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Damage by deer barking and browsing and subsequent rots in Norway spruce stands of Forest Range Mořkov, Forest District Frenštát p. R. (the Beskids Protected Landscape Area)

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ABSTRACT: The paper deals with the determination of the rate of damage by deer barking and browsing, the subsequent rot caused by *Stereum sanguinolentum* and the rate of its progress, elucidates causes of damage and quantifies volume and financial losses in the region of Forest Range Mořkov, Forest District Frenštát pod Radhoštěm. In the most damaged 2nd age class, decay by *Stereum sanguinolentum* was recorded in 59% of damaged trees. The progress of rot ranged from 1 to 70 cm/year. The high number of red deer is considered to be the main reason of extensive damage by bark stripping in the Forest Range Mořkov. The actual financial loss caused by depreciation of wood by the rot is greatest in the 5th age class amounting to CZK 64,320 per ha.

Keywords: bark stripping; browsing; rot *Stereum sanguinolentum*; red deer, financial loss

Bark scaling by red deer and subsequent rots appear to be one of the most important problems of forestry in the Czech Republic. It is a long-term and unresolved problem. As early as 1970, it was found by inventory that browsing and subsequent rots caused 100% damage to 70 thousand hectares of the spruce stand reduced area (ČERNÝ 2001). In the Czech Republic, 106 thousand hectares were found in 1994 and in 1999, already 220 thousand hectares of the reduced area of damaged stands. ČERNÝ (2001) gives damage to 80 thousand hectares of Norway spruce stands by deer barking and subsequent rots in mountain regions. A report on the condition of forests and forestry in 2000 states that bark scaling caused by hoofed game remained virtually on the same level in the period 1995–2000, however, the total area of stripped stands increased (MZE ČR 2001).

The massive extent of damage caused by deer barking and browsing is not, however, a specific matter of the Czech Republic only. Reports on the damage can be found in forest publications throughout the world. For example, in Austria BUCHSENMEISTER (1995) gives damage by deer barking to 257 million stems for the period 1986–1990 (i.e. 8% all stems of production forests). Some 92.4% of the figure were damage to Norway spruce.

Infection caused by *Stereum sanguinolentum* (Alb. et Schw.: Fr.) Fr. (syn. *Haematostereum sanguinolentum* (Alb. et Schw.: Fr.) Pouz.) permeating into stems through wounds is a marked phenomenon in barked stems of spruce. Although under normal conditions, it is rather a case of a saprophyte on dead wood in case of any injury to bark it penetrates into a stem significantly decreasing the mechanical stability of stems at the same time depreciating the most valuable part of wood. It can get naturally into stems thanks to symbiosis with giant wood wasp (*Urocerus gigas*) which infects wood by *Stereum sanguinolentum* in laying eggs (CARTWRIGHT, FINDLAY 1938).

Game damages (browsing, barking) reported for the whole Czech Republic and at present determined according to the MZe ČR No. 55/1999 Gaz. markedly fluctuate. After high damages exceeding CZK 50 million per year at the beginning of the 90s and a minimum in 1998 amounting to 8.2 million they reached CZK 34.4 million in 2001 (MZE ČR 2002). These damages, however, cover only those which are declared because actual damages are markedly higher and can be assessed only with difficulties. Standard determination of yield losses takes into account consequences of mechanical damage only and not a subsequent rot caused by *Stereum sanguinolentum*. Moreover, we have at our disposal only general information on the rate of the rot progress. Comparing the curves of development of the average height of barked and unbarked stands SIMON and KOLÁŘ (2001) came to an average difference in wood prices in these stands amounting to about

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CZK 266,000 per hectare. The data show that due to their extent game damages appear to be one of the greatest harmful effects in forestry. The extent of actual losses if we consider also risks related to the disturbance of mechanical stability of a stand due to the rot progress and also its predisposition effects increasing other risks is markedly higher than the calculated damage and it cannot be simply quantified.

