WOLF-LIVESTOCK CONFLICT IN TZOUMERKA NATIONAL PARK AND COMPARISONS WITH OTHER PROTECTED AREAS OF GREECE

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CONTENTS

1. INTRODUCTION

Livestock depredation is one of the main wolf-human conflict issues both in Europe (Fernadez-Gil et al. 2018) and worldwide (Treves and Karanth 2003), while it is characterized by a history of millennia (Linnell and Lescureux 2015), (**Fig. 1**). In Europe, the recent natural recolonization of many areas by wolves the last few decades has increased conflicts with humans (Chapron et al. 2014), which are especially prevalent in areas where farmers have ceased practicing traditional methods for protecting their livestock (Boitani et al. 2010, Reinhardt et al. 2012).

A recent analysis on European compensation data on livestock killed by large carnivores found that on average 19,320 sheep were compensated as being killed by wolves (2012-2016, data from 19 countries, Linnell and Cretois 2018). Portugal, Greece, Croatia, France, and Italy stood out as hot-spots for wolf depredation, representing 75% of the overall compensation costs in EU. In Greece, wolf depredation on livestock affects thousands of livestock farmers each year and is responsible for an average of €934,700 in annual compensation (corresponding to approx. 7,600 killed animals) paid to producers from the Hellenic Farmers Insurance Organization (2010-2016 data, ELGA). These numbers do not necessarily represent the real magnitude of the problem, as compensated losses can constitute only a fraction of the actual ones (Iliopoulos et al. 2000, Iliopoulos and Petridou 2012).

On the other hand, it is widely recognized that the overall wolf predatory impact on total livestock capital is rather low [e.g. (Kaczensky 1999, Linnell and Cretois 2018)] when it is expressed as absolute percentage losses. Wolf depredation losses are equivalent to approximately 0.05% of the total sheep stock on mainland Europe (Linnell and Cretois 2018) or may be as low as 0.6% of available free-ranging livestock at a national scale (Álvares et al. 2015, Fernández-Gil et al. 2016). However, predation intensity can be considerable at the local scale; individual farmers may suffer severe losses or frequent attacks and specific regions can be strongly affected by wolf predation due to inadequate husbandry practices, presence of risky landscapes favoring predation and /or low densities of wolf natural prey (Fernadez-Gil et al. 2018, Linnell and Cretois 2018).

Moreover, in most Mediterranean countries, sheep and goat herds are being replaced by cattle for meat production favored by EU incentives, leading to cultural loss, and often a complete abandonment of traditional preventive measures (Fernadez-Gil et al. 2018). The need to support and further develop the traditional free-ranging sheep-goat breeding sector has been recently recognized from European Parliament (EP 2018), in order to: a) conserve biodiversity, ecosystems and environmentally important areas, b) constrain rural depopulation by creating and preserving employment in disadvantaged areas, such as remote and mountainous regions and c) preserve the cultural heritage of many EU members while producing at the same time high quality traditional products.

However, livestock depredation, can have a direct economic impact on local economies, and may constitute a serious conservation problem as often results in retaliatory killing of wolves (Treves and Karanth 2003). In Greece, illegal human-caused mortality remains high and may locally reach up to 25% of estimated wolf numbers (Iliopoulos 2010, Iliopoulos et al. 2015a). Moreover, illegal use of poisoned baits for wolf extermination , consists one of the main causes for the dramatic decline of vultures in Greece, including the critically endangered Egyptian vulture (Ntemiri et al. 2018).

Therefore, the need for practical solutions to mitigate wolf depredation on livestock is indispensable (Linnell and Boitani 2011, Chapron et al. 2014). The implementation of management strategies that promote the adoption of preventive measures and reduction of counterproductive husbandry practices could promote tolerance and coexistence with wolves. This is mostly important particularly in regions where strongholds of wolf populations exist within human dominated landscapes (Fernadez-Gil et al. 2018).

The aim of the project is to study and evaluate wolf-livestock conflicts in the National Park of Tzoumerka, Acheloos valley, Agrafa, and Meteora (hereafter Tzoumerka NP) and to compare our findings with other protected areas in Greece. We have in particular set the following six research objectives:

1. To assess and describe traditional free-ranging livestock raisers' profile in Tzoumerka NP.
2. To record wolf depredation levels on cattle, sheep and goat herds as the main baseline metric of wolf-human conflicts in Tzoumerka NP.
3. To identify and evaluate the principal damage prevention methods adopted by local livestock farmers in Tzoumerka NP.
4. To assess levels of livestock guarding dog mortality due to the illegal use of poisoned baits as a major conservation problem in the area in Tzoumerka NP.
5. To evaluate satisfaction levels of livestock farmers regarding the national compensation system in Tzoumerka NP.
6. To compare the main results stemming from Tzoumerka NP with other similar studies previously completed in other protected areas and draw relevant conclusions.

Figure 1: A wolf, sneaking up on sheep (Bestiary, England, c. 1200-c. 1210, Royal MS 12 C. xix, f. 19r). In: Linnell & Lescureaux 2015.

2. METHODS

2.1 Study area

Our study area lies within the National Park of Tzoumerka, Acheloos valley, Agrafa, and Meteora (hereafter Tzoumerka NP). This is the largest National Park of Greece, extending over 4000 km² and encompassing 12 sites of the Natura 2000 network. The Park is managed by the respective Management Authority, established in 2009.

Tzoumerka NP is a highly mountainous and sparsely human populated area, with great landscape diversity due to its large extent and extreme altitudinal range (i.e. altitude range: 100-2500 m.a.s.l.). It is an area with exceptional ecological value, hosting several endemic and protected species under the European and national legislation (Epirus 2006, Dimopoulos and Kati 2007). Livestock husbandry is a main economic activity (ELSTAT 2016).

The area hosts an important wolf population with wolf densities ranging from 2.2 to 2.9 wolves per 100 km² (Iliopoulos 2003, 2015). Wolf-livestock conflict is particularly intense in the National Park: average annual compensation paid for depredated livestock was €157,000 corresponding to 1,380 killed animals, accounting for approximately 17% of the total compensation spent nationwide for wolf attacks on livestock (**Fig. 2**, data 2010-2016, ELGA).

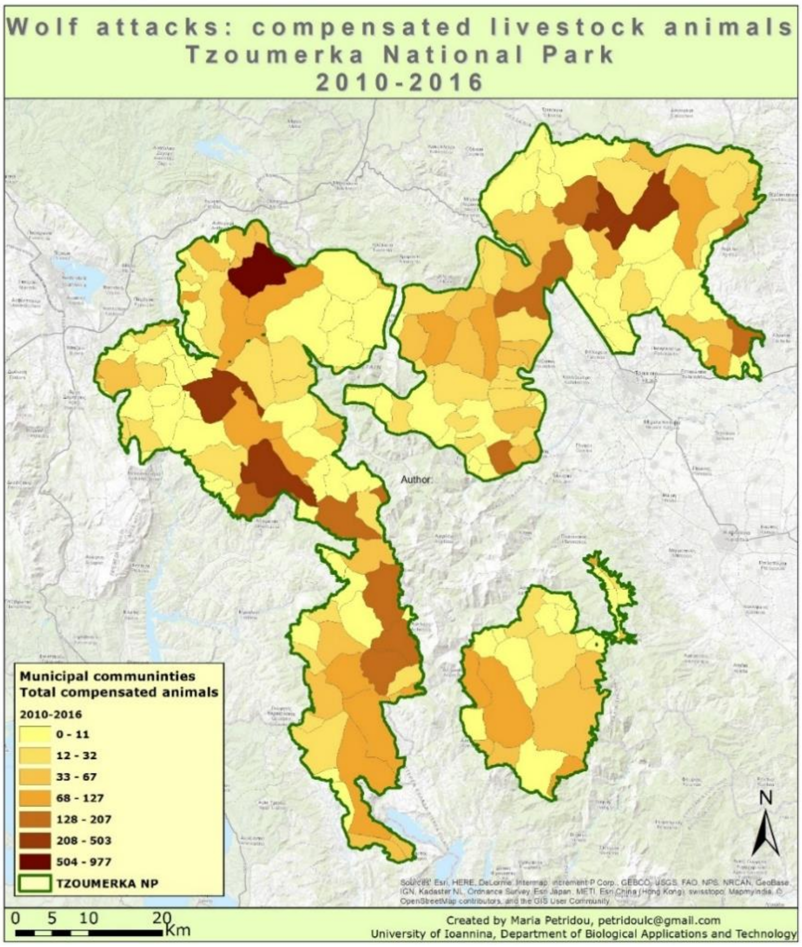

Figure 2: Total number of compensated livestock animals per municipal community in Tzoumerka National Park for the period 2010-2016 (data: ELGA).

2.2 Data collection

We conducted 55 interviews with livestock farmers from August to October 2018 (i.e. summer grazing period) when livestock raisers occupied summer pastures. We interviewed farmers according to their availability, attempting to cover areas with different depredation levels, on the basis of ELGA data (**Fig. 2**). Although shepherds spend much of their time guarding and attending livestock herds - so they could provide valuable information on the project's topics - they may be employed only for a short seasonal basis and not even in an annual basis. Therefore, we targeted livestock farm owners instead, in order to acquire data on a long-term basis regarding management of the farm, annual damage levels and livestock protection methods. Interviews were conducted on-site or at villages closest to farmers' occupations (**Fig. 3**). Study involved both transhumant (i.e. long-distance seasonal migrations from wintering to summer grazing areas) and local farmers (i.e. stationary), as we are interested in both categories.

