Forest Systems
26(1), e011, 8 pages (2017)
eISSN: 2171-9845
https://doi.org/10.5424/fs/2017261-10365
Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria (INIA)

RESEARCH ARTICLE

OPEN ACCESS

Work accidents during cable yarding operations in Central Europe 2006 – 2014

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Abstract

Aim of study: This study is focused on detailed analysis of accidents in yarding during the years 2006–2014. There is still not enough information about such accidents in Central Europe in the literature available.

Area of study: We collected the data on occupational accidents recorded in timber yarding from the databases of the Slovak state forest enterprise.

Material and Methods: The data on occupational accidents were recorded according to actual European Regulation, the form of the record meets the requirements of the ESAW (European Statistics on Accidents at Work) methodology. To analyze the data, we used the multiple regression and correlation analysis, contingency tables, and a χ^2 –test.

Main results: Almost half of the accidents were the foot injuries and the most frequent type of injury was fracture of a bone. The most hazardous operation was yarding. Most of the accidents occurred between 13^{01}-14^{00} h (22 %). The most frequent agent causing accidents were Particles, dust, splinters, fragments, etc. (14.05 by ESAW).

Research highlights: This study informs about the most important risk factors in timber yarding, the most hazardous parts of shift, as well as the days when the most accidents occur during the week, and as such contributes to better understanding of how the accidents happen in timber yarding. The information can be subsequently used in knowledge-based improvement of safety trainings in forest enterprises.

Keywords: cable yarder; timber logging; work accident.

Citation: Allman, M., Jankovský, M., Allmanová, Z., Ferenčík, M., Messingerová, V., Vlčková, M., Stoilov, S. (2017). Work accidents during cable yarding operations in Central Europe 2006–2014. Forest Systems, Volume 26, Issue 1, e011. https://doi.org/10.5424/fs/2017261-10365.

Received: 26 Aug 2016 **Accepted:** 07 Mar 2017

Funding: This paper was financed by VEGA project number 1/0783/15 "Prediction and projection of risks of soil disturbance by forest harvesting as a basis for temporal and spatial planning of forest maintenance in the conditions of climate change.

Competing interests: The authors have declared that no competing interests exist.

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Introduction

Forestry covers many occupations, out of which forest harvesting is the most hazardous with the most fatal and severe accidents out of all occupations in the industry (Kawachi *et al.*, 1994; Myers & Fosbroke, 1994; Paulozzi, 1987; Salisbury *et al.*, 1991; Parker *et al.*, 2002; Evanson *et al.*, 2001). Occupational risks in forest harvesting is a combination of natural and material agents (Melemez, 2015), due to the fact that the workers carry out their jobs in a physically demanding environment, such as extreme climatic conditions, falling trees, fatigue, hazardous tools, heavy machinery, and frequently work isolated (Crowe, 1986; Slappendel *et al.*, 1993; Peters, 1991; Foley, 1994; Gandaseca & Yoshimura, 2001; Parker *et al.*, 2002; Lilley *et al.*, 2002; Klun & Medved, 2007; Mitchell *et al.*, 2001).

Mechanizedor non-mechanized logging is particularly difficult on steep slopes, where the risk of occupational accident is very high (Tsioras *et al.*, 2014). Slope is an important factor when considering the optimal harvesting technology, though cable yarding is considered the most suitable technology in slopes

steeper than 40% from the environmental point of view on one hand, and occupational safety on the other (Visser & Stampfer, 1998). This slope is considered a threshold, beyond which it is safer and environmentally friendly to use cable yarding than using ground-based skidding technologies (Tajboš *et al.*, 2012), as it causes less harvesting induced erosion than ground based machinery (Worell *et al.*, 2011). Cable yarding is not a riskless technology, because mostly during mounting and dismounting the yarder, there is an increased risk of slip and fall injuries, or accidents caused by the cable, which is one of the reasons why sustainable forestry needs new set of standards in forestry operations (Tsioras *et al.*, 2011).

