Response of birch (*Betula pendula* Roth) phytophages to liming

E. Kula

Faculty of Forestry and Wood Technology, Mendel University of Agriculture and Forestry in Brno, Brno, Czech Republic

ABSTRACT: In the course of 2004–2007, the effects of compensation liming at the application dose of 1.5–3–6 t/ha dolomitic limestone on the elimination or activation of phytophages or other types of damage resulting in the loss of assimilatory organs did not become evident yet. A shift was noted in the fluctuation expressed indirectly by the extent of damage to the assimilatory area in feeding caused by an undetermined hymenopterous larva (summer increase), weevils (spring and summer decline and increase in 2007), *Coleophora serratella* (decline), *Eriocrania* sp. (increase), mites *Acalitus rudis* (increase), *Eriophyes leionotus* (increase in 2006–2007). Only signs of a positive response to higher doses of dolomitic limestone characterized the mite *Eriophyes leionotus*.

Keywords: birch *Betula pendula* Roth; liming; dolomitic limestone; phytophages; *Eriophyes leionotus*

Compensation liming not only affects the soil environment but also influences the nutrition of trees, when the content of some elements as well as the vitality of trees are changed. Changes in the chemistry of assimilatory organs of birch (*Betula pendula* Roth) after the application of dolomitic limestone became evident particularly by an increase in calcium and magnesium, decrease in phosphorus and potassium and partly in manganese and cadmium (Hrdlička, Kula 2007a). If some papers dealing with the impact of dolomitic limestone on soil and epigeous fauna (earthworms, soil mites etc.) were published (Huhta 1979; Hågvar, Amundsen 1981; Winter 1990; Weber, Eisenbeis 1992; Rundgren 1994; Kula, Matějková 2007), then information on the response of phytophages developing on leaves (sucking, mining and leaf-eating) is nearly missing. Cates (1980) reported that larvae of monophagous and oligophagous species preferred young extending leaves while larvae of polyphages developed on mature leaves. The variability of herbivorous species is affected by chemistry (Claridge, Wilson 1978; Strong, Levin 1979), seasonal changes in the content of nitrogen and the growth of indigestible components of food (Rhoades 1979; Mattson 1980) and by the antiherbivorous strategy of plants (Rhoades 1979).

The crown fauna of birch includes quite a broad spectrum of phytophages. Some of them can also be classified as pests, e.g. *Lochmaea capreae* L., *Eriocrania* sp., *Coleophora serratella* (L.), *Operophtera fagata* (Scharf.) (Kula 2006b; Kula, Pražanová 2007).

The aim of the paper is to evaluate the response of some phytophages to changes being in progress in assimilatory organs in the first four years after the application of dolomitic limestone.

A hypothesis: the content of elements in assimilatory organs as well as the quality of food for phy-

Supported by the Ministry of Agriculture of the Czech Republic, Project No. QH 82113, and Ministry od Education, Youth and Sports of the Czech Republic, Project No. MSM 6215648902. It was sponsored by the following companies and organizations: Netex Co. and Alusuisse Co. in Děčín, Municipal Office in Děčín, ČEZ Co. Prague, Cement Works Co. in Čížkovice, North-Bohemian Mines Co. in Chomutov and Dieter Bussmann Co. in Ústí nad Labem.

tophagous insects change as a result of liming, and they can response by a change in their abundance.

MATERIAL AND METHODS

Liming was carried out on 28th August 2003 at a planned dose of 1.5–3–6 t/ha crushed dolomitic limestone applying the Deutche Heli Forst/DHD technology using a HUGHES 500D/E helicopter. Main research plots were situated in the zone of air pollution threat (lower limit of the potential area recompensation liming), locality Buttersteig 1 at an altitude of 710–730 m, moderate southern slope below a road (plots 1–4, stand 338B3c birch 65, rowan 20, spruce 10, age 27 years, forest type group 6K) and on the central slope above a road Buttersteig 2 at an altitude of 720–770 m (plots 5–8, stand 36B2 birch 80, rowan 15, spruce 5, age 20 years, forest type group 6K). Particular stand parts with birch monocultures are separated from each other by forested clearcut areas with stabilized plantations.