The objective of the paper was to determine the rate of damage to stands by deer barking and browsing, to determine the rate of damage by subsequent rots, to find the rate of rot progress, to clarify causes of the damage and to determine volume and financial losses in the area of Forest Range Mořkov (the Beskids Protected Landscape Area).

MATERIAL AND METHODS

Forest Range Mořkov belongs to the management-plan area Frenštát pod Radhoštěm. It is situated in two natural forest areas, viz. the Below-Beskids Upland (Podbeskydská pahorkatina) and the Moravian-Silesian Beskids (Moravskoslezské Beskydy). Spruce monocultures with a broadleaved admixture (particularly beech) of the management group of stands No. 451 – spruce management of nutrient-rich sites at medium locations predominate on largely mesotrophic brown forest soils at about 450–850 m altitude. The area of the forest range is part of a hunting district classified into the 3rd quality class for red deer with a standardized spring stock of game 17 deer (10 deer/1,000 ha) and a coefficient of expected production 0.8.

In 2002, on the basis of a preliminary monitoring in total 16 representative plots for a detailed monitoring were placed in the area of the forest range. These plots of an area of 50 × 50 m were situated in spruce stands or in stands dominated by spruce aged 22–93 years (6 in stands of the 2nd age class, 4 in the 3rd age class, 3 in the 4th and 3 in the 5th age class). In each of the plots, spruce trees were classified into the following categories: health tree, damaged tree and damaged tree with a rot (open wounds, oozy occluded wounds, wounds of a large extent). In total, 3,988 trees were analyzed. For particular stands and age classes, the proportion of damaged trees was expressed (the percentage of damaged trees of all monitored trees) and the proportion of trees with the rot (the percentage of damaged trees with the rot of all damaged trees). Further, sample trees were selected of mensurational quantities approaching values of an average stem. These trees were cut down and in each of them, its total length, mid-diameter, length of the butt part with the rot (by means of dividing the stem into 1 and 0.5 m long sections) and its mid-diameter. Using the data, volumes were calculated by means of Huber's formula and subsequently volume losses (wood volume damaged and depreciated by the rot) and percentage losses (the percentage of wood damaged by the rot of the total volume of the sample tree stem). In selected sample trees, cuts were carried out right in the wound and the time of the damage origin was determined. The rate of the rot progress in cm/year was determined as the length of a stem affected by the rot divided by the number of years elapsed from the year of the damage origin. In total, 52 sample trees were cut down. On the basis of standing volumes per hectare, the proportion of damaged trees, the proportion of trees with the rot and average percentage losses average volume losses per hectare were derived for particular stands and age classes.

The determination of financial losses was based on actual prices of wood in the given region at the beginning of 2003. It is possible to suppose that wood damaged by rot, if saleable at all, will be sold as fuelwood irrespective of an age class. Thus, a difference was determined between the price of fuelwood and the price of an assortment characteristic of the given age class: stands of the 4th and 5th age classes – round timber of the 3rd A class, stands of the 3rd and 2nd age classes – pulpwood. Relative realization of wood in a stand was also determined, i.e. how many % forms a financial profit when selling with the present loss as against the maximum profit (compared with a hypothetical sale of the whole growing stock without losses).