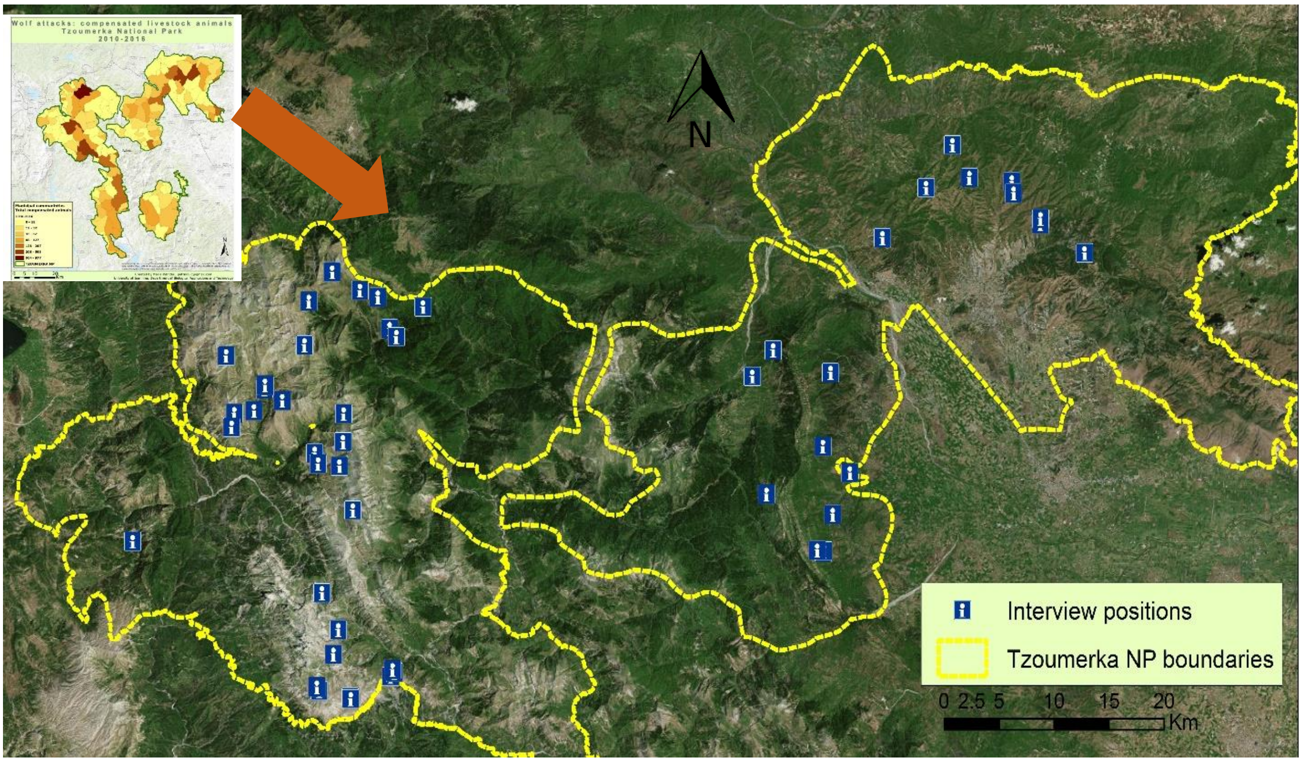

Figure 3: Localities of livestock farms linked to interviewed owners within the boundaries of Tzoumerka National Park (n=55).

Data collection regarding both livestock losses and enforcement of husbandry methods was implemented by directly interviewing farmers, preferably at pastures and/or infrastructures used to accommodate livestock during night hours (**Fig. 4**). For interviewing farmers, we used as a baseline a semi-structured questionnaire created under the framework of an ongoing PhD study on wolf-livestock conflict minimization (M. Petridou, University of Ioannina). We added further questions so as to be able to compare farmer's responses from Tzoumerka NP with those of other areas, collected in the frame of past projects (Iliopoulos and Petridou 2012, Skartsi et al. 2014, Iliopoulos et al. 2015b, Iliopoulos and Petridou 2017). This permitted us to compare data and information gathered during this study with results from those studies undertaken in other national parks (Oiti NP and Lake Prespes NP).

The following data were collected during the interviews:

a. Age of farmers.
b. Experience of farmers in livestock farming.
c. Size and type of livestock farms.
d. Perceived wolf-caused livestock losses claimed by farmers for the period 2016-2018.
e. Damage prevention measures applied (recorded in the field and reported from farmers).
f. Livestock Guarding Dog (LGD) mortality related to illegal use of poisoned baits.
g. Satisfaction levels of farmers regarding existing compensation system enforced by the state (ELGA).

Figure 4: On site visits to livestock farmers of Tzoumerka NP for conducting interviews.

2.3. Data analysis

2.3.1. Tzoumerka National Park

Data was analyzed in terms of descriptive statistics, using adequate frequency analysis (Gardener 2012), in order our results to be comparable with previous studies in Greece (see 2.3.2).

2.3.2 Comparison with other areas in Greece

To compare wolf-livestock issues (i.e. damage levels and livestock protection methods enforced) between Tzoumerka NP and other protected areas in Greece we used available reports from previous relevant studies and conservation projects.

In **Oiti National Park and Prespes National Park** (**Fig. 5**), semi-structure questionnaires were used in both areas for site interviews with livestock farmers to collect data on **wolf-farmer conflicts** and **prevention methods** enforced. As the survey protocol and questionnaire used was similar in all three areas (Tzoumerka, Oiti, Prespes), we were able to compare results on almost all critical topics of the study (**Table 1**) using the following technical reports:

- *Iliopoulos Y. & Petridou M. (2012). Preliminary study for addressing the conflict with large carnivores in Mt. Oiti National Park. Management Body of Oiti National Park. Final report 123 p.*
- *Iliopoulos Y., Petridou M., Giannakopoulos A., Ntolka E., Tsaparis D. (2015). Addressing the conflict with wolf in Mt. Oiti National Park. Callisto NGO, Management Body of Oiti National Park. Final report 185 p.*
- *Iliopoulos Y. & Petridou M. (2017). Preliminary study for addressing the conflict with large carnivores in Prespes National Park. Management Body of Prespes National Park. Final report 122 p.*

Furthermore, we compared our results with those from a **Regional case study covering Northern, Western, and Central Greece** (encompassing 15 Natura 2000 sites, **Fig. 6**) compiled under the framework of a LIFE project for the protection of Egyptian vultures. Only data regarding livestock farmers were analyzed, provided by WWF (Dora Skartsi, *pers. com.).*

- *Skartsi Th., Dobrev V., Oppel S., Kafetzis A., Kret E., Karampatsa R., Saravia V., Bounas T., Vavylis D., Sidiropoulos L., Arkumarev V., Dyulgerova S. and Nikolov S. C. (2014): Assessment of the illegal use of poison in Natura 2000 sites for the Egyptian Vulture in Greece and Bulgaria during the period 2003-2012. Technical report under action A3 of the LIFE+ project "The Return of the Neophron" (LIFE10 NAT/BG/000152). WWF Greece, Athens. 75 pp.*

Since, the questionnaire used in the regional case study was very different from those one used in Tzoumerka NP (i.e. qualitative instead of quantitative analysis on wolf-livestock conflicts), we were able to provide comparisons only in three from the seven main topics (**Table 1**).

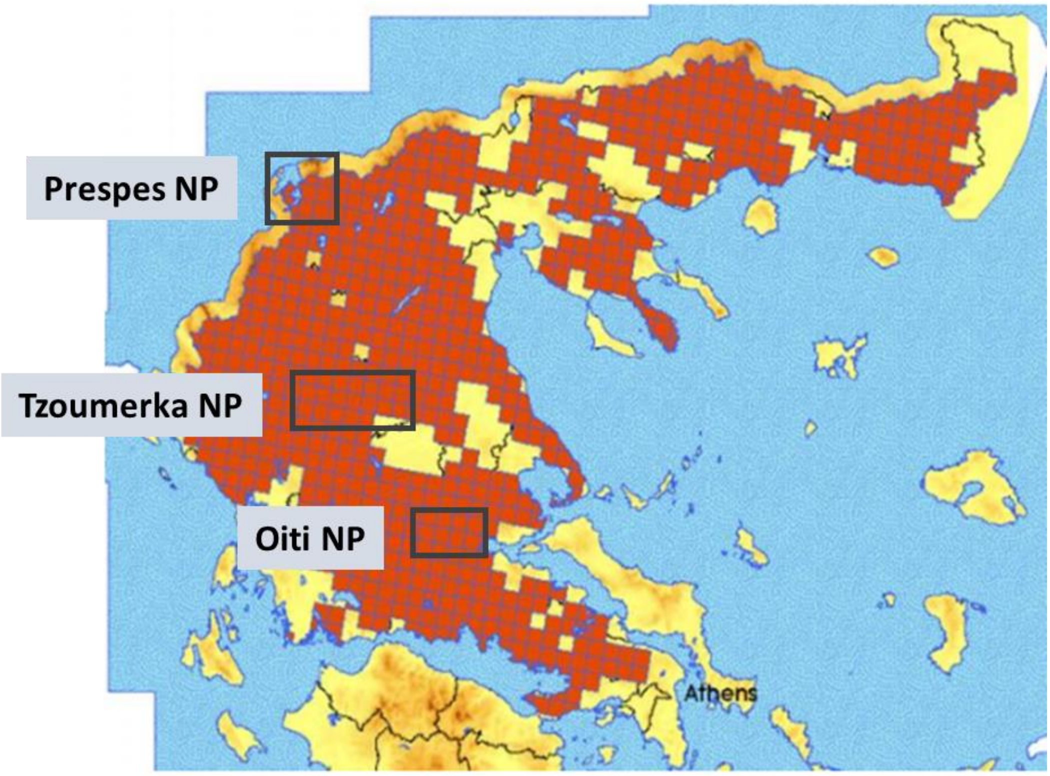

Figure 5: Location of the three study areas where wolf-livestock conflicts have been evaluated: a) Tzoumerka National Park (present study), b) Prespes National Park (Iliopoulos and Petridou 2017), and c) Oiti National Park (Iliopoulos and Petridou 2012, Iliopoulos et al 2015). Map shows most current wolf distribution in Greece [adapted from: (Iliopoulos et al. 2016)]

Figure 6: Location of the 15 Natura 2000 sites encompassed in the regional-scale case study related to the effects of the illegal use of poison baits in the endangered Egyptian vulture population in Greece (adapted from Skartsi et al. 2014).

Table 1: Research topics examined during the implementation of the aforementioned case studies in: a) Tzoumerka National Park, b) Prespes National Park, c) Oiti National Park and d) Egyptian vulture distribution (regional study). Comparisons amongst results were performed according to common traits.

Chapter	Research question	Tzoumerka NP	Oiti NP	Prespes NP	Regional
4.2.1	**Wolf-livestock conflict levels** (% of farmers with livestock losses from wolf attacks)	●	●	●	●
4.2.2	**Severity of losses per farmer** (Mean percentage annual losses)	●	●	●	
4.2.3	**Distribution of farmers on severity loss classes**	●	●	●	●
4.2.4	**Intensity of livestock surveillance**	●	●	●	
4.2.5	**Adoption of guarding dogs** (percentage of farmers using Livestock Guarding Dogs - LGDs)	●	●	●	
4.2.6	**LGD Capacity levels per farm** (Mean number of LGDs per herd and per 100 animals)	●	●	●	
4.2.7	**Farmer satisfaction levels regarding existing compensation system** (ELGA)	●			●

3. RESULTS

3.1 Livestock farmers' profile

The majority of respondents owned sheep/goat herds and less cattle. A large percentage of the livestock farmers interviewed (53%) were transhumant - i.e. moving to higher altitude summer pastures during late spring and until late autumn. The rest of the sampled farmers (47%) were defined as "local farmers" - i.e. using the pastures of the area year-round. "Local farmers" may use the same permanent pen for livestock accommodation year-round, or alternatively, perform short-distance local migrations and use additional temporal summer pens for livestock accommodation (**Table 2**).