Using yarders is advantageous mainly in mountainous countries, to which we place, among other countries, Slovakia, as more than 40% of its total forest area meets the above mentioned criterion on slope steepness, and should be therefore yarded with cable yarders (Messingerová *et al.*, 2009). Despite the favorable natural conditions, cable yarding is not popular in Slovakia at the moment, as only around 7–8 % of the total harvested volume is yarded. In the Slovak state forest enterprise (SFE), about 400 000 m^3 of timber was yarded in 2015, which is about 10–11% share of the total harvested timber in the enterprise (Lesy, 2016).

However, Slovak forestry was a pioneer in yarding timber once, as during the 1950s and 1960s 27% of total harvested timber (1.1 million m^3 out of 4.1 million m^3) was yarded. The decline of this technology (10% in 1975, 3.5% in 1985, and 1.4% in 1998) was due to the technological advancement of the ground-based technologies in the 1970s, which enabled lower operational costs in steep terrains, as well as low regard for the environment (Lukáč *et al.*, 2001).

In this study we focused on determining the temporal distribution of accidents in yarding, identifying the agents causing accidents, and modes of injuries, as well as identifying which groups of workers were the most prone to accidents in SFE during the years 2006–2014.

Material and methods

Slovak state forest enterprise manages 1.04 million ha (54% of the total area) of Slovak forests (Green Report Brochure, 2015). Annual cut in SFE varied between 4–5 million m^3, depending on the amount of incidental fellings (Green Report Brochure, 2015). Slovak state forest enterprise is divided into 32 forest districts located around the country. Harvesting and construction works that are not outsourced are supplied by the Enterprise of Forest Technique in Banská Bystrica (EFT). This enterprise harvested circa 5% of the total volume, mainly by yarders and cut-to-length technologies. The remaining volume was harvested by contractors.

In the year 2015, EFT owned and operated 20 cable yarders — three Steyr KSK 16, 11 Larix 3T, four Larix Lamako, one Larix Kombi H, one Mounty 4000. Individual yarders were operated by a crew of four people — a chainsaw worker, choker setter, yarder operator at the bottom station, and skidder operator. Work was organized into day shifts (eight hours per day, five days per week). The number of employees working with cable yarders during the years 2006–2015 gradually increased from 48 to 80 people (Table 1), following the increasing number of yarders owned by the company. The Enterprise of Forest Technique yarded more than 100 000 m^3 of timber and another 300 000 m^3 were yarded by contractors.

We collected the data on occupational accidents recorded in timber yarding from the databases of the SFE. The company records all occupational accidents according to the Regulation n. 500/2006 Coll., through which the Regulation of the European parliament and Council n. 89/391/EEC on the introduction of measures to encourage improvements in the safety and health of workers at work was transposed into Slovak legislation. The form of the record meets the requirements of the ESAW (2013) methodology. The following information was recorded when an accidents was reported: (i) data on the injured employee (age, sex, years of practice, etc.); (ii) regional department of the EFT in which the accident occurred; (iii) date of the accident (day, month, and year of the accident); (iv) the place of the accident (Forest district); (v) the operation at which the accident occurred (yarding, felling, de-limbing, yarder maintenance, bucking, and mounting or dismounting

Table 1. The number of yarders owned by Forestry machinery branch of Slovak state forest enterprise, the number of people employed in yarding, and the volume of yarded timber in the years 2006–2015

Year	Number of yarders	Number of employees	Volume of yarded timber (m^3)
2006	12	48	65 963
2007	14	56	73 321
2008	14	56	74 448
2009	14	56	74 924
2010	15	60	77 608
2011	16	64	78 865
2012	17	68	83 032
2013	19	76	97 649
2014	19	76	97 635
2015	20	80	100 183

the yarder); (vi) body part injured (arm, hand, leg, foot, ribs, back, shoulder, pelvis, chest, and multiple injuries); (vii) type of injury (fracture, contusion, scrape, laceration, wrench, cut, stretch, concussion, internal injury, rupture, blunt trauma, dislocation, amputation); (viii) severity of the injury (minor – up to six days sick leave; severe – more than six days sick leave; fatal); (ix) material agent (e.g. hand tools, machines, lifting equipment, vehicles, etc.); (x) mode of injury (e.g. slippage of material agent, horizontal motion of the victim, vertical motion of the victim, etc.)

To analyze the data, we used the multiple regression and correlation analysis, contingency tables, and a χ^2 –test.