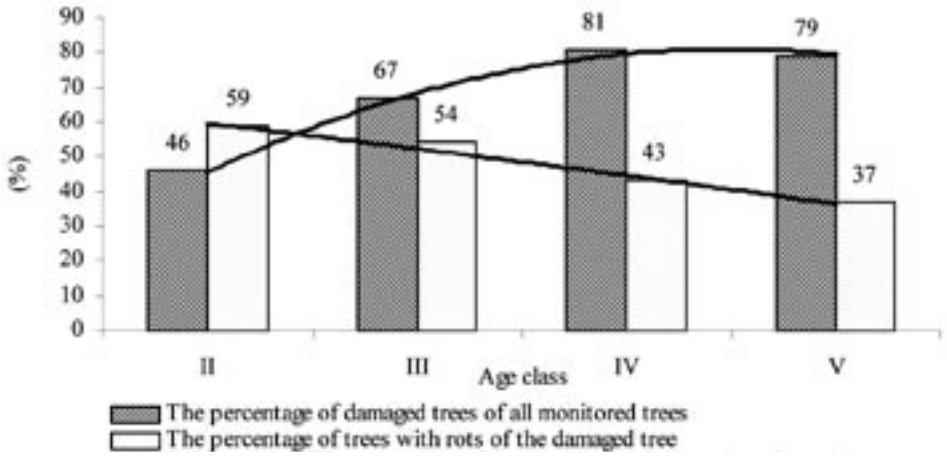

Fig. 1. The proportion of damaged trees and the proportion of damaged trees with rots

Table 1. Standing volumes of Norway spruce per hectare and determined volume losses for particular age classes

Age class	Standing volume of spruce (m^3/ha)	Volume of spruce depreciated by rot (m^3/ha)
2nd	79[1]	12.2
3rd	200[2]	25.6
4th	302[2]	35.4
5th	480[2]	48.0

[1]standing volume calculated on the basis of the mean volume of a sample tree
[2]standing volume according to the forest management plan

Fig. 2. Average percentage loss (% of wood depreciated by the *Stereum sanguinolentum* rot)

RESULTS

Of the total number of 3,988 evaluated trees, 2,587 trees were in the 2nd age class, 589 in the 3rd age class, 348 in the 4th age class and 464 in the 5th age class. With the increasing age class the total proportion of damaged trees increases (up to the 4th age class) and the proportion of trees with rots decreases (% of damaged trees) from 59% in the 2nd age class to 37% in the 5th age class (see Fig. 1). From 52 felled sample trees 37, 3, 2 and 10 trees were in the 2nd, 3rd, 4th and 5th age classes, respectively. Damaged trees in the 2nd age class are characterized by the highest average percentage loss (% of wood depreciated by rots), viz. 60%. In the 3rd–5th age classes, the average percentage loss decreases (Fig. 2). Average volume losses per hectare caused by rots increased with the increasing age class from 12.2 m^3/ha in the 2nd age class to 48 m^3/ha in the 5th age class (Table 1). In trees of the 2nd age class, the rot spread at an average rate of 23 cm/year (from 1 to 70 cm/year), in the 3rd age class the rot spread at an average rate of 9 cm/year (from 10 to 17 cm/year), in the 4th age class at an average rate of only 5 cm/year (from 1 to 13 cm/years). In the 5th age class, it was not possible to detect the rate of progress of the *Stereum sanguinolentum* rot because the studied sample trees were simultaneously infected by *Heterobasidion annosum* (Fr.) Bref.

By means of backward dating it was found that trees in the 2nd age class were most frequently damaged in 1997, 1992 and 1993. A relationship was proved between the intensity of damage by bark stripping in the 2nd age class and the number of red deer or between the percentage of tress damaged in the year (of all sometimes damaged trees) and red deer hunting in the previous year ($r = –0.63715$, $P < 0.05$). In total, 33% injured trees were damaged in 1997. In 1996, the lowest bag of red deer was recorded (23 deer) of the whole period with available information on game management (Fig. 3). Low bags were not the consequence of low numbers of game but of bad game management. It resulted in increasing the game population in the following year and thus also higher intensity of deer barking. On the other hand, high bags in the period 1993–1994 resulted in the decrease of game stock and thus also of damages. In higher age classes, the number of sample trees is insufficient for authoritative conclusions on dating the damage, however, damage coming from the 70s dominates.

Present relative realization of wood in the stand would differ in particular age classes only very little ranging from 91 to 93% of the maximum realization (the sale of the whole standing volume without losses due to wood depreciation). An actual financial loss caused by wood depreciation by rots expressed in absolute figures increases with an age class from CZK 5,917/ha in the 2nd age class to CZK 64,320/ha in the 5th age class (Table 2).

