larch stands in R. Macedonia.

Larch casebearer was not mentioned at all as a pest on larch in our country until 1997. We thought that our larch stands are sufficiently distant from the native areal of larch and we were expecting to appear much later.

During the year 1997 these insects were recorded on several localities in R. Macedonia (Kazani near Bitola, near Krusevo and also near Resen) in the small larch stands [2,13].

The intensity of the attack in this stands was estimated as strong (fig. 6). On the entire territory of R. Macedonia this species was represented on 20 ha. In the next three years (1998, 1999, 2000) larch caeseberer continued to cause defoliation with strong intensity in early spring almost everywhere where larch was present.

The largest area on which was observed is in 2005, when these species were present on 68,9 ha. In the latest years its presence is observed only on several localities near Kochani, Resen, Bitola and Krushevo in which the intensity of the attack is estimated as a medium (Fig. 6).

Abundance of the larch casebearer was 453,5 cases on loc. Pasadzikovo (near Kochani in 1997 to 805,4 in 1999 on the same locality.

4 CONCLUSIONS

Based on the field analysis and laboratory research we can give the following conclusions.

Th. pityocampa generation 2015/2016 was again a threat for the normal development of black pine stands on 13,000 ha in the Republic Macedonia.

Population density of the pine processionary moth, although with a trend of retrogradation in certain regions in 2015, is still high, ranging from 0.35 to 11.0 caterpillars nests by tree or from 700 caterpillars nests by 1ha, like in Kalaslari near Veles, to 22000 caterpillars nests by 1ha in Crnilishki rid –near Sveti Nikole.

Medium to high intensity of attack of pine processionary moth is observed in the following regions near: Kamenica, Vinica, Kocani, Stip, Radovis, Sveti Nikole, Negotino, Prilep, Bitola, Skopje, Kumanovo and Kriva Palanka, with serious threats for total defoliation in spring 2016.

For the total area of 13000 ha attacked by pine processionary moth aviosuppression was recommended for the September 2016

Not taking suppression measures may lead to deterioration not only of individual trees but also to deterioration of whole complex of black pine cultures.

From the pine bark beetles 3606.25 ha of pine forests were infested in 2015, and according to our knowledge area that is attacked is far greater.

Regions most affected by bark beetles in 2015 are: Kochani, Kamenica, Kriva Palanka, Kratovo, Bitola, Berovo, Pehcevo, Strumica and Prilep. Control measures are required to prevent their gradation in the spring 2016.

The other harmful insects registered in the conifer forests and cultures like *N. sertifer, Rh. buoliana, Pissodes notatus, Coleophora laricella*, are within normal range, their abundance is in latency and they are not threat for the normal development of these forest ecosystems.

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