Results

During the observed period, 72 occupational accidents happened in the SFE. Forty-four of these accidents (62%) were minor injuries, 27 (38%) were severe injuries, and one (1%) was fatal. The total annual count of accidents was from five, in 2008, up to 11, in 2014 (Fig. 1). The mean count of accidents was nine (six minor injuries and three severe injuries). The fact that in the observed period of nine years only one fatal accident occurred shows that the crews followed the occupational safety standards thoroughly and that when the standards are kept, timber yarding is a safe technology.

The greatest count of accidents happened in the second half of the observed period, when 53% of all accidents occurred, when the total harvested volume of timber in the company, increased (Fig. 1). We studied the relationship between the number of accidents occurring, total harvested volume of timber, and the share of incidental fellings through multiple regression and correlation analysis. The analysis proved a strong relationship with the correlation coefficient of 0.79 ($p = 0.003$). Circa 63% of the variability of the number of accidents was explained through the variability of the share of incidental fellings and the annual total harvested volume of timber (Table 2). The development of the number of yarders in operation, the number of employees employed in timber yarding and the number of accidents during the observed period is also interesting. On Fig. 2 we can see the increasing number of yarders and employees and the fluctuating number of accidents on average, one accident happened to every eight employee on every second yarder.

Two thirds of the accidents were hand and foot injuries, 13 % were head and neck injuries, 8% were torso injuries, 7 % multiple injuries, and 6 % shoulder injuries. Almost half of all accidents (33; 46 %) were foot injuries, from which 15 accidents (46 %) happened during yarding, nine (27 %) during felling, and eight (24 %) during de-limbing. During bucking, in the bucking yards, only one accident happened. Out of 15 hand injuries, seven (47 %) injuries happened during felling. Head and neck injuries most commonly happened during de-limbing. The most hazardous operation was yarding, during which 30 (42%) accidents happened, followed by felling with 22 accidents (30%), and de-limbing

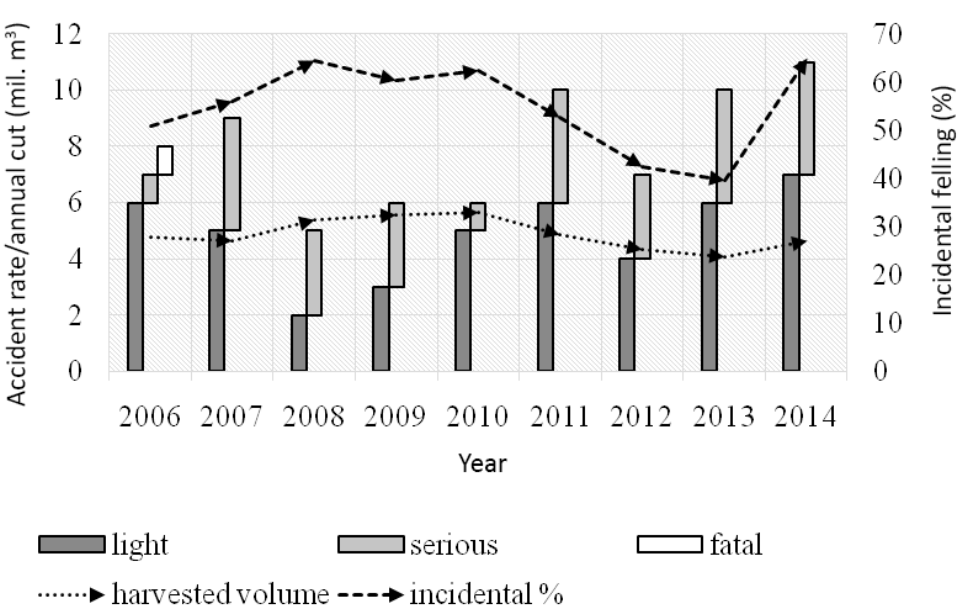

Figure 1. The number of accidents in timber yarding according to their severity during the years 2006–2014 in Slovak state forest enterprise; volumes of timber harvested in particular years; share of incidental fellings in particular years.