In all stands (8) of Buttersteig localities (Litvínov Forest District), damage to the assimilatory organs of birch was evaluated in the spring (VI) and summer aspect (VIII) on permanent sample trees (3 trees/stand). Two branches were taken from each sample trees, one in the lower part of the crown 6–8 m and one in the upper part 10–12 m. Defoliation was evaluated by a qualified estimate of the percentage of damaged area on the randomly selected group of 70 leaves from each of unit branches (Σ 48 samplings). A factor causing damage was determined according to Schnaider (1991) and Uhlířová and Kapitola (2004). In wild caterpillars and hymenopterous larvae, feeding was not specified to the level of a species, because, with the exception of mining insects, this difference could not be determined.

For statistical evaluation one-way ANOVA procedures were used (95% Scheffe HSD test). Eight stands were tested in relation to the applied dose of dolomitic limestone in the particular years, number of samples from a stand 6 (420 leaves).

RESULTS AND DISCUSSION

Defoliation and the health condition of birch

The broad spectrum of phytophages, some of which can cause heavy defoliation and even complete defoliation, is nutritionally related to the assimilatory organs of birch (Kula 2000; Kula 2007b; Kula, Pražanová 2007). At the same time, birch can be exposed to air pollution impact, fungal pathogens, physiologically functioning factors with specific manifestations of damage detected according to Schnaider (1991) and Uhlířová and Kapitola (2004). During inspections, 33 types of damage were noted.

In 2004–2007, the area of the Litvínov transect is characterized by the spring 16.4–12.8% defoliation of birch and the summer 17.8–12.6% loss of assimilatory area (Kula, Pražanová 2007). Stands of birch differed under the effect of liming in the total loss of assimilatory area in the particular years (Table 1). Changes between the particular years are known not only in the content of elements (Hrdlička, Kula 2004) but also in the activity of particular pathogens due to e.g. the course of weather (Kula et al. 2004). Therefore, it was inevitable to analyze particular limed stands in relation to dynamic changes (Table 1) and thus to eliminate the effects of climatic factors because the monitored stands show identical site conditions (altitude, aspect, soil).

If certain heterogeneity became evident in the development of defoliation on monitored check plots

Table 1. The development of total defoliation of birch on limed plots of the Buttersteig locality in spring and summer (Litvínov Forest District, 2004–2007)

Aspects		Spring				Summer			
Plots	Application (t/ha)	2004	2005	2006	2007	2004	2005	2006	2007
1	control	13.50	8.64	8.48	12.74	17.95	11.83	12.90	21.60
2	1.5	8.45	13.95	8.10	13.21	9.98	9.14	10.98	14.36
3	3	9.71	10.5	12.57	16.17	13.29	10.69	14.43	13.62
4	6	9.57	15.62	18.36	22.79	12.26	13.45	14.29	21.43
8	control	11.12	13.21	7.67	7.57	15.90	10.52	8.71	17.14
5	1.5	9.64	16.1	16.36	15.45	11.83	12.62	12.52	15.26
6	3	9.36	12.12	16.79	16.60	15.79	9.50	16.45	14.05
7	6	14.14	12.69	9.50	11.00	17.95	13.86	11.93	15.02
Average defoliation		16.42	12.78	14.39	13.63	17.84	16.54	12.62	15.62

(unlimed) and stands with the application of 1.5 t/ha in the spring aspect, then in stands with the higher application of dolomitic limestone (3 and 6 t/ha) mainly an increase in the total disturbed assimilatory area became evident during the monitored four-year period. In the summer aspect the total defoliation did not manifest itself by the specific regularity of periodic changes. The cause can consist in the high stability and proportion of spring species related to expanding leaves (mites, mining insects). But exceptions, no fundamental deviations occurred in the extent of defoliation on limed plots as compared with the total loss of the assimilatory area on the level of the Litvínov transect monitored for a long time (Kula, Pražanová 2007).