Table 2: General profile of the 55 livestock farmers (owners) interviewed (2018) in Tzoumerka NP

Profile of livestock farmers and farms in Tzoumerka National Park		
No of interviewed farmers	-	55
Sex of interviewed farmers	Male Female	93% (n=51) 7% (n=4)
Seasonal migration pattern	Transhumant farmer Local farmer	53% (n=29) 47% (n=26)
Type of livestock farm	Sheep/goat Cattle	65% (n=36) 35% (n=19)
Size of livestock farms [mean (min-max)]	Sheep/goat	358 (80-1020)
	Cattle	157 (29-850)

Figure 7: On site interviews of livestock farmers in Tzoumerka NP.

3.1.1 Age class of livestock farmers

The average age of farmers in Europe is on the rise and this brings concerns about the professions' viability and continuity in the forthcoming decades (EC 2017, EP 2018). In Greece free-ranging livestock farmers in many regions are far beyond middle age, as a result of an increasing unpopularity and unattractiveness of their profession for both social and financial reasons amongst the youngsters in rural areas (e.g. Oiti National Park, Iliopoulos and Petridou 2012). During our survey we assessed the age distribution of interviewed livestock farmers.

We grouped farmers in four age classes: a) <30, b) 30-40, c) 40-50, d) 50-60 and e)> 60 years old. Results are presented in **Figure 8.** Farmer distribution pattern in the different age classes was very interesting. What is worth mentioning is the fact that 75% of all farmers were younger than 50 years old, with a good percentage of **young professionals <40 years old being involved in the free-ranging livestock rearing sector (36%).**

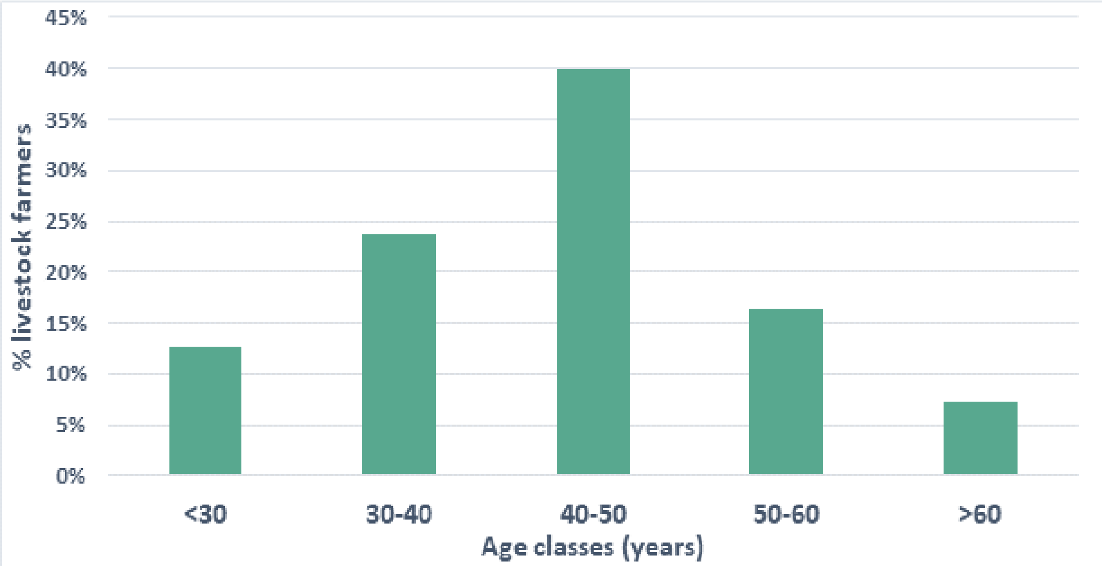

Figure 8: Percentage distribution of interviewed farmers (n=55) at preset age classes.

3.1.2 Experience of farmers in livestock farming

Farmer experience - expressed in years or generations - can play an important and positive role in successful free-ranging livestock farming as it is related to the amount of traditional knowledge transferred amongst generations for rearing livestock under unfamiliar outdoor conditions and prevent carnivore attacks.

Farmer experience was expressed in two ways:

1. **Age of first involvement in livestock farming.**
   Farmers were grouped into two classes: a) involvement at age <18 years old and b) above >18 years old. Interestingly, **the majority of farmers (73%)** falls into the first category, been **involved in the family business at a very young age** (<18 years old) (**Fig. 9**).

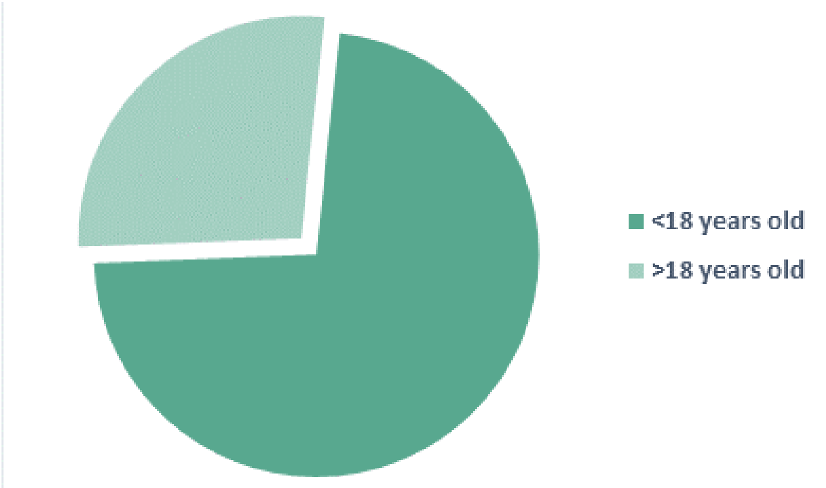

Figure 9: Percentage distribution of farmers in the two age classes according to their professional experience: age of first involvement in livestock farming: a) <18 years old; b) >18 years old.

2. **The number of generations that each farmer's family is working on livestock farming**. Farmers were classified into one of the following four classes:
   a. As a **first-generation** farmer: When he/she was the first one in the family to work with free-ranging livestock.
   b. As a **second-generation** farmer: when his/her parents were the first starting the family business.
   c. As a **third-generation** farmer**:** when grandparents were the first to start working with livestock farming.
   d. As a **multiple generation** farmer: in cases where his/her family had a long experience in livestock farming that goes back in time for several generations.

Remarkably, the **greatest majority of farmers (80%) falls within the last and most experienced category (d),** (**Fig. 10**). It is worth mentioning that despite several financial incentives the last decades a quite small percentage (9%) of farmers fall into the first class- i.e. new farmers working with livestock breeding without prior family experience in the business.

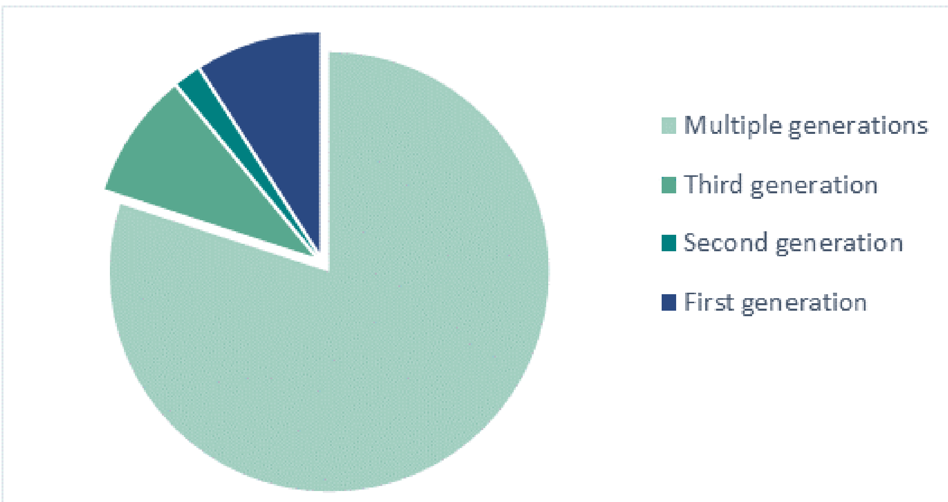

Figure 10: Percentage distribution of farmers in the "family experience" classes measured in generations.

3.1.3 Size and type of livestock farms

Number of livestock animals per species and per farm. Livestock farms were classified in four categories according to livestock species raised: a) pure sheep, b) pure goat, c) mixed sheep and goat and d) cattle. For cattle farms we report both numbers of adult cattle and calves <1-year-old (**Table 3**). Sheep herds were slightly larger than goat herds, while mixed herds outnumbered pure herds in size, with sheep predominating greatly in numbers in this type of herd. Cattle herds were large, averaged 112 adults (range=23-700) and 44 calves (range=5-150). The sheep/goat size recorded was similar with that of transhumant farmers in the region of Sterea Ellada (Mitsopoulos et al. 2015), whilst the cattle size was larger as compared with other areas of Greece (Ragkos et al. 2013).

Table 3: Size of livestock farms (N=55) per breeding class: a) pure sheep, b) pure goat, c) mixed sheep and goat and d) cattle (adult & calves).

Species		Sheep farms (n=14)	Goat farms (n=11)	Mixed sheep & goat farms (n=11)	Cattle farms (n=19)
Sheep	Mean	**326**	-	**455**	-
	SD	131	-	286	-
	Range	150 - 610	-	25 - 1000	-
Goat	Mean	-	**274**	**27**	-
	SD	-	177	19	-
	Range	-	80 - 600	10 - 71	-
Adult cattle	Mean	-	-	-	**112**
	SD	-	-	-	146
	Range	-	-	-	23 - 700
Calves	Mean	-	-	-	**44**
	SD	-	-	-	38
	Range	-	-	-	5 - 150

Size of livestock farms in animal units (AU). According to animal unit definition (AU) by the Greek Agricultural Insurance Organization (ELGA), one adult sheep/goat corresponds to 0.15 AU and one adult cattle to 1.0 AU. We attributed the value of 0.4 AU to one calf<1 year for simplicity [two categories in ELGA: 0.4 AU (<0.5 years) and 0.5 AU (0.5-1 year)], following the definition of Livestock Units (Eurostat 2013). Animal units were used as a standard unit to compare livestock losses between farms independently of their breeding species composition.