DISCUSSION

In the Forest Range Mořkov, the number of damaged trees increases due to the gradual accumulation of damage

Table 2. An actual financial loss caused by wood depreciation by rot according to age classes

Age class	Spruce wood depreciated by rot (m^3/ha)	Pulpwood (CZK 895/m^3) (CZK/ha)	Roundwood IIIA (CZK 1,750/m^3) (CZK/ha)	Fuelwood (CZK 410/m^3) (CZK/ha)	Loss (CZK/ha)	Present relative realization[1] (%)
2nd	12.2	10,916	–	5,002	5,917	92
3rd	25.6	22,912	–	10,496	12,416	93
4th	35.4	–	61,950	14,514	47,436	91
5th	48.0	–	84,000	19,680	64,320	92

[1]Present relative realization = $(P – Z)/P$. 100; where P is the sale of a whole standing volume per ha of a stand as the assortment of pulpwood or roundwood IIIA (standing volumes in m^3/ha are given in Table 1); Z is a loss

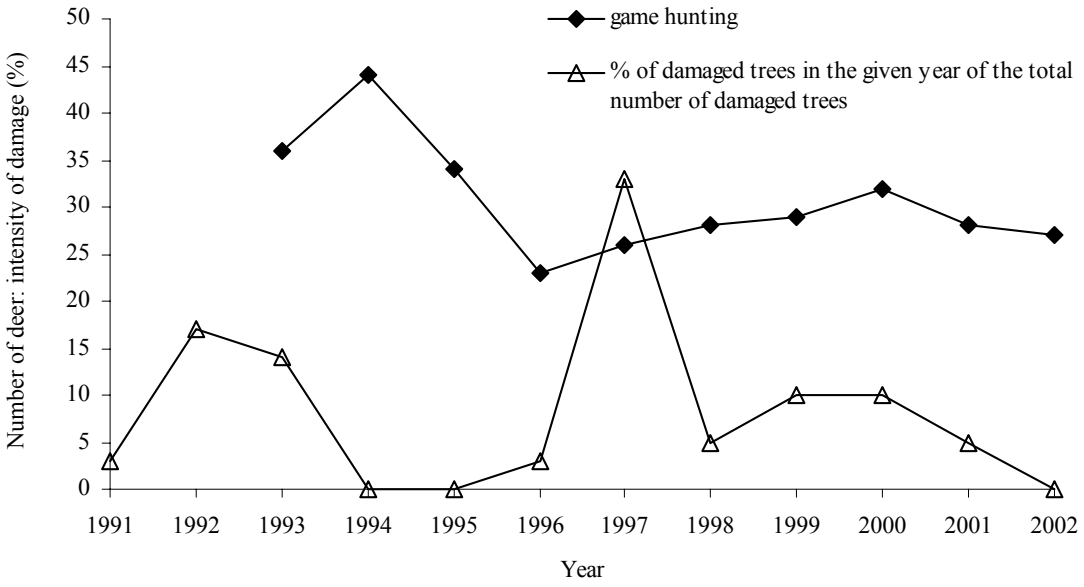

Fig. 3. Intensity of damage to trees in the 2nd age class and red deer hunting

trees up to the age of about 70–80 years (the highest proportion of damaged trees is in the 4th age class, viz. 81%), then it slightly decreases (disappearing the damaged trees from the stand). Thus, the proportion of damaged trees in stands of particular age classes shows another trend than that found in similar surveys and also another trend that we could expect. With respect to thick fissured bark, higher age classes are not suitable for bark stripping and browsing and thanks to open canopy they are not even an attractive resting haunt for deer. With respect to the fact and with regard to the gradual removing of damaged trees from stands within tending fellings, a decrease in the proportion of damaged trees with the increasing age is logical. It was, e.g., found during the survey of stripping damage in Forest Range Samčanka, Forest District Ostravice (PEKA 1996). The highest proportion of damaged trees was recorded in the 2nd age class, viz. 60%, then the proportion decreased, in the 3rd age class amounted to 49% and in the 4th age class 18%. In the region of the Frenštát pod Radhoštěm Forest Enterprise, ŠTEFEK (1986) gives the highest proportion of damaged trees in the 3rd age class, viz. 47%, in the 2nd age class 35% and in the 4th age class 15%. An increase in the proportion of damaged trees up to the 4th age class in Forest Range Mořkov can be explained by two ways. First, very high intensity of damage by bark stripping in the 60s and 70s in the 2nd or 3rd age classes, an intensity markedly exceeding damage in the 90s. It is indicated by sample trees from higher age classes with damages coming from the 70s although it is a case of a sample with insufficient representativeness. Second, damage to trees occurs up to a high age, however, the explanation appears to be improbable.

Rots caused by *Stereum sanguinolentum* were noticed in the Forest Range Mořkov in 59% damaged trees in the 2nd age class. Nearly the same rate of damage give PECHMANN and AUFSESS (1971) for Bavaria, viz. 60% trees with stem injuries. However, cases are also described with the markedly higher presence of rots in stems damaged by bark stripping. For example, ROEDER (1971) gives 99.7% attacked trees from northern Germany. A progress of the rot at a range of 1–70 cm/year does not markedly differ from that given by ČERNÝ (1989) who mentions 30 to 80 cm/year. In studies conducted in the Křtiny Training Forest Enterprise Masaryk Forest in 2002, the rot progress amounting to 20–40 cm/year was found (ČERMÁK, JANKOVSKÝ unpubl.).