Dynamics of factors causing defoliation

The most important group of defoliators (free-living Lepidoptera larvae) did not show a relationship that would be affected by the application of dolomitic limestone (Fig. 1a). Changes in the fluctuation and resulting feeding of moth larvae became evident in the whole area of the eastern Krušné hory Mts. not being affected by local conditions (Kula 2006a, 2007a; Kula, Pražanová 2007). Changes in the chemistry leaves, which became evident by the marked fall of sulphur in 1995–2007 (Hrdlička, Kula 2006, 2007b), did not affect the long-term fluctuation. Niemelä and Haukioja (1982) ranked birch among the species with continuously accruing leaves when the spectrum of caterpillars was differentiated by food relations to young leaves and mature leaves. According to Feeny (1970), the attractiveness of leaves is limited by the content of nitrogen, water and by the accumulation of proteins bound to tannins of mature leaves.

The feeding of hymenopterous larvae occurring in the summer aspect became evident by an increase in the course of studied years in all localities. A partial fall in the population density was noted on plots with the highest application dose. With respect to the generally low proportion in feeding it is necessary to accept this finding conditionally with the necessity of further testing.

In *Curculionidae*, feeding generally decreased in 2004–2006 with a consequential marked increase (Fig. 1j), which corresponded to changes in the fluctuation of species of e.g. the genus *Phyllobius*. Deviations in the extent of feeding in stands with the application of 1.5 t/ha as compared to the control and higher application doses were considered to be significant (Fig. 1b). The increased content of nitrogen in leaves induces partial preferences of weevils in searching birch as a nutritive plant (Kula et al. 2008). The feeding of weevils became markedly evident e.g. in the Janov transect (approximately 50°32'N, 13°24'E) (500 to 900 m a.s.l.), being less markedly determined in the area of the Litvínov transect (approximately 50°38'N, 13°37'E) (500 to 900 m a.s.l.) (Kula et al. 2006). In *Apion simile* Kirby, no relationships were determined either in fluctuation or with respect to liming. Although the representatives of mining insects are important pests of birch, their density in birch stands is not balanced (Kula 2005) in the eastern Krušné hory Mts.

Existing developmental changes in the extent of harmfulness in *Coleophora serratella* can be explained by the permanent fall in the population density (2004–2007) not related to liming. Differences between the particular years are not statistically significant and the difference between the spring and summer aspect is related to the spring feeding and persistence of leaves with mines even in the summer season (Fig. 1c). In the case of mining insects of the genus *Eriocrania* it is not possible to support unambiguously low abundance at the application of 6 t/ha by statistical dependence in spite of the indicated trend of decrease with the increasing application of dolomitic limestone (Fig. 1d). The oviposition preference of *Eriocrania* females on variously stressed birch showed that plants with the higher content of nitrogen in leaves were less attacked (Kula, Kaňová 2005). Koricheva and Haukioja (1995) reported a negative correlation of the population density of solitary-mining species of the genus *Eriocrania* and the total content of nitrogen in leaves. Drought affected the attack negatively. The definite effect of the content of sulphur in leaves (1.5–4.9 mg/g DM) was not proved. The lower number of leaves with two caterpillars in variants with increased nitrogen nutrition and with drought stress can be a result of the lower attractiveness of these birch trees for females laying eggs and decreased population density of *E. semipurpurella* (Step.) and *E. sparrmannella* (Bosc) even under natural conditions (Kula, Kaňová 2005). Although we determined the lower content of nitrogen in birch leaves in stands with the application of 3 and 6 t/ha dolomitic limestone as compared with the control, generally, it corresponds to the content of nitrogen (15–31 mg/g) determined under conditions of controlled stress (Kula, Kaňová 2005).