Table 2. Relationship between the number of accidents, the annual volume of harvest, and the share of incidental fellings;

Regression results R= 0.79; R^2=0.63 F(2.6)=5.09 p<0.05 Standard error: 1.49						
N=9	**b***	**Standard error of b***	**b**	**Standard error of z b**	**t(6)**	**p-value**
Intercept			22.314	4.788	4.66	0.003
Volume of harvest (m^3)	-1.150	0.387	-4.440	1.495	-2.970	0.025
Share of incidental fellings (%)	0.593	0.387	0.135	0.088	1.531	0.177

with 15 accidents (21%). In other operations (repairs, maintenance, bucking, mounting and dismounting) five accidents were recorded.

The employees most frequently fractured their bones, 20 such injuries were recorded by the Slovak state forest enterprise, followed by 13 (18%) contusions, and nine (13%) of scrapes and lacerations each (Fig. 3). All of these injuries resulted from the nature of work in timber yarding, where employees work with heavy and moving loads and in difficult terrains.

Most of the accidents occurred before noon — 44, or 61% of the total count (Fig. 4). The most hazardous however, was the time between 13:01 and 14:00, when 16 (22%) accidents happened, followed by pre-noon hours between 8:01 and 9:00 with 14 (19%) accidents, and 11:01 and 12:00 with 13 (18%) of accidents. From the total count of pre-noon accidents, 25 were minor, 18 were severe, and one was fatal. In the afternoon, 19 accidents were minor and nine were severe. Despite the culmination between 13:01 and 14:00 we can conclude that working in the afternoon was less hazardous than working in the morning and pre-noon. We tested whether the working hour affected the severity of the injury, but through the χ^2–test we determined that this variable has no significant effects on the severity of the injury (χ^2=15.13<23.68, df=14, p=0.37).

The distribution of accidents throughout the week can be seen in Fig. 5. From the records we concluded that the most accidents (23; 32 % of the total count) occurred on Tuesday. On the other hand, least accidents (9; 14%) happened on Monday. Statistical analyses did not confirm any relationship between the day of week and the severity of injuries occurring throughout the week (χ^2 = 8.98<15.51, df = 8, p = 0.34).

The number of accidents in individual months varied from two (3% of total count) in December

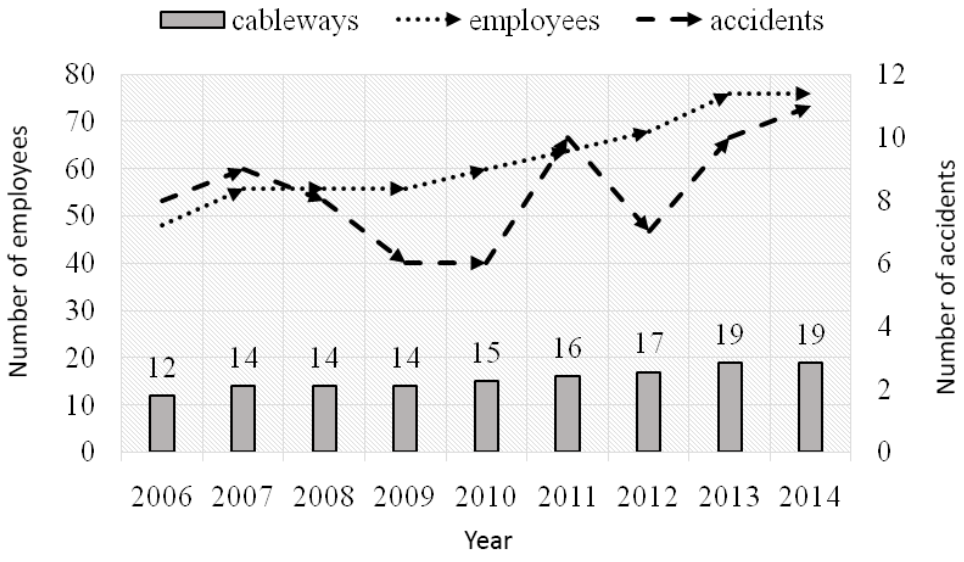

Figure 2. The number of cable yarders, the number of employees and accidents during the years 2006–2014.