The decreasing trend in the proportion of trees with rots is caused above all by sanitation fellings aimed preferentially at the most damaged trees (with open dry wounds of a large extent or oozy occlusions). In newly occurred injuries at a higher age, it is often a case of small wounds which need not result in the origin of spores of a pathogen or the spread of rot. A decrease in the proportion of trees with rot with the increasing stand age give also ŠTEFEK (1986) and PEKA (1996).

Findings on the course of damage by deer barking in Forest Range Mořkov corroborate a known fact that spruce stands aged 21–40 years (2nd age class) are most attractive for red deer barking. Therefore, the predominant majority of damages originated just at that age (e.g. ZÁRUBA, ŠNAJDR 1966; ECKMULLNER 1985).

Demonstrated relationships between stem damage by deer barking and the amount of bags in the previous year indicate that the main reason of the extensive damage by deer barking in the Forest Range Mořkov is the high number of game. A number of other authors considers high game stocks to be the main reason of damage by deer barking and browsing. A positive relationship between the rate of damage by barking and red deer standing crop (the number of bags in the given year) was found by TRISL et al. (1999) in Germany. Positive correlation between damage by deer barking and red deer density in various regions of Poland gives SZUKIEL (1978). Also MRKVA (2001) considers game stocks to be the primary cause of

damages. On the other hand, VODŇANSKÝ (2001) considers disturbances in the food rhythm of game by public as well as by implementing the hunting rights to be the main cause of extensive damages by deer barking. According to him, high game stocks are a factor significantly increasing the risk of damages. Also VOLK (1999) considers feeding regime and habits to be important. In his survey carried out in mountain locations of Austria he did not find significant relationships between the intensity of barking and the number of game, however, he stated that damages by deer barking could be reduced either by marked reduction in game feeding (decrease in the concentration of game near feed racks) or, on the contrary, by its intensification particularly in case of a considerable amount of snow (decrease in damages in other parts of the region). The structure of a stand is also considered to be an important factor affecting the degree of damages. Lower damages by deer barking were noticed in multistoreyed stands (VOLK, HASENAUER 2000). Effects of the stand structure were also corroborated by LINDEMANN (1952) who stated higher damage by deer barking in even-aged extensive stands as against smaller all-aged stands.