Phytophagous mites of birch occur above all at altitudes of 500–600 m, but with a certain regional variance and different long-term fluctuation, which [according to a hypothesis expressed by Kula et al. (2008b)] can be related to site conditions, changing

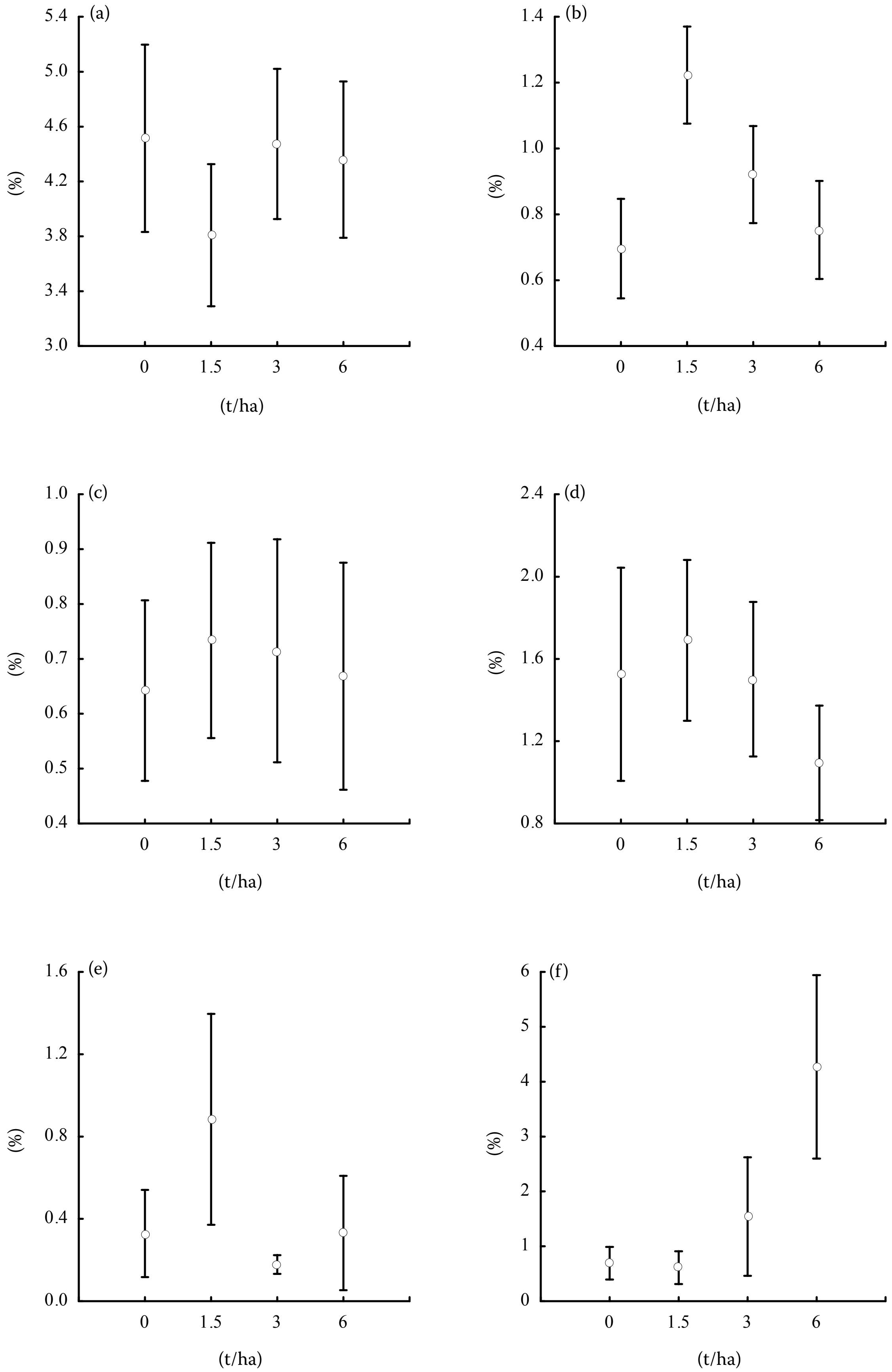

Fig. 1 a–f. The proportion of freely living caterpillars and hymenopterous larvae (a), Curculionidae (b), *Coleophora serratella* L. (c), *Eriocrania* sp. (d) in the defoliation of birch (%) and the proportion of *Acalitus rudis* (Can.) (e), *Eriophyes leionotus* (Nal.) (f) depending on the applied dose of dolomitic limestone (t/ha)