Studied farms were grouped into 5 classes according to their size in AU: a) 1-30, b) 31-60, c) 61-90, d) 91-120 and e) >120. Most livestock farms were either medium-sized (31-60 AU, equivalent to 200-400 sheep/goats or 31-60 cattle) or relatively large-sized (91-120 AU, equivalent to 600-800 sheep/goats or 91-120 cattle) (**Fig. 11**).

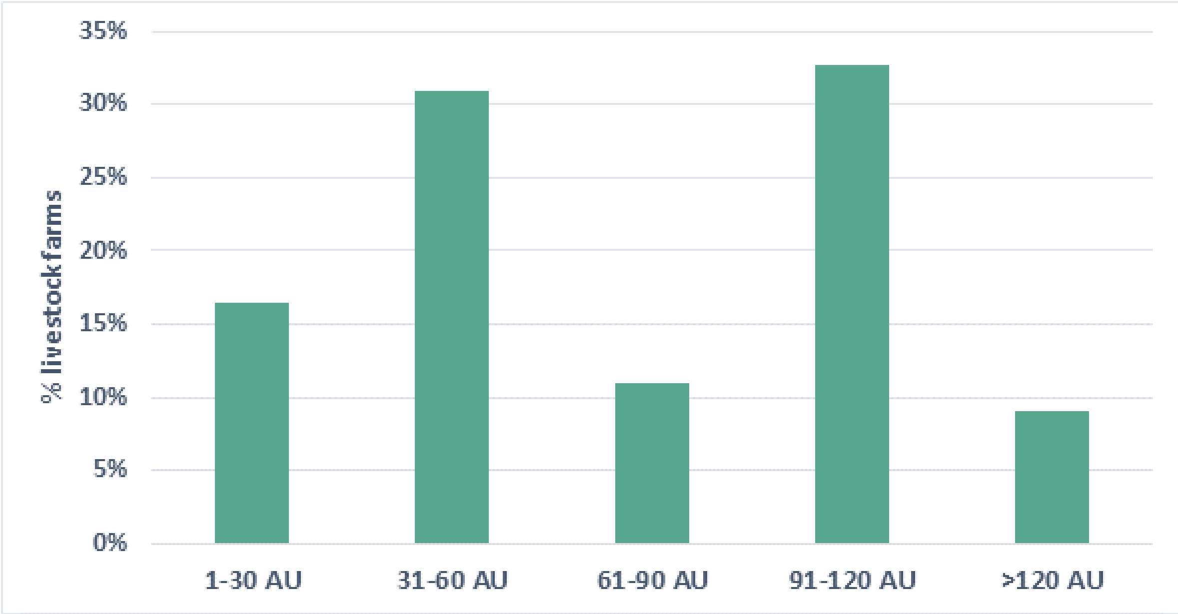

Figure 11: Percentage distribution of livestock farms (n=55) according to their size in AU (animal units).

3.2 Livestock losses caused by wolves

To evaluate livestock depredation levels caused by wolves per farm we used data provided by livestock owners themselves during interviews. We asked for the most recent information on the number of livestock animals killed by wolves during the years 2016, 2017 and 2018. To express the magnitude of losses we used the **Mean Percentage of Annual Losses (MPAL) index** (Iliopoulos & Petridou 2012; Iliopoulos & Petridou 2017), namely the **mean percentage of depredated animals per farm and per year** for the period examined (2016-2018).

We assume that MPAL index is a highly correlated metric to actual losses for each livestock farm although the exact relation is not known. Figures on actual losses remain largely unknown as many killed animals are never found/ retreated by farmers. On the other hand, some claims are falsely attributed to wolf predation when they are actually representing just missing animals, or in some other cases simply wolves scavenged an already dead animal which is mistakenly registered as a wolf-killed (i.e. post-mortem consumption). Therefore, results on depredation levels should be interpreted with caution. Nevertheless, perceived damages as contrasted to actual ones, are also an important aspect of wolf-human conflict and even as such, the MPAL is a very informative index.

In **Table 4** we present data for a) all farms, b) pure sheep, pure goat and mixed sheep/goat herds pooled together in one category, hereafter sheep/goat and c) cattle herds.

Universal **MPAL for all farms (n=55) averaged 2.25%** with loss levels varying greatly amongst farmers - i.e. SD value (2.81%) is quite high. Losses are **similar for sheep/goat and cattle farms.** However, the **range of losses is much greater in cattle farms**, (range: 0- 16.41%).

Table 4: Summary table of Mean Percentage of Annual Losses (MPAL) per livestock farm (n=55) in Tzoumerka NP for a) all farms, b) sheep/goat farms and c) cattle farms.

Type of farm	N	Statistical value	MPAL %
All farms	55	Mean	2.25
		SD	2.81
		Range	0.00 - 16.41
Sheep/Goat	36	Mean	2.20
		SD	2.00
		Range	0.00 - 8.67
Cattle	19	Mean	2.35
		SD	3.99
		Range	0.00 - 16.41

To examine which livestock species/age-class is more vulnerable to wolf predation, we estimated MPAL for each livestock farm breeding category: a) sheep, b) goat, c) mixed (sheep and goat) and d) cattle. Results are presented in **Table 5**.

The most vulnerable category was cattle calves' and averaged 6.37**%** per farm. Calf losses by wolves showed great variability and can reach very high values up to 66.27% (**Table 5**). High vulnerability of calves has been documented in other studies as well: in Portugal, farms bringing calves <3 months old to pastures were associated with about 90% of attacks to cattle farms (Pimenta et al. 2017). In Italy, cattle farms in which births occurred directly on pastures had high risk of wolf predation (Dondina et al. 2015). In Greece, calves <6 months old grazing unattended during night hours increased predation rates by wolves (Iliopoulos et al. 2009).

The **second most vulnerable species are goats** irrespectively of the type of livestock farm (pure or mixed). It seems that in the case of mixed sheep/goat herds, wolves may select for goats, since the predation of sheep is substantially lower in mixed herds than in pure sheep ones (**Table 5**). Goat preference by wolves has been demonstrated in other studies in Greece (Iliopoulos et al. 2009, Petridou et al. 2019) and Portugal (Vos 2000, Torres et al. 2015). Wolf preference for goats is very likely related to their **easier accessibility**. Goats tend to scatter extensively while grazing, feeding on more remote, dense and steep areas, thus, favoring wolves to approach and attack (Iliopoulos et al. 2009). In contrast, sheep graze in more open pasture areas, in dense and compact flocks, making them a difficult target (Torres et al. 2015).

Table 5: Summary table of MPAL index for sampled farms (n=55) in Tzoumerka NP, i.e. mean percentage of livestock species killed per farm type and per year, for the period 2016-2018.

		Percentage of Annual Losses %			
		Sheep farms (n=14)	**Goat farms (n=11)**	**Mixed sheep & goat farms (n=11)**	**Cattle farms (n=19)**
Sheep	Mean	**2.11**	-	**0.92**	-
	SD	1.38	-	0.78	-
	Range	0 - 4.5	-	0 - 2.17	-
Goats	Mean	-	**3.36**	**3.62**	-
	SD	-	2.79	7.39	-
	Range	-	0 - 8.67	0 - 22.22	-
Adult cattle	Mean	-	-	-	**1.96**
	SD	-	-	-	3.9
	Range	-	-	-	0 - 16.67
Calves <1 year	Mean	-	-	-	**6.37**
	SD	-	-	-	15.2
	Range	-	-	-	0 - 66.67

MPAL index was also estimated for losses expressed in animal Units (AU). We grouped livestock farms into four classes of MPAL (Iliopoulos et al. 2009): a) 0% (no losses) b) 0-1% AU (small losses), c) 1-5% AU (moderate losses) and d) ≥5% AU (large losses).

Nearly **half of livestock farmers experience moderate losses from wolf attacks** annually (1-5% MPAL) (**Fig. 12**). An important percentage of farmers, reaching almost **13%, experiences large losses each year**, (≥5% MPAL). This means that a typical herd with 300 sheep, may lose ≥15 sheep/year which translates to a cost of ≥1500 euros/year. These figures can be much higher for cattle herds (e.g. a 1-year-old calf of the meat-producing Red Greek Breed has a market value of approximately 1200 euros and a female adult cattle of the same breed 800-1000 euros).

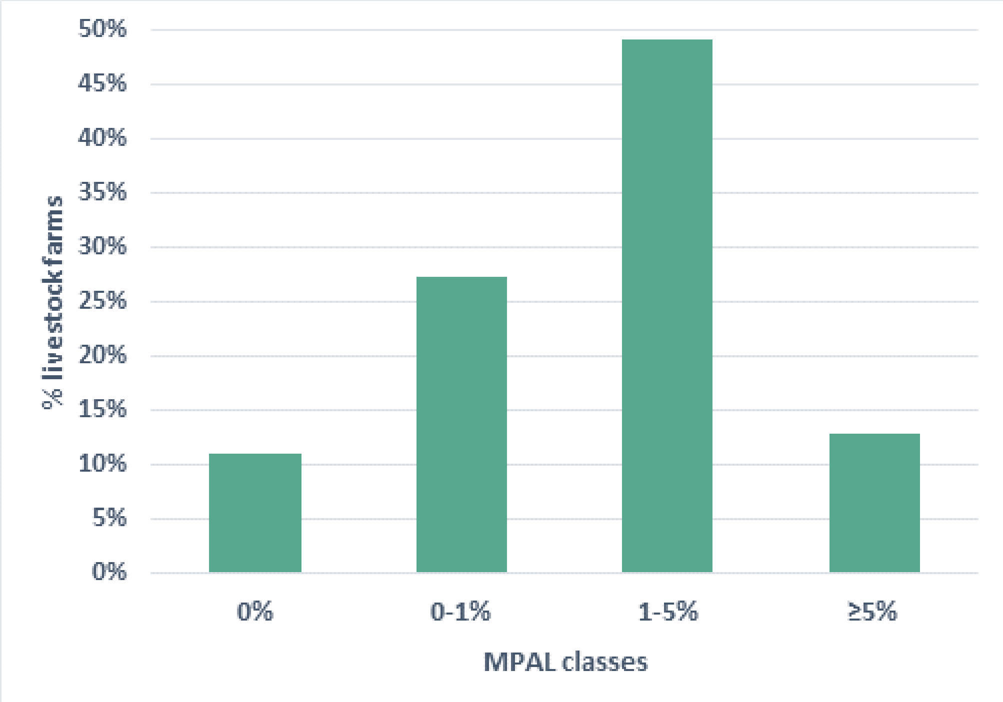

Figure 12: Distribution of livestock farms (n=55) according to Mean Percentage of Annual Losses (MPAL) caused by wolf predation, for the period 2016-2018. MPAL is expressed in Animal Units: a) 0% (no losses), b) 0-1% (small losses), c) 1-5% (moderate losses) and d) ≥5% (large losses).

