The game damages on agricultural crops in Croatia

Štete od divljači na poljoprivrednim kulturama u Hrvatskoj

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Abstract

Conflicts between wildlife and humans have been reported from all over the world, but in Croatia the extent and intensity of the conflict is increasing. Agricultural damage by game is a major concern for both agricultural and wildlife agencies at the national level. In this study 4,695 cases of game damage over a 4-year period were analysed. Results indicated that the total amount of economic impact on agriculture from game damage was significant. The distribution of payments shows that a majority of payments have lower economic value with an average amount of single payment being 477.08 €. The annual number of payments was found to have a negative correlation coefficient (-0.469) to the total payment amount for damages. According to the number of payments (68% of the number of payments) and the payment amount (60% of total payment amount), the crop most often damaged was maize. Analysis of the data found that there was a negative growth trend of payment frequency and total payment amount for grape vineyards. The correlation between yearly number of payments and yearly production was not calculated for any crop. The high seasonal nature of payments was a determent of seasonal regression using a dummy variable regression (r^2=0.93). A comparison of the monthly number of payments and monthly amounts is depicted by a time series using a seasonal line. The impact of wild boar damage on agriculture crops, in total, leads to the conclusion that this game species is a major problem. The results showed a specific subset of game damage in Croatia and, as such, it can be extrapolated to provide insight into the damage caused by wild boar in other countries.

Keywords: Croatia, agriculture, crop damage, wildlife - human conflict

Sažetak

Sukobi ljudi i divljih životinja zabilježeni su diljem svijeta. U Hrvatskoj se učestalost i intezitet ovih sukoba u poslijednjih nekoliko godina znatno povećava, a štete od divljači na poljoprivrednim kulturama predstavljaju rastući problem poljoprivrednih i lovačkih institucija na nacionalnoj razini. U radu je obrađeno ukupno 4,695 slučajeva šteta počinjenih u četverogodišnjem istraživanom periodu. Rezultati analize ovih podataka upućuju na ekonomski visoku značajnost počinjenih šteta. Distribucija isplaćenih odšteta ukazuje da je većina počinjenih šteta niže ekonomske vrijednosti te da je za pojedinačnu štetu prosječno isplaćeno 477.08 €. Utvrđena je negativna korelacija (0.469) između broja godišnjih isplata i visine odgovarajućih isplata. Prema broju isplata (68% ukupnih isplata) i isplaćenom iznosu (60% ukupno isplaćenog iznosa) kukuruz predstavlja dominantnu kulturu. Za razliku od kukuruza za vinograde je analizom podataka utvrđen negativan trend povećanja broja šteta i vrijednosti njihove odštete. Korelacija godišnjeg broja isplaćenih šteta s godišnjom produkcijom nije utvrđena niti za jednu analiziranu kulturu. Visoki sezonski karakter počinjenih šteta utvrđen je pomoću “dummy variable” regresije (r^2=0.93). Usporedba mjesečnog broja i vrijednosti isplaćenih šteta opisana je vremenskim nizom s linijom sezonskog utjecaja. Prikazani rezultati predstavljaju specifičan podskup počinjenih šteta od divljači u Hrvatskoj ukazujući na značajan utjecaj divljih svinja u štetama nad poljoprivrednim kulturama.