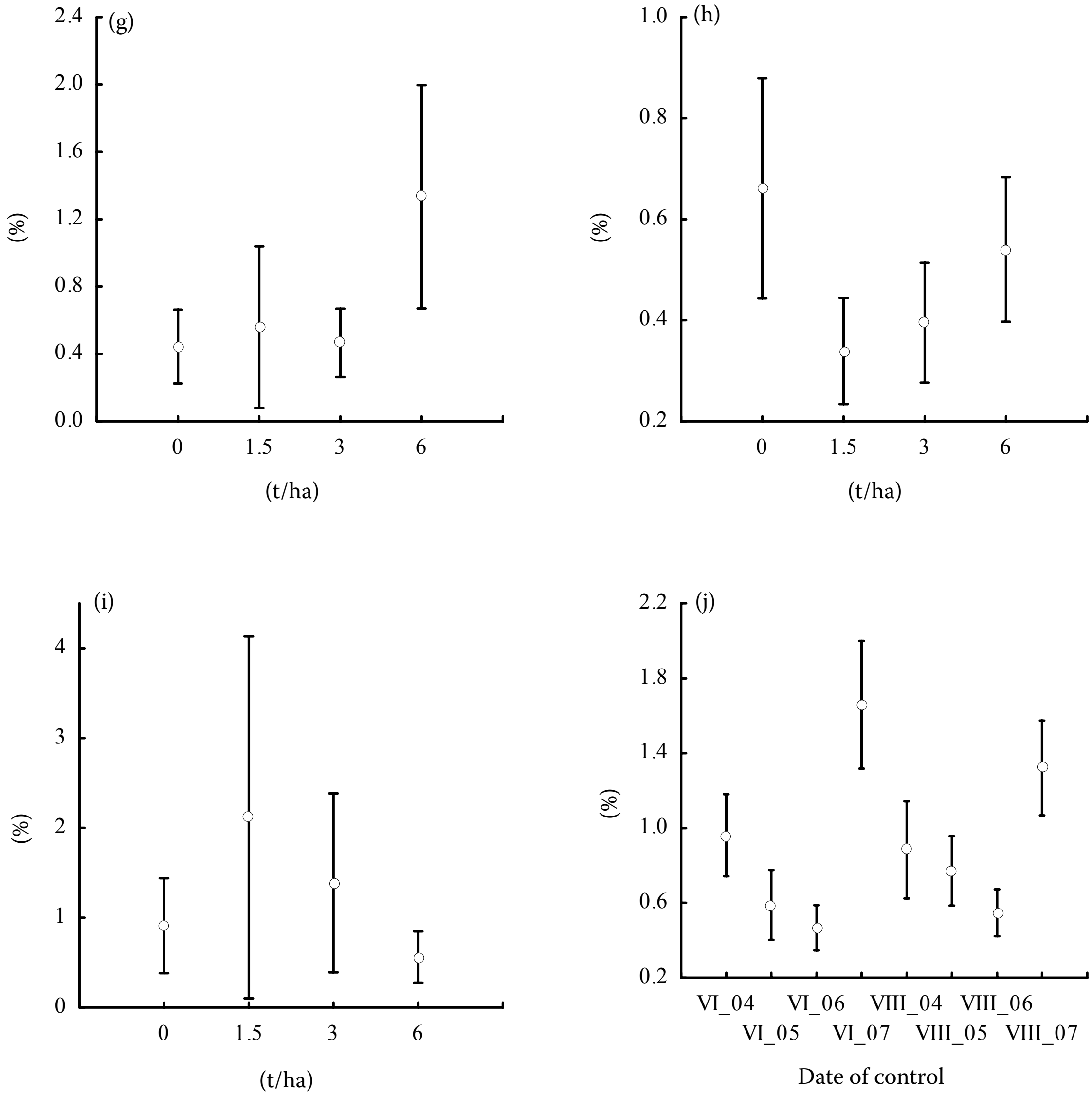

Fig. 1 g–j. The proportion of the rust *Discula* (g) in damage to leaves of birch (%) and birch leaves disturbed by disintegration (h), yellowing leaves of birch (i) depending on the applied dose of dolomitic limestone (t/ha) and the proportion of Curculionidae depending on the date of the control (Buttersteig 2004–2007)

air pollution load and thus also the chemistry of leaves.