3.3. Damage prevention methods

3.3.1 Surveillance by a shepherd

Livestock surveillance by shepherds has been practiced for millennia and is a widespread method enforced for the protection of livestock and part of the traditional shepherding system in Greece. Shepherding is practiced mostly in areas where large carnivores were never exterminated but tends to be less common in areas where large carnivores have been recently recovered. During the study we surveyed the extent and magnitude in which this traditional method still persists in Tzoumerka NP. We classified the magnitude of surveillance, in three classes:

a. **"Never":** livestock herd grazes mostly unattended during daytime, without a shepherd's presence.
b. **"Partly"**: livestock herd is partially attended by a shepherd during daytime grazing.
c. **"Always":** livestock herd is constantly attended by a shepherd during daytime grazing in pastures.

We found that **most livestock herds graze under the attendance of a shepherd**. **Most sheep/goat herds** (58%, **Fig 13**) graze with a shepherd being **always present.** However, **a significant percentage of sheep/goat herds (42%)** graze with a shepherd being **only partly present.** None of the sheep/goat herds (0%) grazes unattended without the presence of a shepherd.

However, surveillance intensity is quite different for cattle herds: only a small part of cattle herds (21%) graze with a shepherd being always present. **The largest proportion of cattle herds (63%)**

graze only partially attended by a shepherd during daytime grazing. Also, a notable percentage of cattle herds (16%) graze completely unattended.

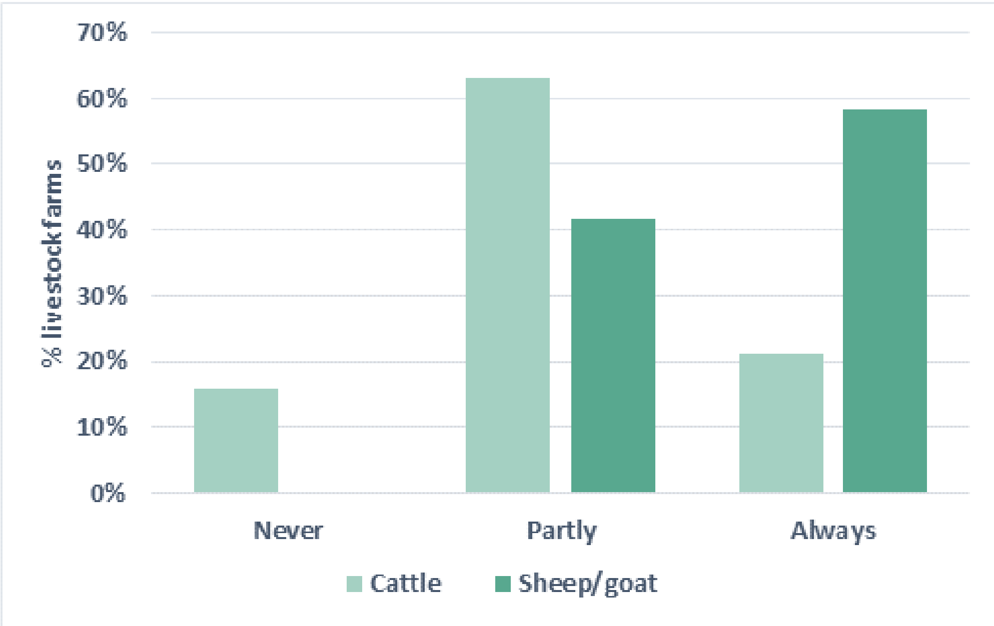

Figure 13: Percentage distribution of farms according to livestock shepherding during daytime grazing, in the three surveillance intensity classes (Never, Partly, Always), and per breeding type (cattle, sheep/goat).

Shepherding is an ancient practice and is critical for successfully reducing livestock depredation (Iliopoulos et al. 2009, Eklund et al. 2017). It is strongly encouraged and promoted, especially in areas where farmers have never dealt with wolves before [e.g. USA (Stone et al. 2017)]. However, farmers and their families must invest a substantial amount of time, otherwise they must hire a shepherd. This renders surveillance difficult and expensive, which often causes farmers to only partially attend their herd during grazing time. For this reason, **financial support should be supplied to farmers** so they can afford hiring shepherds for constant surveillance of livestock.

Figure 14: High intensity surveillance of a sheep herd under the constant presence of its owner on the alpine pastures of Tzoumerka NP.

3.3.2 Livestock confinement during nighttime

Confinement of livestock herds during the night is part of the traditional husbandry system in many parts of the world (Linnell et al. 2012) and is recognized as a key mitigation measure for reducing losses by wolves (Stone et al. 2016). Confinement can take place using various infrastructure and materials: from well-build permanent constructions with carnivore-proof fences to temporary pens made by casual materials with very basic low-height wire-netting fences, complemented with several natural materials or artifacts such as wooden pallets, logs and wires. Confinements can be situated on private or public-communal land. On public or communal land confinements can be a) municipal property provided to livestock farmers for use during summer months, or b) constructed using private funds.

In Tzoumerka NP we came across of various types of livestock pens. In the **higher altitude summer pastures, communal pens** were relatively common. Those permanent pens were heavily built constructions consisting of a concrete shelter for livestock protection during nighttime and/or bad weather with usually a small -also concrete- house to accommodate shepherds (**Fig. 15**). Each communal pen was used either by one or, sometimes, was shared by two or even three transhumant farmers. However, those communal infrastructures were built only on those areas with adequate funds to support construction costs, while in less favored villages a lack of such infrastructure was evident with available pens to be sufficient enough to accommodate only a few farmers, if any. Moreover, many of these pens were in bad condition, as they were built several decades ago by the state, without securing for additional maintenance costs in the following years. Most of them don't have electricity or running water, while access roads are often in bad condition. Farmers usually pay by themselves to make the necessary repairs of these pens while taking financial risks; it is not guaranteed that each farmer will be allowed by the state to use the same pen for the upcoming year. As a result, very often, transhumant farmers raise their livestock under harsh natural conditions, getting exposed to bad weather, often resulting in animal illness, likewise in 2018, when many herds suffered from infectious foot dermatitis due to prolonged rainy and cold weather. Moreover, as shepherd pens do not provide even the basic accommodation facilities, this results to uninviting conditions under which shepherds and farmers live for several months, also rendering transhumant lifestyle unattractive, especially for younger generations.

Another temporary type of pen, found in Tzoumerka NP is the **"greenhouse-type" shelter, a lightweight construction to accommodate livestock,** made of a wooden frame covered with a nylon protective sleeve (**Fig. 16**). This type of shelter is used especially by transhumant farmers, in the absence of communal concrete pens, as they are cheap, mobile and easy to assemble. Other materials used to construct temporary shelter for livestock protection from weather elements was: tarpaulin sheets, iron sheets, wood and stones (**Fig. 17**). We even encountered transhumant herds (usually consisted of more resilient to weather conditions local livestock breeds) spending the night without a shelter, bedding at a fenced area (usually herds with local resilient breeds, **Fig. 18**) or unfenced area (cattle, **Fig. 19**).

Figure 15: Communal pen used by transhumant farmers in sub-alpine summer pastures. These infrastructures are comprised by a concrete shelter for livestock protection and usually a small house to accommodate shepherds.

Apart from human and livestock guarding dog presence, carnivore proof confinement is the basic preventive measure against wolf attacks at night. Inadequate fencing increases the chance a wolf enters the confinement and the risk of surplus killing of livestock, especially in the absence of dogs and/or a shepherd. Such attacks on gathered livestock can result in the killing or wounding of many times more animals than those occurring in pastures (Ciucci and Boitani 1998, Gazzola et al. 2008, Iliopoulos et al. 2009).

Figure 16: Temporary "greenhouse-type" shelters, covered with nylon. They are mainly used by transhumant shepherds in high altitude summer pastures.

Figure 17: Temporary livestock farm pen in Tzoumerka NP. Materials used by transhumant farmers to build shelters for livestock may include wood pallets as well as tarpaulin and iron sheets. The pit in the front was used for treatment of infectious foot dermatitis.

Figure 18: Transhumant sheep herd in alpine pasture spending the night in an improvised temporal fence without any use of shelter for livestock.

Figure 19: Transhumant cattle herd that spends the night gathered in the open without the use of any fences or shelter.

Livestock pens used in wintering areas are usually constructed with better quality materials and are far more robust. They are used as permanent infrastructures year-round or to withstand harsh weather conditions in winter (**Fig. 20**).

Figure 20: A permanent pen used throughout the year, in the lowlands of Tzoumerka NP.

During our survey we also investigated how many of sampled livestock herds spend the night in night-time enclosures. Results are presented separately for sheep/goat herds, adult cattle and calves (**Fig. 21**). The vast **majority of sheep/goat** herds (86%) **overnights inside a fenced area every night.** A small percentage of sheep/goat herds (14%) periodically overnights outside a fence, while none of the sheep/goat herds never use any kind of enclosure for livestock during night time.

However, results are strikingly different regarding cattle herds: only a very small percentage of **adult cattle** (16%) spends each night inside a fence/enclosure, one third of them (32%) periodically overnights outside, while **a large proportion** of them (53%) **overnights outside of a fence/enclosure**, usually gathered in one or more spots.

Considering **calves,** a large proportion of farmers (53%) has adopted an important prevention measure: either they guide calves to spend the night inside a fenced area or they keep them permanently inside a fence/enclosure during the whole grazing season. However, an important percentage (42%) leaves calves to overnight outside any sheltered area accompanied by their mothers.