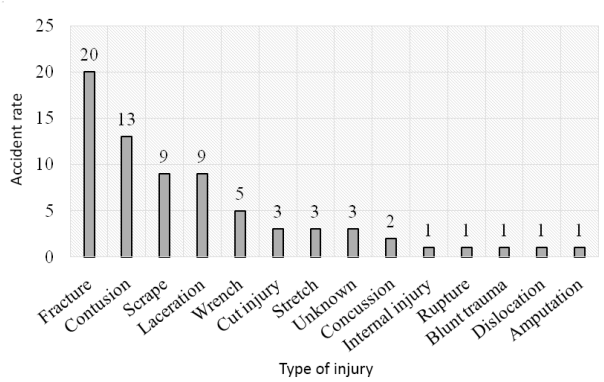

Figure 3. The frequency of occupational accidents according to the type of injury.

to 12 (17%) in June. As can be seen in Fig. 6, the number of accidents is more or less even, with extremes in February and June. Increased accident rate in February could be due to increased risk in this month — unsuitable climatic conditions, slippery terrain, etc. Similarly, climatic conditions were also the most feasible factor for increased accident rate in June, when mean outside temperatures reach 30°C. The lowest accident rate on the other hand, was recorded in December, and this was most likely caused by the winter holidays. We tested whether any differences in the severity of injuries showed in particular months, however through the χ^2–test we determined there was no significant effect of the month of year on the severity of injuries sustained in an accident ($\chi^2 = 23.94 < 33.92$, df = 22, p = 0.35).

The most frequent agent causing accidents were Particles, dust, splinters, fragments, etc. (encoded 14.05 by ESAW) (Fig. 7), which caused 26 (36% of the total count) accidents. Another 18 accidents (25 %) were due surfaces at ground levels (encoded 01.02 by ESAW), followed by 15 accidents (21%) caused by loads transported by mechanical handling devices. Both mechanical hand tools for sawing (07.02) and hand tools for drilling, turning, or screwing (06.05) caused four accidents each (6% each). Numerous other material agents caused one accident each, the details can be seen on Fig. 7. As for the mode of injury, 41 accidents (57% of the total count) happened when the victims were moving, 13 (18%) happened when the material agents fell from above, six accidents (8%) happened when the victims lost control of their hand tools, and four (6%) happened due to contact with a sharp agent.

Practice is an important factor, which has fundamental effect on the frequency of accidents. Victims with less practice had accidents more frequently, 49 (68%) accidents happened to victims with less than five years of practice and another 10 accidents (14%) happened to victims with 5–10 years of practice (Fig. 8). The figure shows that the decrease of occupational accidents is exponential. The χ^2–test also showed that length of practice significantly affects the severity of accidents the victims had ($\chi^2 = 27.71 > 5.10$, df = 14, p = 0.02).

Discussion

Österreichische Bundesforste (2004) state that in the year 2003 increased frequency of occupational accidents was reported, mainly due to increased incidental fellings, which corresponds with our results. Eiwegger (2009)