Ključne riječi: Hrvatska, štete na poljoprivrednim kulturama, štete od divljači

Introduction

The populations of game species are increasing both in numbers and in geographical distribution (Putman and Moore, 1998) and because of that, negative game-plants interactions are reported more frequently. Conflicts between humans and game have attracted the attention of ecologists, conservationists and community development researchers (Cai et al., 2008), and have been reported from all over the world. Problems include transmission of disease from wild populations to domestic animals, damage to forests by game ungulates, negative impacts on endangered flora and fauna, and road traffic accidents (Cahill et al., 2003). However, the most common problem is damage by game to agriculture crops which has resulted in higher economic losses (Schley et al., 2008). In many European countries compensation to farmers for crop damage exceeds several million € (Moore et al., 1999; Schley and Roper, 2003; Calange et al., 2004; Geisser and Reyer, 2004). With a daily need for food and a daily or seasonal migration, game have different impacts on their environment, which when found to be above the threshold of tolerance is known as game damage. Three different methods have been developed for reducing the impact of game damage (Geisser and Reyer, 2004). The first approach is to conduct an intensive harvest throughout the year. Another approach involves hunters offering supplemental food in the forest on a regular basis to keep the animals out of the farmland. The third method entails farmers installing electrical fences to stop animals from entering fields. The control of game damage has become an important component of wildlife management (Retamosa et al., 2008). Along with preventing game animals from damaging crops, some means of reducing agricultural production risk is often implemented. Insurance is one of the more frequent ways to reduce agricultural production risk (Meuwissen et al., 2001). Insurance is a method for neutralizing the negative financial losses from game damage where the insured pays a premium so that in case of damages, the insured will receive the appropriate compensation from the insurance company.. In cases where there are high implementation costs for preventing game damage, reducing agricultural production risk is an acceptable solution. The game population size (Conover, 2001), length of the border between crop field and forest (Retamosa et al., 2008) and population abundance (Schley et al., 2008) are some of the factors that have a bigger impact on damage frequency than the availability and production of agriculture crops. Comparing results of game damage research requires special attention to site specific ecological conditions that can affect research conclusions (Wilson et al., 2009). Social, territorial and economic difference among geographic regions makes comparisons even more complicated in number and value. Our objective was to estimate the game damage to agriculture crops on a nationwide basis. The results of this study may allow wildlife specialists to adopt a proactive approach to reducing game crop damage.

Material and methods

This study was carried out over the entire territory of Croatia, which is located between 42°23’ and 46°33’ Northern latitude and between 13°30’ and 19°27’ Eastern longitude, with a total surface area of 56.542 km². Data were collected from 2005 to 2008 which were provided by Croatian’s official insurance companies. Researchers analysed 4,695 cases of crop damage for which compensation was paid. Descriptive data analysis, grouped by year, included the number of payments, minimum and maximum value of damage payoff, average value of damage payment with standard deviation, median and mode value of damage payment and variance coefficient for damage payment value. The frequency of damage values are shown by crops, years and total, where the amount of payments are grouped according to which best describes the analysed data.

A one-way analysis of variance (ANOVA) with fixed effects was used to determine the difference of total damage payment amount between years using the statistical model $Y_{ij} = \mu + \tau_i + \varepsilon_{ij}$. Eventual determent differences between years were tested by the Tukey test (HSD). ANOVA results were obtained by using the GLM procedure. Correlation coefficient of yearly payment numbers and yearly payments value were also calculated. The dynamics of seasonal effect on the monthly damage value and number of damage reports on agricultural crops were represented by seasonal dummy regression and time series. For determining the seasonal effects of game damage, dummy variable regression was used and, for each season, one dummy variable was introduced which represented a value of 0 or 1 (Koop 2006). The regression model for seasonal dummy variable regression was $y_{ij} = \beta_0 + \sum_{j=0}^{11} \beta_j D_j + \varepsilon_i$. Spatial damage distributions were based on government defined county units which were calculated using the ratio between total payment amount and total agriculture area (in hectares).

Descriptive statistics, statistical analysis, statistical tests and results represented in shown figures were generated by SAS 9.2 for Windows (SAS Institute, 2007) and Microsoft SQL Server (Microsoft®, 2008) applications.

Results and discussion

Over a four year period 4,695 reports of game damage on agriculture crops were analysed for the entire area of Croatia. Compensation payments amounted over 2 million Euro. Seven different game species were listed by respondents as causing the worst problems in their respective states, wild boar (*Sus scrofa*), red deer (*Cervus elaphus*), fallow deer (*Dama dama*), roe deer (*Capreolus capreolus*), brown bear (*Ursus arctos*), badger (*Meles meles*) and brown hare (*Lepus europaeus*). The highest number of damages (1,217) were recorded in 2007, and the fewest number of damages (1,145) were recorded in 2005, which indicates a relatively small deviation over the years. The biggest payment amount was recorded in 2008 and the smallest payment amount was recorded in 2007 which amounts to a difference of 18,248.92 €. A big difference between analysed years is also expressed through high range and deviation in average yearly payment amounts. However, the variance coefficient, as a measure of relative dispersion, points to a much smaller variability for a single damage value among analysed years (Table 1).