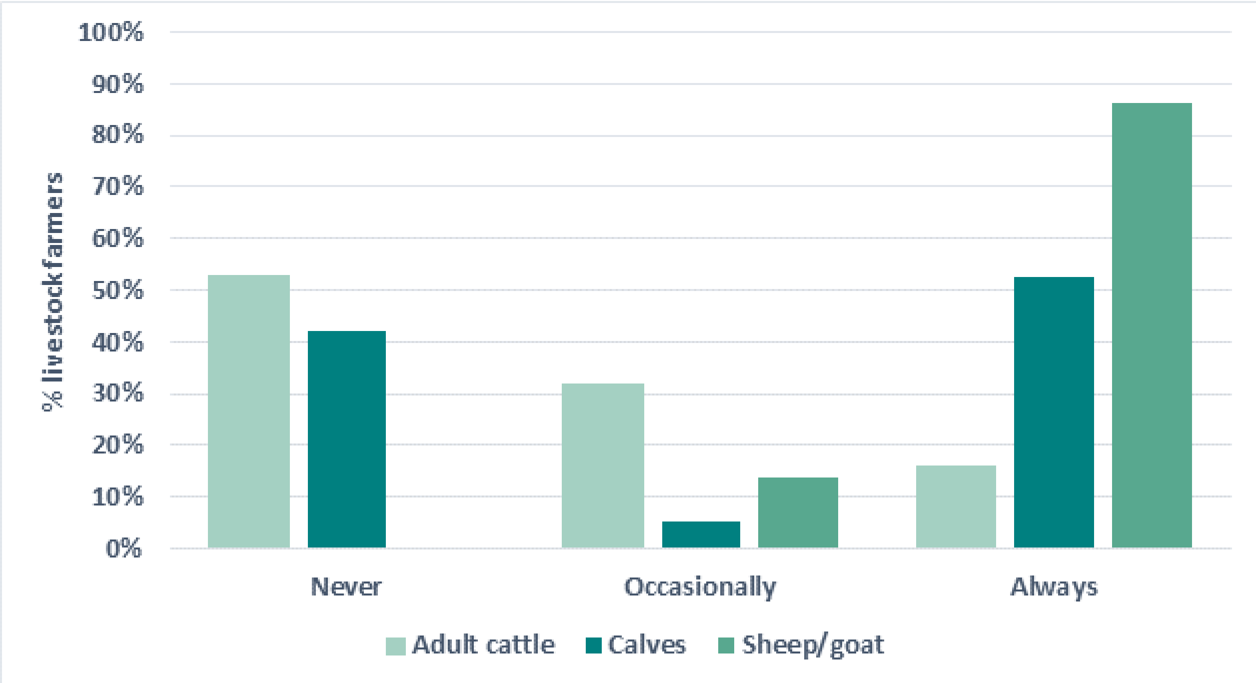

Figure 21: Percentage distribution of livestock farm according to the type of livestock confinement during night time (Never-Occasionally-Always) per breeding type (Cattle-Calves-Sheep/Goat).

Figure 22: Sheep farmer is guiding her herd to spend the night in a temporal fenced enclosure.

3.3.3 Availability of young livestock (<6 months old) in pastures

Bringing neonatal or very young calves, lambs and kids to pastures can dramatically increase predation by wolves, as young animals are particularly vulnerable to wolf predation (Breitenmoser et al. 2005, Iliopoulos et al. 2009, Pimenta et al. 2017). During our field surveys, we asked farmers specific questions considering presence and management of livestock offspring (<6 months) in pastures.

Results showed that the greatest **majority of cattle farmers** (74%) **allows young calves** (<6 months) **to freely graze in pastures** (**Fig. 23 & 24**). In contrast, **most sheep/goat farmers keep lambs and kids** (<6 months) **constantly penned** until this age (78%). Most sheep and goat births are synchronized during the wintering period when livestock are kept most of the time inside permanent pens. This allows most farmers to achieve the best timing possible between onset of grazing in summer pastures and post weaning period of young livestock. This is much less prominent in cattle farms were cows may deliver outdoors year-round.

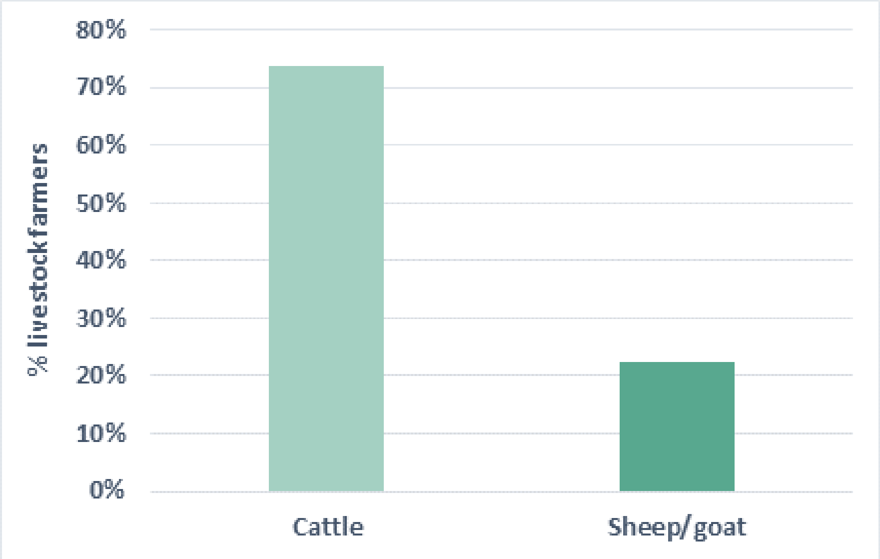

Figure 23: Percentage distribution of cattle and sheep/goat livestock farmers that bring young animals <6 months old to pastures during grazing.

Figure 24: A very young calf following its mother during grazing. Calves are very vulnerable to wolf predation especially when separated from the rest of the herd.

3.3.4 Livestock Guarding Dog use for the protection of livestock

The use of large dog breeds to protect livestock against carnivore attacks has been used worldwide from farmers since ancient times, i.e. for more than 6000 years (Rigg 2001). In Greece, use of livestock guarding dogs (LGDs) is one of the most common and traditional damage prevention measure adopted from livestock raisers (Giannakopoulos et al. 2017, Fig. 25). Three indigenous dog breeds are in the country for livestock protection: the **Greek sheepdog**, the **Greek white sheepdog** and **Molossos of Epirus**.

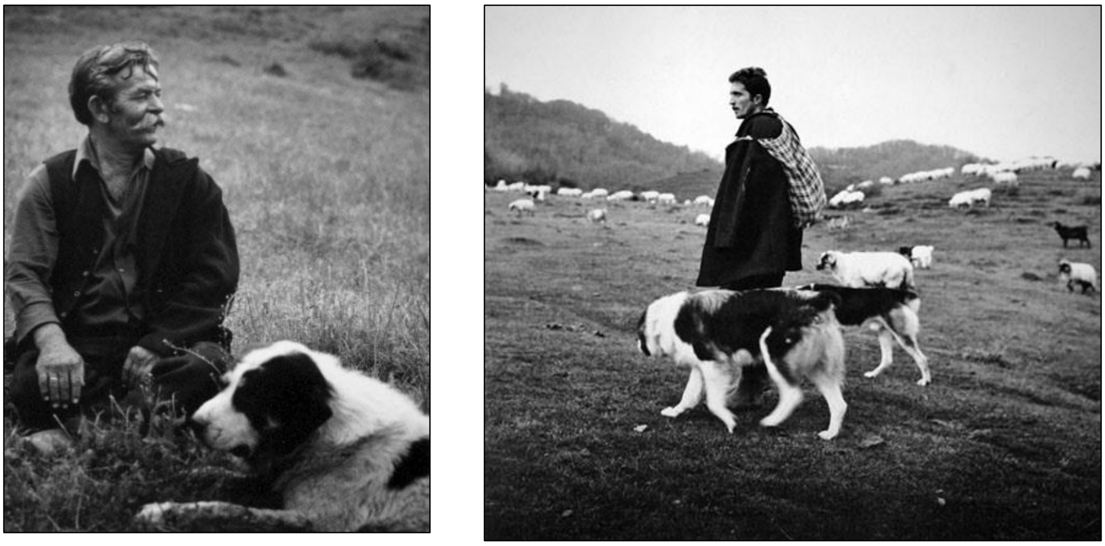

Figure 25: Traditional livestock farmers with their LGDs in Pindos range during the 1960s (photos: K. Balafas).

In our study area the **use of LGDs seems to be widespread**. In our sample, 100% of sheep-goat farmers (n=36) and a remarkable percentage (84%) of cattle farmers (n=19) are currently using LGDs for livestock protection (Fig. 26). Use of LGDs in our area was satisfactory especially in the case of cattle farmers. For example, in Portugal only 12% of interviewed cattle farmers were using LGDs (Pimenta et al. 2017).

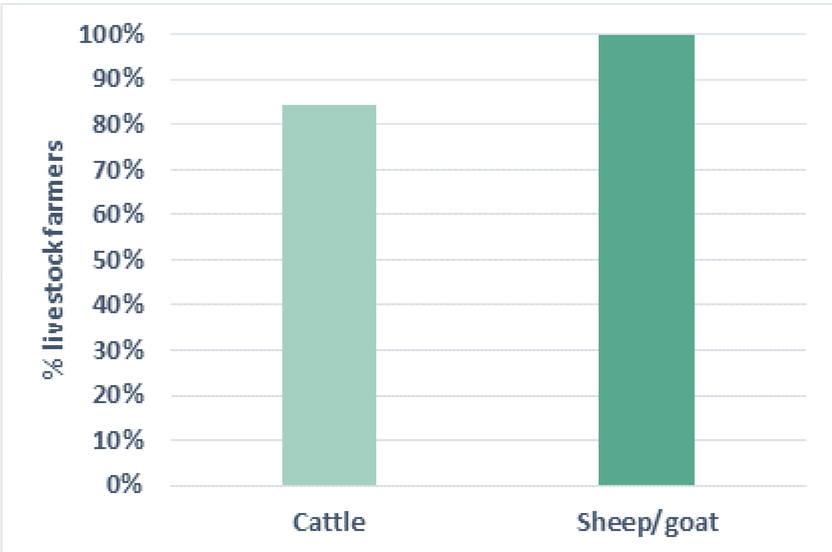

Figure 26: Percentage of cattle (n=19) and sheep/goat (n=36) livestock farms that use Livestock Guarding Dogs (LGDs) for livestock protection in the study area.

Capacity of livestock farms in LGDs was expressed in three ways: a) total number of LGDs per herd, b) number of LGDs per Animal Unit (AU) and c) number of LGDs per 100 livestock animals. We present results for a) all farms, b) sheep/goat farms and c) cattle farms in Table 6. Number of LGD's averaged **5 LGDs/herd** and **2.4 LGD/100 animals for the overall sample size**, with cattle farms using more dogs per 100 animals than sheep/goat farms (1.9 vs 3.4 respectively).

Table 6: Capacity of livestock farms in Livestock Guarding Dogs (LGDs).