In *Acalitus rudis* (Can.), a deviation in the abundance of leaf attack occurred at site 5 with the application of 1.5 t/ha dolomitic limestone (Fig. 1e). In *Eriophyes leionotus* (Nal.), we noted changes in population dynamics (increase in 2006–2007), but without statistical significance. The abundance of leaf attack on plots with higher inputs of dolomitic limestone (2005–2007) with statistical significance between the control or low applications and maximum application (6 t/ha) is very interesting (Fig. 1f).

The attack of assimilatory organs of birch by rusts of the genus *Discula* is affected by a number of factors (altitude, humidity, temperature) (Kula et al. 2002a,b; Kula 2006b). At the generally low occurrence, it is interesting that in both stands with the application of 6 t/ha dolomitic limestone the presence of the rust was markedly increased both in the spring and summer aspect with the subsequent decline and nearly statistical significance (Fig. 1g). Nevertheless, it is not possible to draw a conclusion that high inputs of dolomitic limestone would result in its development. Its response at heavy occurrence and optimum climatic conditions will be decisive for its development.

The disintegration of leaves for non-specific reasons (abiotic, physiological disorders) was not dependent on the aspect. The higher proportion of damaged leaves occurred in stands without liming and at both localities with the maximum dose of dolomitic limestone. An increase in the leaf disturbance with higher application dose was indicated, however, it was not statistically proved (Fig. 1h). The same evaluation is accepted in physiological disorders causing colour abnormalities (yellowing) (Fig. 1i) which can be related to drought stress and changes in the content of nitrogen in leaves. In other biotic pests, which were identified in low proportions, it has not been possible to use a more detailed evaluation yet.

CONCLUSION

In the period of 2004–2007, the impacts of the application of dolomitic limestone on the elimination or activation of phytophages or other types of damage resulting in the loss of assimilatory organs did not become evident. No significant changes in the fluctuation (expressed indirectly by the extent of damage to assimilatory organs) of an undetermined hymenopterous larva (summer increase), weevils (spring and summer decline and increase in 2007), *C. serratella* (decline), *Eriocrania* sp. (increase), mites *A. rudis* (increase), *E. leionotus* (increase 2006–2007) were recorded.

Only significant signs of a positive response to higher doses of dolomitic limestone characterized the mite *E. leionotus.*

References

CATES R.G., 1980. Feeding patterns of monophagous, oligophagous, and polyphagous insect herbivores: The effect of resource abundance and plant chemistry. Oecologia (Berlin), *46*: 22–31.

CLARIDGE M.F., WILSON M.R., 1978. British insects and trees: a study in island biogeography or insect/plant coevolution? American Naturalist, *112*: 451–456.

FEENY P.P., 1970. Seasonal changes in oak leaf tannins and nutrients as a cause of spring feeding by winter moth caterpillars. Ecology, *51*: 565–581.

HÅGVAR S., AMUNDSEN T., 1981. Effects of liming and artificial acid rain on the mite (*Acari*) fauna in coniferous forests. Oikos, *37*: 7–20.

HRDLIČKA P., KULA E., 2004. Obsah prvků v listech břízy při odlišných ročních srážkových úhrnech v imisním území transektu Litvínov. Sborník z konference Výsledky lesnického výzkumu v Krušných horách v roce 2003, Teplice 22. 4. 2004. Opočno, VÚLHM, VS Opočno: 120–129.

HRDLIČKA P., KULA E., 2006. Obsah síry a jejích forem v listech břízy (*Betula pendula* Roth) v imisní oblasti Krušných hor a Děčínské pískovcové vrchoviny (1994 a 2004). In: SLODIČÁK M., NOVÁK J. (eds), Lesnický výzkum v Krušných horách. Recenzovaný sborník z celostátní vědecké konference, Teplice 20. 4. 2006. Opočno, VÚLHM, VS Opočno: 153–162.