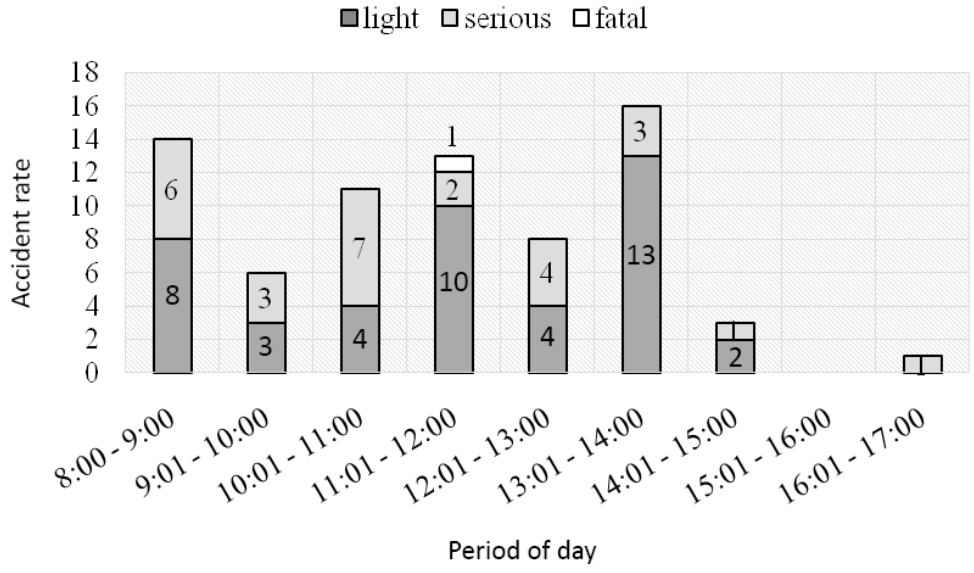

Figure 4. Frequency of occupational accidents according to their severity and the hour when the accidents happened.

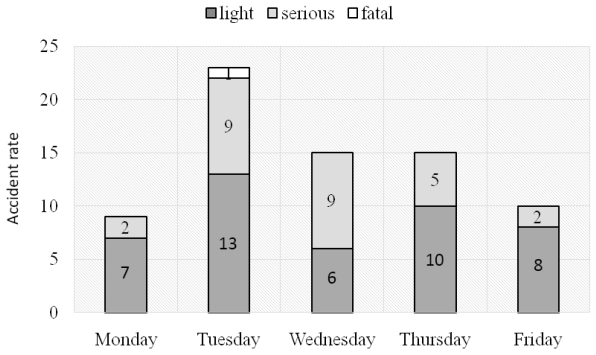

Figure 5. Frequency of occupational accidents according to their severity and the day of week when the accidents happened.

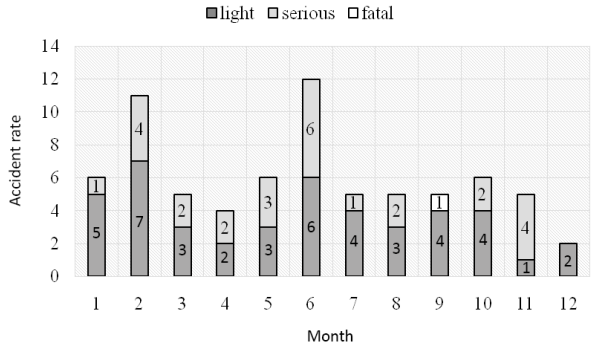

Figure 6. Frequency of occupational accidents according to their severity and the month of year when the accidents happened.

reported similar results, stating that due to the increased volume of incidental fellings, more employees worked in Austrian state forests. This increase in employment changed the structure of yarder crews, which caused increased frequency of accidents occurring that year (Odenthal–Kahabka, 2005; Sonnleitner & Seebacher, 2003).

Potočnik *et al.* (2009) and KWF (2014) report that contusions were the most frequent types of injuries, followed by dislocations, cuts, and fractures. To compare, in Austrian state forests, as well as Germany fractures constituted 9% of the total count of accidents, whereas in Slovenia it was 6%. Contusions constituted 40% of all accidents in Austria, 56% in Slovenia (Potočnik *et al.*, 2009), and 41% in Germany (KWF, 2014). Lindroos & Burström (2010) state that fractures are the most frequent types of injuries (25% of the total count of occupational accidents), damage to teeth (23%), and dislocations (19%). According to statistics conducted by hospitals, more than one third of all patients were admitted with contusions (Lindroos & Burström, 2010). The differences between countries, and our results were

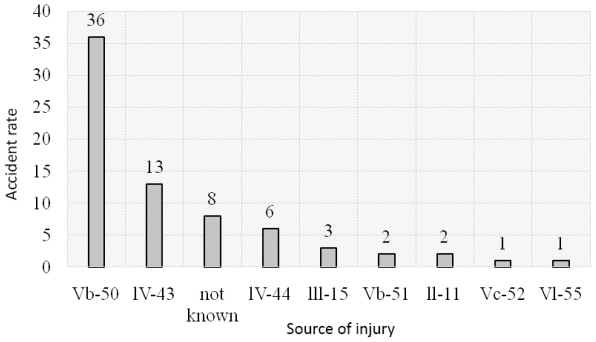

Figure 7. Frequency of occupational accidents according to individual agents causing the injuries according to the Regulation n. 500/2006 Coll., Vb-50 – Loads (material – moved or otherwise manipulated objects) –injuries caused by loads, IV–43 – roads, including railways, slips of employees on flat terrain, IV–44 – spaces inside buildings, communication spaces, floors, slips/falls of employees on flat terrain, III–15 - circular saws, frame saws and other saws for wood, Vb-51 – material and objects (which caused the injury with its sharp edges when manipulated, walk around etc.), II-11 – lifting and transport devices – tools, Vc-52 – small pieces of materials or tools flying away during after breaking the objects or during hand processing of materials (eye impact, skin perforation…), VI-55 – small hand tools.