Type of farm	Statistical value	Total num of LGDs/farm	Num of LGDs/100 animals	Num of LGDs/AU
All farms (n=55)	Mean	**5.0**	**2.4**	**0.10**
	SD	3.6	2.3	0.08
	Range	0 - 15	0.0 - 12.5	0.00 - 0.36
Sheep/goat farms (n=36)	Mean	**5.4**	**1.9**	**0.13**
	SD	3.0	1.3	0.08
	Range	2 - 15	0.3 - 5.3	0.02 - 0.36
Cattle farms (n=19)	Mean	**4.2**	**3.4**	**0.04**
	SD	1.0	3.4	0.04
	Range	0 - 15	0.0 - 12.5	0.00 - 0.14

We grouped livestock farms in four classes, according to the number of LGDs used per 100 livestock animals: a) 0-1 LGDs, b) >1-2 LGDs, c) >2-3 LGDs and d) >3 LGDs. Most **sheep/goat farms** (39%) **were classified in the second class** (>1-2 LGDs/100 animals), while contrary, most **cattle herds** (42%) **were classified in the fourth clas**s (>3 LGDs/100 animals). Results are presented in Figure 27.

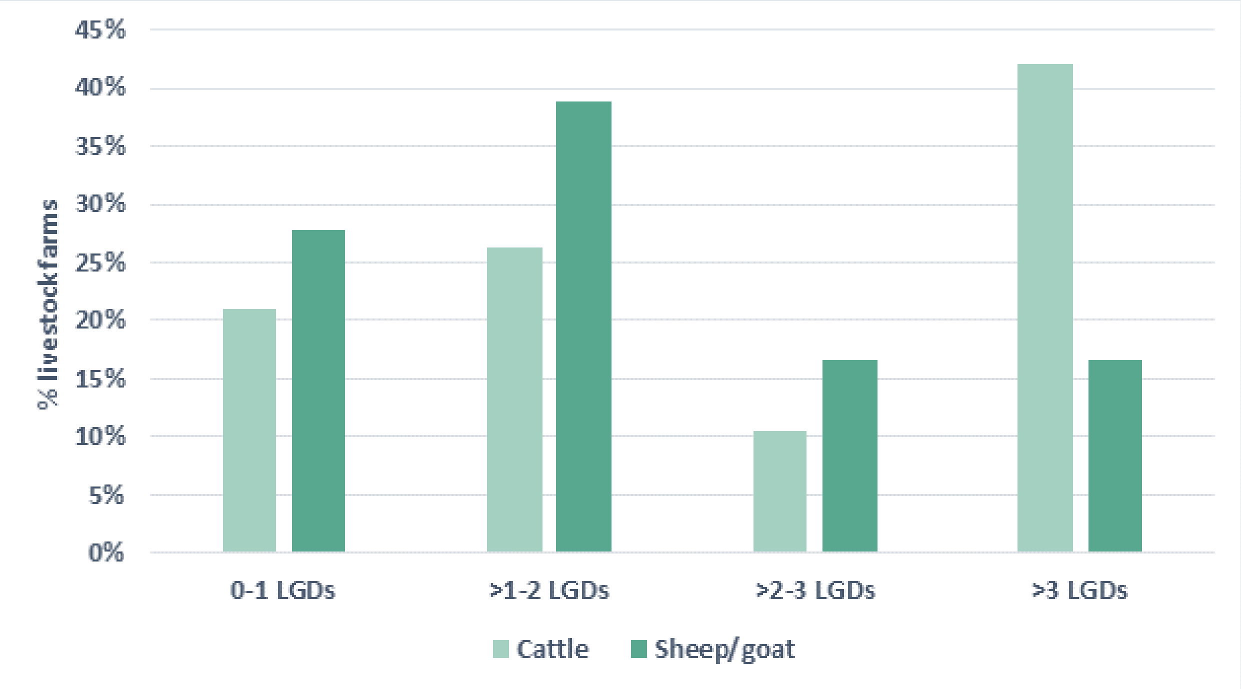

Figure 27: Percentage distribution of farms in LGD capacity classes (LGD's/100 animals) presented separately for cattle and sheep/goat farms.

During our survey we asked those farmers who already use LGDs (n=52) to score their own dogs according to their performance on repelling wolf attacks. Farmer satisfaction (in a scale from 1-10) **averaged 6.8** and was similar between sheep/goat and cattle farms, with LGD performance to **score slightly higher** in **sheep/goat** farms (Table 7).

Table 7: Farmer satisfaction summary results considering LGD efficiency to repel wolf attacks (score: 1-10).

Type of farm	Statistical value	LGD score
All farms (n=52)	Mean	**6.8**
	SD	0.4
	Range	1 - 10
Sheep/goat farms (n=36)	Mean	**6.9**
	SD	2.4
	Range	1 - 10
Cattle farms (n=16)	Mean	**6.6**
	SD	2.8
	Range	1 - 10

We then grouped cattle farmers (n=16) and sheep/goat farmers (n=36) in four classes according to LGD rating: a) <5 points (inadequate LGDs), b) 5-6 points (moderate LGDs), c) 7-8 points (good LGDs) and d) 9-10 points (very good LGDs). **More than 60% of cattle and sheep/goat farmers score their LGDs as "good" or "very good"** (Fig. 29). Homogeneity on satisfaction scores between cattle and sheep-goat farms was evident in the two upper classes while, in the contrary, lower class is represented more in cattle herds, which had a highest percentage of "inadequate" LGDs.

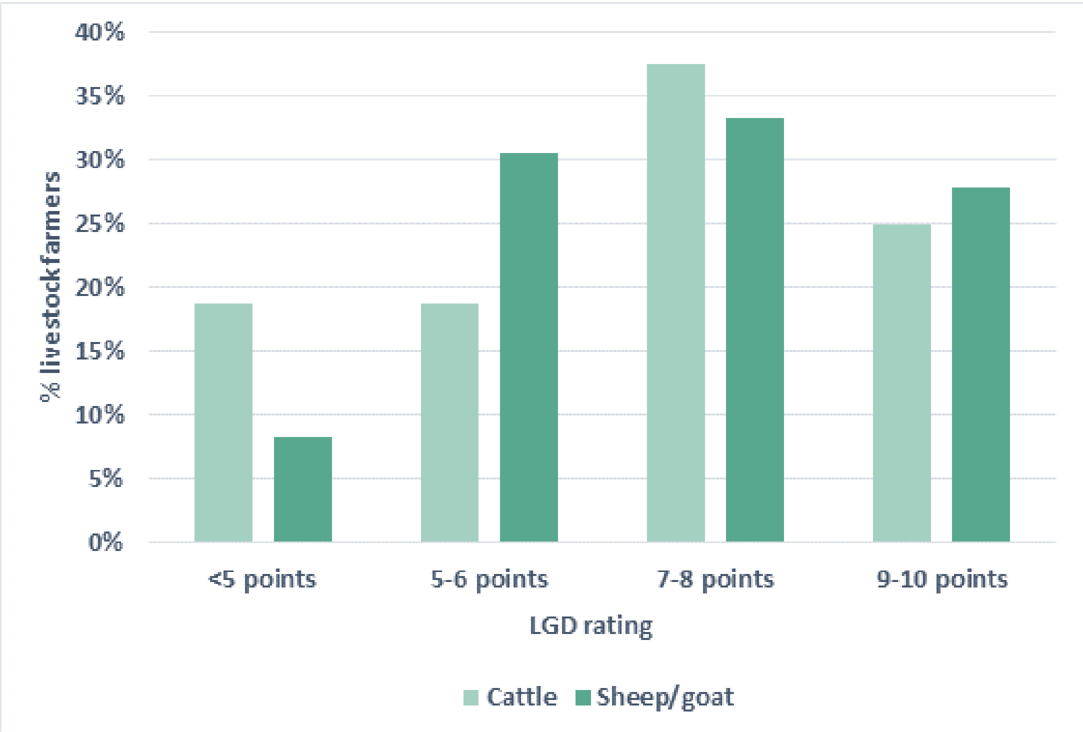

Figure 28: Percentage distribution of cattle and sheep-goat farmers according to their satisfaction on LGD performance.

Figure 29: Livestock Guarding Dogs in Tzoumerka NP. A and b: Molossos of Epirus, c: Greek Sheepdog, d: local mixed breed and e: Greek Sheepdog mixed with Polish Tatra Sheepdog. Use of spiked collars protect dog from neck bites and serious injuries.

3.4 Livestock Guarding Dog mortality by poisoned baits

In many parts of Greece livestock farmers are facing a major problem: the loss of high numbers of LGDs by the widespread illegal use of poisoned baits (Ntemiri et al. 2018, Petridou et al. 2018). LGD poisoning adversely affects protection of herds from large carnivore attacks and any attempts to re-establish traditional Greek LGD breeds (Giannakopoulos et al. 2017).

During interviews, we collected information on LGD poisoning during the last decade, level of LGD losses per farmer, seasonality of LGD poisoning and spatial distribution of losses (i.e. whether poisoning was more an issue on wintering areas in cases of transhumant herds). Moreover, we recorded farmers' beliefs considering motivations related to this illegal practice. **Nearly half (n=22) of farmers using LGDs (n=52) experienced at least one incident of LGD poisoning during the last decade with a total reported number of 202 poisoned dogs** and a mean loss of 4 LGDs per farmer (range = 0-50) (**Table 8**).

Table 8: Poisoning of Livestock Guarding Dogs (LGDs) in Tzoumerka National Park during the period (2009-2018) as reported from 52 livestock farmers.

Poisoned LGDs in Tzoumerka NP during 2009-2018	
Percentage of farmers that lost LGD from poisoning	42% (n=22)
Total number of poisoned LGDs	202
Mean losses per farmer	3.9
SD	8.3
Range	0-50

Considering severity of LGD poisoning amongst local and transhumant farmers in Tzoumerka NP, results showed a striking difference: loss of LGDs from poisoning is much more **frequent in local farms** (64% affected, n=25) than in transhumant ones (19% affected, n=27), (**Fig. 30**).