Table 1. Descriptive indicators of heights paid losses to agricultural crops (N total number of payment, MIN smallest payment, MAX highest payment, $\bar{x}$ average value, STD standard deviation, M median, MOD, CV variability coefficient)
Tablica 1. Deskriptivni pokazatelji visine isplaćenih šteta na poljoprivrednim kulturama (N ukupni broj isplata, MIN najniža vrijednost, MAX najviša vrijednost, $\bar{x}$ prosječna vrijednost, STD standardna deviacija, M centralna vrijednost, MOD dominantna vrijednost i CV koeficijent varijance)

Year Godina	N	MIN	MAX	$\bar{x}$	STD	M	MOD	CV
2005	1,145	6.94	12,876.68	418.43	953.80	139.40	40.65	30.89
2006	1,168	9.49	9,061.34	372.04	849.12	128.23	162.60	30.92
2007	1,217	3.12	16,972.55	557.83	1,222.17	173.44	5,149.05	29.69
2008	1,165	8.54	18,252.03	564.31	1,226.82	154.80	5,149.05	29.46
All years Sve godine	4,695	3.12	18,252.09	477.08	1,076.71	148.80	5,149.05	30.58

According to the frequency of payment amounts, between 135 € and 678 € were the most common payment values.. Single payments with amounts bigger than 13,550.00 € were only recorded in 2007 and 2008. Payments bigger than 6,800.00 € represent only two percent of the total number of damages. 86% of the total number of payments were payments with a value of less than 678 €, which indicates a relatively small economic value for single game damage (Figure 1).

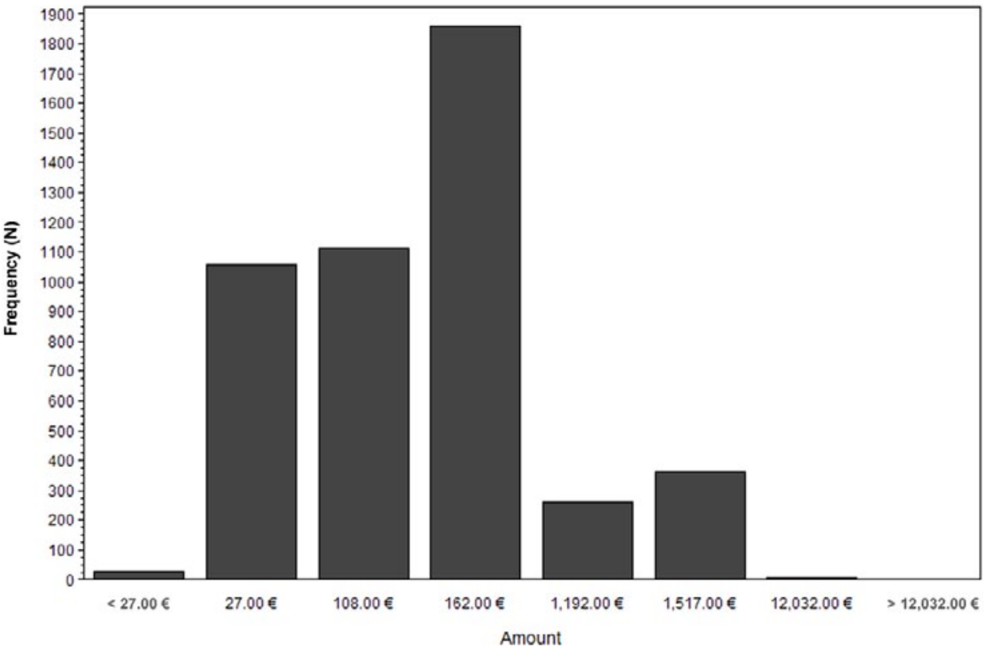

Figure 1. Frequency histogram level of payment of damages in analyzed period
Slika 1. Histogram frekvencija isplaćenih iznosa u analiziranom periodu

Our data suggests that in Croatia, damage seems to be more severe than in other parts of Europe. A mean value of 477.08 € per case is higher than in other studies. Schley et al (2008) investigated damage over a 10-year period in Luxemburg and found a mean of 396 € per case. Linderoth and Elinger (2002) investigated 808 cases of damage in Germany and found a mean of 328 €, whereas Geisser (2000) reported an even lower amount of roughly 145 € per case in Switzerland. Independent of economic value, damage to agricultural crops has a negative psychological impact on producers (Galhano-Alves, 2004). Average payment amounts, often shown by researchers, cover up the more significant impact of rare but economically very important damages (Treves, 2007).