caused by the differences in the technologies used in yarding.

Regarding the distribution of occupational accidents throughout the day, Tsioras *et al.* (2014) reported results similar to ours. However, they found that most accidents occur between 10:00 and 10:59 and 11:00 to 11:59. Bentley *et al.* (2005); Wetmann (2005); Fischer (1991); Stadlmann (1991) state that most workers work most intensively between 10:00 to 12:00. Bentley *et al.* (2002); Kirk (1996); Parker & Ashby (2005) state that fatigue of workers in this period increases, due to depleting the energy the workers received from breakfast begins to deplete and dehydration often occurs. Camino–Lopéz *et*

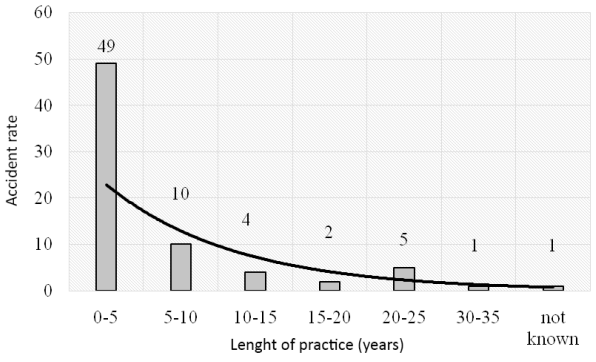

Figure 8. Frequency of occupational accidents according to the practice the injured employee had.

al. (2011) state that the accident rate is connected with food intake. In our case, the most accidents happened between 13:01 and 14:00, whereas Tsioras *et al.* (2014) report culmination of frequency of accidents an hour later — between 14:00 and 14:59.

Tsioras *et al.* (2014) state that the most, almost one quarter, accidents happen on Monday and thereafter the accident rate decreases steadily until Sunday. Wetmann (2005) and Fischer (1991) state that Monday and Tuesday are the days when most accidents occur, which corresponds with our results. The authors state that the frequency of accidents on Friday was less than half of the frequency on any other day. Tsioras *et al.* (2011) report similar results. Jacke (1989) states that the increased number of accidents on Monday can be attributed to the change of occupations after the weekend (e.g. yarder operator can work as chainsaw worker the next week, etc.), he attributes higher accident rate on Wednesday to fatigue in the middle of the work week, and the decrease of accident rate at the end of the week to the fact that most workers work more than eight hours per day from Monday to Thursday and a shorter shift on Friday.

The most frequent mode of injury was that the victims fell or slipped. This result corresponds with the findings of Tsioras *et al.* (2014), who state that 36 % of accidents were falls or slips, followed by accidents caused by the material agent falling (23 %). These types of accidents are common in forestry, as reported by Driscoll *et al.* (1999). Falling material agents are a broad term, the agents can vary from small particles to whole stems of trees during yarding (Brodie & Ibrahim, 2010).

Conclusions

In this study we focused on the analysis of accidents occurring during timber yarding in Central Europe. Compared to other studies, the accident rate in particular years varied significantly, and the total accident count depended on the volume of harvested timber and share of incidental fellings in SFR. This study informs about the most important risk factors in timber yarding, the most hazardous parts of shift, as well as the days when the most accidents occur during the week, and as such contributes to better understanding of how the accidents happen in timber yarding. The information can be subsequently used in knowledge-based improvement of safety trainings in forest enterprises.

Acknowledgements

We would like to thank to Miroslav Slotta, director of Enterprise of Forest Technique in Banská Bystrica and to Ján Sokol from the same enterprise, who helped us with gathering the data for the research.

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