HRDLIČKA P., KULA E., 2007a. Effect of liming on element content in leaves of birch (*Betula pendula* Roth). Reviewed Proceedings from the National Scientific Workshop Forestry Research in the Ore Mts., Teplice 19. 4. 2007. Brno, Ediční středisko MZLU: 19–25.

HRDLIČKA P., KULA E., 2007b. Obsah prvků v asimilačních orgánech břízy *Betula pendula* Roth a jejich dynamika (1995–2007). [Výzkumná zpráva.] Brno, MZLU, LDF: 1–32.

HUHTA V., 1979. Effects of liming and deciduous litter on earthworm (Lumbricidae) populations of a spruce forest, with an inoculation experiment on *Allolobophora caliginosa.* Pedobiologia, *19*: 340–345.

KORICHEVA J., HAUKIOJA E., 1995. Variations in chemical composition of birch foliage under air pollution stress and their consequences. Environmental Pollution, *88*: 41–50.

KULA E., 2000. Minovači rodu *Eriocrania* Zeller – škůdci břízy s gradačním potenciálem. Journal of Forest Science, *46*: 27–33.

KULA E., 2005. Role biotických škodlivých faktorů v dynamice zdravotního stavu porostů břízy (*Betula pendula* Roth) v imisních oblastech. In: KULHAVÝ J., SKOUPÝ A., KANTOR P., SIMON J. (eds), Sborník významných výsledků institucionálního výzkumu LDF MZLU v Brně 1999–2004. Kostelec nad Černými lesy, Lesnická práce, s. r. o.: 239–246.

KULA E., 2006a. Geometridae in stands of substitute species with the dominant position of birch. Journal of Forest Science, *52*: 197–207.

KULA E., 2006b. Činitelé ovlivňující stabilitu porostů břízy ve východním Krušnohoří. In: SLODIČÁK M., NOVÁK J. (eds), Lesnický výzkum v Krušných horách. Recenzovaný sborník z celostátní vědecké konference, Teplice 20. 4. 2006. Opočno, VÚLHM, VS Opočno: 111–144.

KULA E., 2007a. Caterpillars of the crown fauna of stands of substitute tree species. Folia Oecologia, *34*: 30–41.

KULA E., 2007b. Motýli porostů náhradních dřevin v imisním území Sněžníku. Kostelec nad Černými lesy, Lesnická práce, s. r. o.: 1–107.

KULA E. et al., 2002a. Aktuální zdravotní stav porostů břízy a jeho variabilita ve východním Krušnohoří a Děčínské vrchovině. [Výzkumná zpráva.] Brno, MZLU, LDF: 1–48.

KULA E., STIEBER I., VÍCHA Z., 2002b. Listové skvrnitosti břízy a možnosti jejich eliminace. Sborník z konference Výsledky lesnického výzkumu v Krušných horách v roce 2001, Teplice 14. 3. 2002. Jíloviště-Strnady, VÚLHM: 93–102.

KULA E. et al., 2004. Význam břízy pro setrvalý rozvoj ve východním Krušnohoří. [Výzkumná zpráva.] Brno, MZLU, LDF: 1–147.

KULA E., KAŇOVÁ D., 2005. Žír housenek *Eriocrania* spp. (Eriocranidae, Lepidoptera) na břízách (*Betula pendula* Roth) vystavených zvýšené depozici N, S a stresu suchem. [Výzkumná zpráva.] Brno, MZLU, LDF: 1–12.

KULA E., MATĚJKOVÁ R., 2007. Soil fauna and its response to liming. Reviewed Proceedings from the National Scientific Workshop Forestry Research in the Ore Mts., Teplice 19. 4. 2007. Brno, Ediční středisko MZLU : 26–36.

KULA E., PRAŽANOVÁ J., 2007. Dynamics of factors causing defoliation of birch (*Betula pendula* Roth) in the eastern Krušné hory Mts. (1995–2006). Reviewed Proceedings from the National Scientific Workshop Forestry Research in the Ore Mts.,, Teplice 19. 4. 2007. Brno, Ediční středisko MZLU: 160–172.