The highest yearly payment amount, recorded in 2008 was 222,886.72 € higher than the lowest yearly payment amount which was recorded in 2006. The average annual payment amount was 559,977.49 €. Using variance analysis ($F=9.66$, $P_{0.05,3,4691}=2.61$, $P \leq 0.0001$), a significant difference between years for total payment amount was determined. Using the HSD test, the average yearly payment amount differences between years 2007 and 2008 as the first group and the second group of years 2005 and 2006 were determined (Table 2).

Table 2. The probability for $H_0 : \bar{x}_i = \bar{x}_j$, dependent variable amount paid damages to agricultural crops
Tablica 2. Vjerojatnost hipoteze $H_0 : \bar{x}_i = \bar{x}_j$, zavisna varijabla isplaćeni iznos za štete nad poljoprivrednim kulturama

i/j	2005	2006	2007	2008
2005		0.7171	0.0088	0.0051
2006	0.7171		0.0002*	<0.0001*
2007	0.0088	0.0002*		0.9989
2008	0.0051	<0.0001*	0.9989	

*P ≤ 0.005

A negative correlation coefficient (-0.469) between the yearly number of payments and the matching payment amounts for damages on agriculture crops showed that an increase in the value of total yearly payments is correlated with a slight decrease in the number of payments which, when also considering currency as a variable, points to inflation. By showing yearly payment amounts, growth of producer prices, especially in the agriculture sector during the second half of 2007 and first half of 2008, it is easy to see an increase in the total value of damages on agriculture crops. The high negative correlation coefficient found between yearly number of damages and total yearly production of potatoes (*Solanum tuberosum*) -0.784 and wheat (*Triticum* sp.) -0.846 that indicates that increase in their production isn't linked with increase in damage on those crops. For the remainder of analysed agricultural crops, there were no significant correlations between the number of damages and the annual production of those crops.

With a large share in the total payment value and in total number of damages greater than 60%, maize (*Zea mays*) is the most important agriculture crop from the standpoint of damages from game. Wherever maize is grown, it is almost always the most damaged annual crop (Sshley et al., 2008). The fact that maize is damaged more frequently and more severely than other cereals may be due to preferential consumption or may be due to denser vegetative cover. This was also suggested by Kristiansson (1985) who estimated that only 5-10% of crop destruction by game was a consequence of actual consumption, the rest was due to trampling. Besides maize, other economically important crops, with a total payoff amount bigger than 10%, are cereals (barley- *Hordeum vulgare*, oats- *Avena sativa*, rye- *Secale cereale*) and grape vine (*Vitis* sp.). The greatest interest in maize for game is before its maturation (Cerkal et al., 2009) what is recorded as the most frequent damages recorded in the months of August, September and October. Damage frequency distribution on pulses follows the distribution of damage number on maize but with smaller payment amounts. Damages on crops were recorded throughout 11 months of year.

The number of damages was the highest during the time of crop maturation and throughout May, June and July. The sudden decrease in the frequency of crop damage recorded between July and August and the disappearance of damage in

September was due to harvesting. Peak damage on crops matches the second main period of seed maturation when game damages the stem and class (Obrtel and Holišova, 1983) which leads to an irreversible yield reduction (Diekmann, 1983). As results from many different sources document, damage on crops during the winter months does not impact yields at harvest; (Austin and Urness, 1995; Cerkal et al., 2009; Wilson et al., 2009) therefore, the small number of recorded damages on crops during winter months are assumed to be irrelevant. The highest recorded number of damages to grape vines is at the time of grape maturation (August and September) and the drop in number of damages during the period after harvest points to the fruit as the main plant component of game damage.