To compare financial losses caused due to damages by deer barking with other similar studies is not possible in absolute figures with respect to differences in wood prices and their changes, however, it is possible to compare changes in the wood value in a stand in relative figures. In Forest Range Mořkov, the present value of wood is stands ranges between 91 and 93% of a hypothetical value without losses due to damages. EIDMANN (1952) found in studying game damages in Sauerland and in the Teutoburger Wald that the value of stands damaged by barking ranged between 72 and 92% of a hypothetical value without losses due to damages. Of course, it is necessary to take into account that values in the Forest Range Mořkov are determined on the basis of a consideration that all wood affected by rots will be realized as fuelwood which usually does not succeed. Moreover, potential losses caused by damages without rots are not included so that the actual loss will be greater.

CONCLUSIONS

A study of damages caused by red deer barking and browsing and subsequent rots in spruce stands of the Forest Range Mořkov quantified the extent of the damage and its potential financial consequences. The number of damaged trees increases in stands up to the age of about 70–80 years and then slightly decreases. Trees of the 2nd age class are most attractive for deer barking. Rots caused by *Stereum sanguinolentum* were noticed in 59% of damaged trees in this age class. The rot progress ranged from 1 to 70 cm/year. The highest percentage loss (percentage of wood depreciated by the rot) was found in the 2nd age class, viz. 60% of the total wood volume. Average volume losses per hectare increased with the increasing age from 2.2 m^3/ha in the 2nd age class to 48 m/ha in the 5th age class. The higher number of game is considered to be the main cause of extensive damage to stems by deer barking in Forest Range Mořkov. The present total relative realization of wood in the stand could amount to 91–93% of the maximum realization. The actual financial loss caused by wood depreciation by rots and expressed in absolute figures increases with an age class up to CZK 64,320/ha in the 5th age class.

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Škody loupáním a ohryzem jelení zvěří a následnými hnilobami ve smrkových porostech revíru Mořkov, LS Frenštát p. R.

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ABSTRAKT: Práce se zabývá stanovením míry poškození loupáním a ohryzem, stanovením míry poškození následnou hnilobou pevníku krvavějícího a rychlostí jejího postupu, datuje vznik těchto poškození, objasňuje příčiny poškození a kvantifikuje objemovou a finanční ztrátu na území revíru Mořkov, LS Frenštát pod Radhoštěm. V nejvíce poškozované druhé věkové třídě byla zaznamenána hniloba pevníku krvavějícího u 59 % poškozených stromů. Zjištěný postup hniloby se pohyboval v rozsahu od 1 do 70 cm/rok. Za hlavní důvod rozsáhlých škod loupáním v revíru Mořkov je považována vysoká početnost zvěře. Aktuální finanční ztráta vzniklá znehodnocením dřeva hnilobou je největší v páté věkové třídě – 64 320 Kč/ha.

Klíčová slova: loupání; ohryz; hniloba pevníku krvavějícího; jelen lesní; finanční ztráta

Práce hodnotí škody loupáním a ohryzem na území revíru Mořkov, LS Frenštát pod Radhoštěm. Na převážně mezotrofní hnědé lesní půdě v nadmořských výškách 450–850 m tam dominují smrkové monokultury a smrkové porosty s listnatou příměsí (zejména buk lesní) hospodářského souboru 451 – smrkové hospodářství živných stanovišť středních poloh. Území revíru je součástí myslivecké honitby zařazené do III. jakostní třídy pro jelení zvěř s normovaným jarním kmenovým stavem 17 zvířat (10 ks/1 000 ha) a koeficientem očekávané produkce 0,8.

V roce 2002 bylo na základě předběžného monitoringu na území revíru ve smrkových porostech o stáří 22–93 let umístěno celkem 16 reprezentativních ploch o velikosti 50 × 50 m pro podrobný monitoring. Na každé ploše byly smrky zařazeny do kategorií: zdravý strom, poškozený strom a poškozený strom s hnilobou (otevřené rány, mokvavé zavalené rány, rány velkého rozsahu). Celkem bylo vyšetřeno 3 988 stromů. S rostoucí věkovou třídou roste celkový podíl poškozených stromů (do čtvrté věkové třídy, potom víceméně stagnuje) a klesá podíl stromů s hnilobou (% stromů s hnilobou z poškozených stromů) od 59 % ve druhé třídě k 37 % v páté třídě (obr. 1).