KULA E., PRAŽANOVÁ J., ZĄBECKA M., 2006. Aktuální zdravotní stav porostů břízy a dynamika změn v závislosti na faktorech působících defoliaci (1995–2006). [Výzkumná zpráva.] Brno, MZLU, LDF: 1–42.

KULA E., BUCHTA I., HADAŠ P., 2008a. Effects of site conditions on the occurrence of *Acalitus rudis* (Canestrini) and *Aculus leionotus* (Nalepa) (Acarina, Eryophyidae). International Journal of Acarology, *34*: 155–166.

KULA E., PEŠLOVÁ A., BUCHTOVÁ D., 2008b. Vliv dusíku na výběr potravy listohlodem stromovým (*Phyllobius arborator* Herbst). Journal of Forest Science, *54*: 17–23.

MATTSON W.J., 1980. Herbivory in relation to plant nitrogen content. Annual Review of Ecology and Systematics, *11*: 163–196.

NIEMELÄ P., HAUKIOJA E., 1982. Seasonal patterns in species richness of herbivores: Macrolepidopteran larvae on Finnish deciduous trees. Ecological Entomology, *7*: 169–175.

RHOADES D.F., 1979. Evolution of plant chemical defence against herbivores. In: ROSENTHAL G.A., JANZEN D.H. (eds), Herbivores. Their Interaction with Secondary Plant Metabolites. New York, Academic Press: 3–54.

RUNDGREN S., 1994. Earthworms and soil remediation: liming of acidic coniferous forest soils in Southern Sweden. Pedobiologia, *38*: 519–529.

SCHNAIDER Z., 1991. Atlas uszkodzen drzew i krzewów powodowanych przez owady i roztocze. Warszawa, PWN: 1–318.

STRONG D.R. Jr., LEVIN D.A., 1979. Species richness of plant parasites and growth form of their hosts. American Naturalist, *114*: 1–22.

UHLÍŘOVÁ H., KAPITOLA P., 2004. Poškození lesních dřevin. Kostelec nad Černými lesy, Lesnická práce: 1–288.

WEBER M., EISENBEIS G., 1992. Auswirkungen der Waldkalkung auf die Bodenmakrofauna. Ergebnisse aus einem Koefern-Buchen-Standort im Pfälzer Wald. Mitteilungen aus der Forstliche Versuchsanstalt Rheinland-Pfalz, *21*: 175–188.

WINTER V.K., 1990. Auswirkungen der Waldkalkung auf oberirdisch lebende Insekten. Forst und Holz, *6*: 148–151.

Received for publication May 15, 2008
Accepted after corrections July 4, 2008

Reakce fytofágů břízy (*Betula pendula* Roth) na vápnění

ABSTRAKT: V průběhu let 2004–2007 se neprojevil dopad kompenzačního vápnění při aplikační dávce 1,5–3–6 t/ha vápnitého dolomitu na eliminaci nebo aktivizaci fytofágů či jiných typů poškození, vedoucí ke ztrátě asimilačních orgánů. Byl zaznamenán posun v populační dynamice vyjádřený nepřímo rozsahem poškození asimilační plochy u žíru nedeterminované housenice (letní vzestup), nosatců (jarní i letní ústup a vzestup v r. 2007), *Coleophora serratella* (ústup), *Eriocrania* sp. (vzestup), roztočů *Acalitus rudis* (vzestup), *Eriophyes leionotus* (vzestup 2006–2007). Pouze náznak pozitivní reakce na vyšší dávky vápnitého dolomitu charakterizoval roztoče *Eriophyes leionotus.*

Klíčová slova: bříza *Betula pendula* Roth; vápnění; vápnitý dolomit; fytofágové; *Eriophyes leionotus*

Corresponding author:

Prof. Ing. Emanuel Kula, CSc., Mendelova zemědělská a lesnická univerzita, Lesnická a dřevařská fakulta, Lesnická 37, 613 00 Brno, Česká republika
tel.: + 420 545 134 127, fax: + 420 545 211 422, e-mail: kula@mendelu.cz