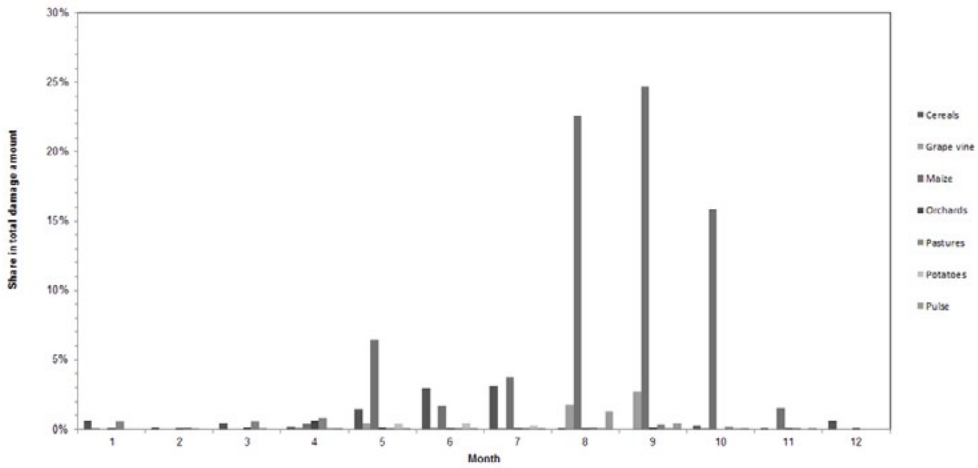

Figure 2. The share of damage by months and agricultural crops
Slika 2. Udio isplaćenih šteta prikazan po mjesecu i poljoprivrednoj kulturi

Damages in orchards are distributed evenly throughout the whole year, with a peak in July. The evenly distributed number of damages throughout the year can be a result of the large variety variability that falls within the category of orchards. The number of damages on potatoes peaks during the months of May, June and July (Figure 2). The majority of damages on pastures occurred during the first four months, primarily by wild boar rooting (Welander, 2000). This is similar to the research results of damages in Luxemburg (Schley et al., 2008) and southern Britain (Wilson, 2004), but different than results found in northwestern Italy where the majority of damages was recorded during autumn (Macchi et al., 1992).

Damage to pastures is, in some respects, more problematic since it is the only type of damage that is made to permanent crops. The reason for pasture damage could be related to wild boar nutrition, which typically contains a low protein content and lacks essential amino acids for nutrition. Thus, increases in pasture damage may be due to the high number of protein rich worms in these fields (Baubet et al., 2003). Given distribution patterns for the number of damages to maize, cereals and pastures follows the patterns observed in previous research on crop damage from wild boar (Schley et al., 2008) and patterns observed in previous research conducted on wild boar nutrition (Herrero et al., 2004) that could indicate possibly greater influence of this specie on crop damage.

The monthly payment amount is greatest during summer and early autumn (from June to October) with over 80% of the total yearly payments occurring during these months. During late autumn and winter (from November to March) payment amounts only account for 7% of the yearly total. The greatest number of damage incidents is recorded during the summer and early autumn with greater than 85% of total damage incidents. Expectedly, during late autumn and winter months the number of damages committed in respect to the rest of the year is relatively small. The peak number of damages to agricultural crops is from July to September which matches the nutritional needs of wild boars (Herrero et al., 2006). Seasonal damage patterns can be associated with seasonal game nutrition patterns that are present in all habitat types (Nugent, 1990). The line of seasonal dummy regression for damage values ($r^2 = 0.77$) and number of damages ($r^2 = 0.93$), using repetition between years clearly demonstrated the seasonal dependence of analysed data. The seasonal occurrence of game damage was also recorded in previous research on the same topic (Boag et al., 1990; Putman and Moore, 1998; Limbu and Karki, 2003; Wilson, 2004; Schley et al., 2008) regardless of the research objectives. Damage was non-uniformly distributed across Croatia (Figure 3); Central and Western regions had a very high level of damage (up to 57.3 € per ha), the next highest level was the Eastern region (up to 3.20 € per ha), while the amount of damage in the Southern region was lowest.