Dále byly vybrány vzorníky s taxačními veličinami blížícími se hodnotám středního kmene. Ty byly skáceny a u každého z nich změřeny parametry potřebné pro zjištění objemu celého kusu a objemu kusu znehodnoceného hnilobou pevníku krvavějícího. Byly stanoveny objemové a procentuální ztráty (% hmoty znehodnocené hnilobou). Celkem bylo pokáceno 52 vzorníků. Průměrné hektarové objemové ztráty způsobené hnilobou s rostoucím věkem stoupaly od 12,2 m^3/ha ve druhé věkové třídě ke 48 m^3/ha v páté věkové třídě (tab. 1). Nejvyšší procentuální ztráta byla ve druhé věkové třídě – 60 %, ve třetí až páté věkové třídě tento podíl klesá (obr. 2). U vybraných vzorníků byl proveden řez přímo v ráně a byla zjištěna doba vzniku poškození. Rychlost postupu hniloby v cm/rok byla stanovena pomocí rozdělení kmene na 1 m a 0,5 m dlouhé sekce jako délka kmene zasaženého hnilobou děleno počtem let uplynulých od roku vzniku poškození. U stromů ve druhé věkové třídě se hniloba šířila průměrnou rychlostí 23 cm/rok (v rozsahu od 1 do

70 cm/rok), ve třetí věkové třídě se hniloba šířila průměrnou rychlostí 9 cm/rok (od 10 do 17 cm/rok), ve čtvrté věkové třídě již pouze rychlostí 5 cm/rok (od 1 do 13 cm za rok), v páté věkové třídě nebylo možné zjistit rychlost postupu hniloby pevníku krvavějícího, protože šetřené vzorníky byly současně infikovány kořenovníkem vrstevnatým *Heterobasidion annosum* (Fr.) Bref.

Zpětnou datací bylo zjištěno, že stromy ve druhé věkové třídě byly nejčastěji poškozeny v letech 1997, 1992 a 1993. Byla prokázána závislost mezi intenzitou poškození loupáním ve druhé věkové třídě a početností jelení zvěře, resp. mezi procentem stromů poškozených v daném roce ze všech zjištěných poškozených stromů a mezi lovem jelení zvěře v roce předchozím (r = –0,63715, P < 0,05). Celkem 33 % poškozených stromů bylo poškozeno v roce 1997, v roce 1996 byl přitom zaznamenán nejnižší úlovek jelení zvěře (23 kusů) z celého období, k němuž jsme měli dostupné informace o myslivecké hospodaření (obr. 3).

Zjištění finanční ztráty vycházelo z reálných cen dříví v daném regionu na začátku roku 2003. Byl zjišťován rozdíl mezi cenou palivového dříví a cenou sortimentu charakteristického pro danou věkovou třídu: čtvrtá a pátá věková třída – kulatina III A třídy, v porostech třetí a druhé věkové třídy – vlákninové dříví. Bylo také stanoveno relativní zpeněžení dřeva v porostu jako procento finančního zisku při prodeji se současnou ztrátou z maximálního zisku, tj. z prodeje celé zásoby bez ztráty. Aktuální finanční ztráta vzniklá znehodnocením dřeva hnilobou v absolutních číslech stoupá s věkovou třídou od 5 917 Kč/ha ve druhé věkové třídě k 64 320 Kč/ha v páté věkové třídě (tab. 2). Současné relativní zpeněžení dřeva v porostu by se v jednotlivých věkových třídách lišilo jen velmi málo, pohybuje se od 91 do 93 % maximálního zpeněžení.

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