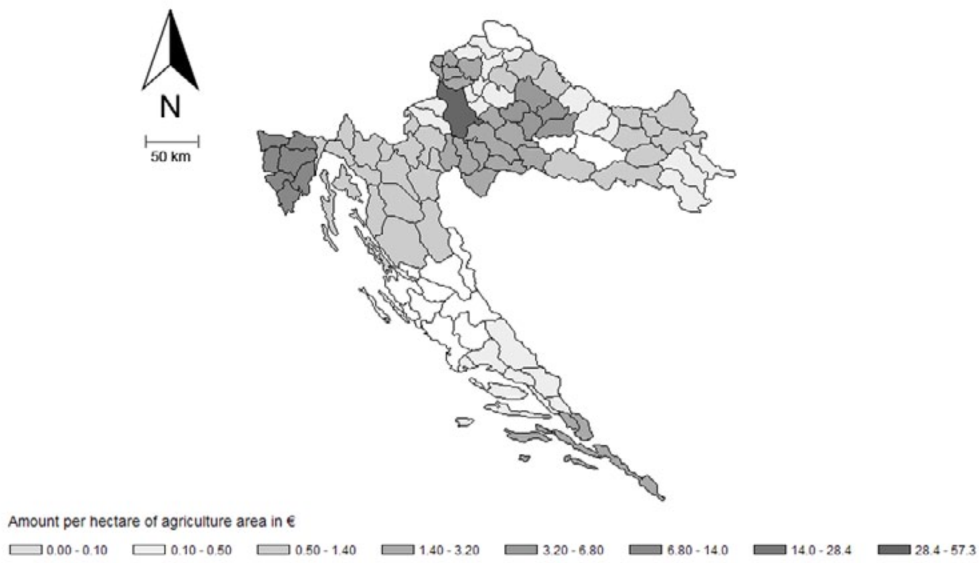

Figure 3. Spatial distribution of game damage in Croatia (2005-2008)
Slika 3. Prostorna distribucija šteta od divljači u Hrvatskoj (2005-2008)

Overall, our results compare to research results from other European countries (Macchi et al., 1992; Calenge et al., 2004; Geisser and Reyer, 2004; Herrero et al., 2006; Schley et al., 2008). Previous studies have identified a number of main factors affecting the level of damage to crops by game (Geisser and Reyer, 2004; Cai et al., 2008; Schley et al., 2008), but only a few of these factors were considered in this study. Game density, especially of wild boar, appears to be the most important predictor of damage. Controlling populations through hunting would seem to be a useful management scheme (Servanty et al., 2009) since wild boar hunting is allowed all year. The number of wild boar harvested during our study was between 0.7 (Western region) animals and 5 animals (East and Central region) per 100 ha. These harvests definitely reduced the incidence of crop damage. Supplementary feeding in some cases can be a dissuasive tool to reduce crop damage (Calenge et al., 2004). During all of the years, supplementary feeding (in most cases, maize) was used as a dissuasive tool in the all of the regions, but in the West and Central region to a greater extent. The quantity of food supplied varied between 0.1 and 1.4 kg per ha per feeding day all year round, and had an affect on reducing crop damage.

The agricultural fields close to forests should not be preferentially planted with cereals, because they attract game. It is recommended that farmers plant fields close to the forest with less attractive crops such as sunflower (*Helianthus annuus*) or sugar beet (*Beta vulgaris*). Utilizing electric fences is the most successful method for reducing crop damage from wildlife (Geisser and Reyer, 2004). However, the main problem in Croatia for protecting crops with electric fences is small agricultural fields (in average only 0.8 ha) which increases the costs of protecting each field. The present results represent the first systematic attempt to quantify the national extent of damage caused by game to agriculture in Croatia. During the analysed period, game damage had been increasing because rural decline has become more prevalent in Croatia. More and more fields are left uncultivated, allowing game to penetrate deeper into agricultural areas. We can expect the upward trend of damage to agricultural fields to gradually continue which may result in a restructuring of the local economy.

Clearly, further research is needed to investigate the causes of game damage, and to determine the best methods of mitigation. Modeling the patterns of game damage by using information on the occurrence in different farm types, cropping patterns, climate and game density in particular areas may provide statistically significant correlations to game damage. This information may improve mitigation and reduce associated economic costs.

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