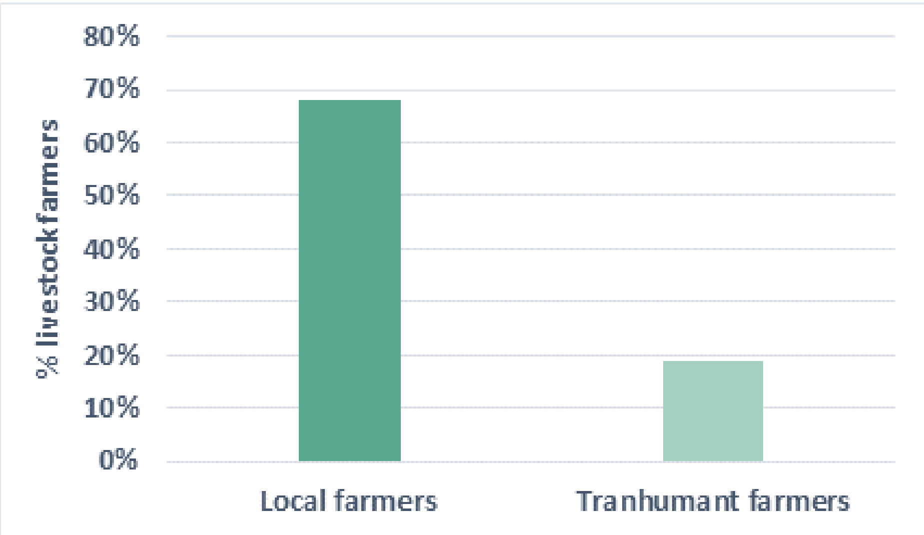

Figure 30: Percentage of local and transhumant livestock farmers that have experienced one or more LGD poisoning incidents in the area of Tzoumerka NP during 2009-2018.

However, when focusing exclusively on transhumant farmers, who may experience LGD poisoning in winter pastures beyond the borders of Tzoumerka NP, the picture changes. The majority of interviewed transhumant farmers-owners of LGDs (63%, n=27) have experienced LGD losses by poisonous baits the last decade. The **greatest majority of transhumant farmers experienced losses only in winter pastures** (44%), less farmers in both wintering and summer pastures (15%), and only a few in summer pastures only (4%), (**Fig. 31**).

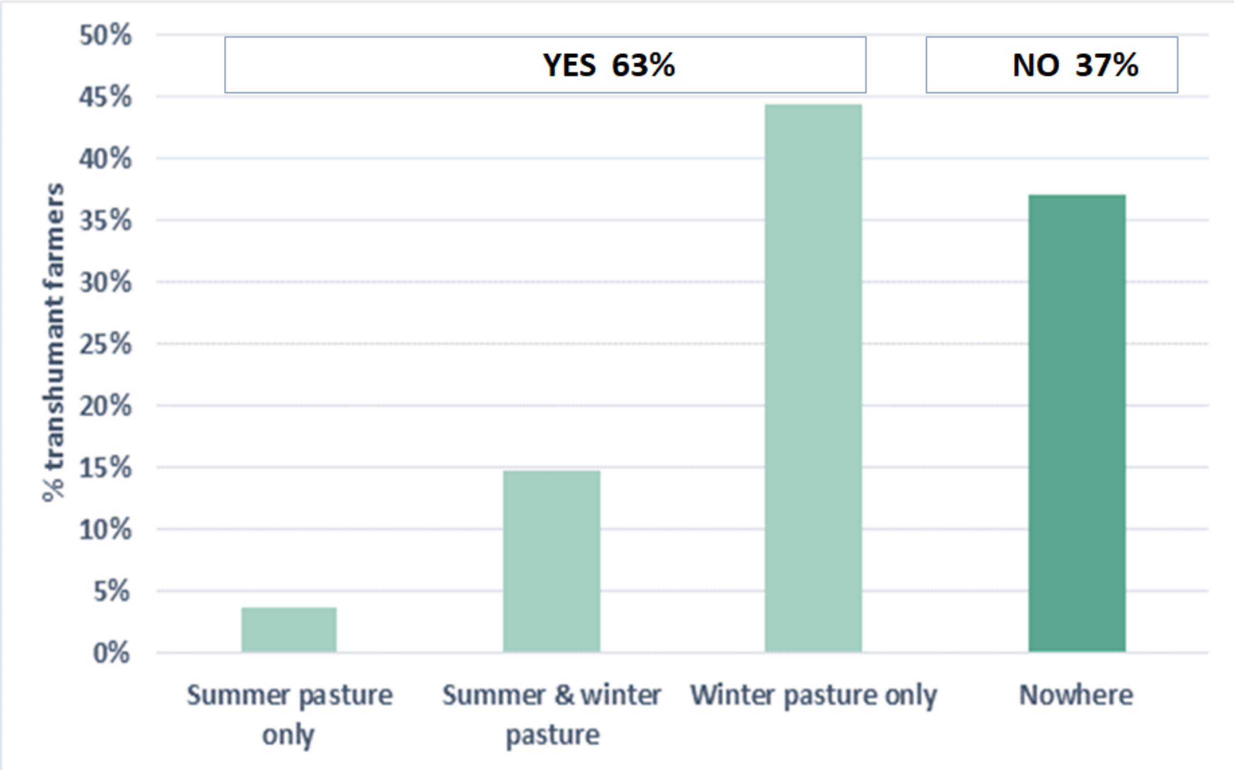

Figure 31: Percentage of transhumant farmers (n=27) that experienced LGD poisoning the last decade in relation to seasonal migrations (summer pastures - wintering areas) - inside or outside Tzoumerka NP.

Farmers who experienced LGD poisoning were asked to report possible motivations for illegal use of poison baits according to their knowledge. In **Figure 32** all mentioned **opinions about motivation scenarios** are shown. Four major motivations were reported by farmers: The most common motive was **illegal fox control** (25%) for game protection. The fox is arbitrarily considered to be responsible for local decreases in hare population and that adversely affects hunting dogs' performance. The second major reason was the deliberate poisoning of **shepherd dogs by hunters** (21%). Since shepherd dogs can attack hunting dogs, hunters use the illegal tactic of poisonous baits against them. The next most important motives were the **illegal wolf control** (14%) for preventing or retaliating livestock predation as well as the deliberate poisoning of **shepherd dogs targeted by other livestock farmers** (14%). The latter is quite complex, as it can include retaliation over personal matters, disputes over land property and grazing rights, or even jealously over a very good shepherd dog.

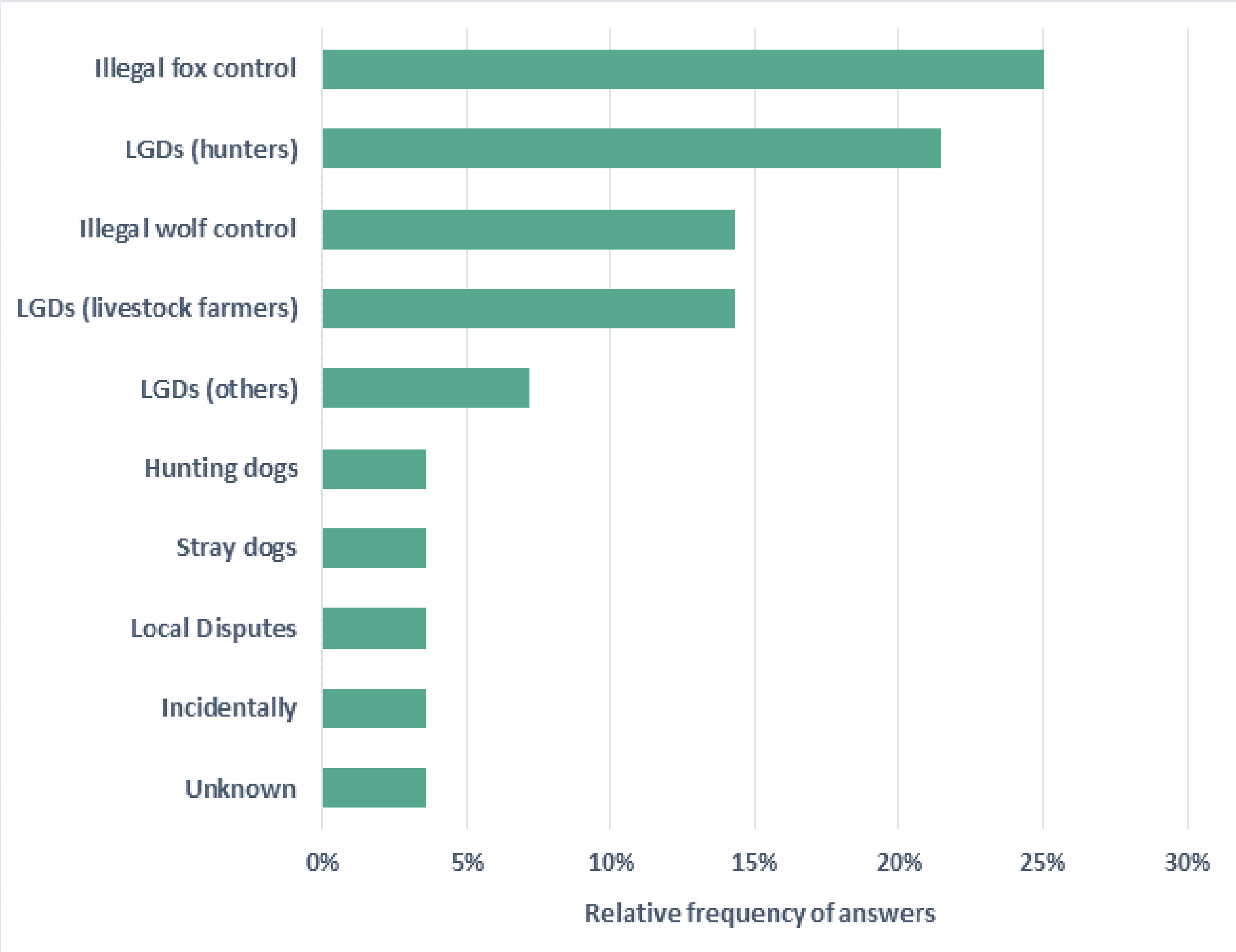

Figure 32: Reported relative frequency (%) of motivations related to illegal use of poison baits use according to farmers' beliefs (total number of answers=28).

Our results on motivations are in line with the results from other areas of Greece. Ntemiri et al. (2018) found retaliatory acts involving shepherd and hunting dogs to be the most significant driver of bait use, while the second most important motive was the illegal extermination of wolves, bears and foxes. Petridou et al. (2018) found that disputes with hunters, illegal fox control and local disputes were the three most important reasons for LGD poisoning, on the basis of interviewed livestock farmers in North-Western Greece.

During the period of our survey, in October 2019, an incident of **wolf poisoning** occurred in the core area of Tzoumerka NP (http://www.ornithologiki.gr/page_cn.php?aID=1941). An autopsy was undertaken by the Anti-Poison Dog Unit of the Hellenic Ornithological Society and a warden from the Management Authority of Tzoumerka NP (**Fig. 33**). During inspection of the surrounding area, cattle remains (skin, legs) laced with poison were found. From this evidence, it can be assumed that the incident was probably a retaliation-related poisoning, motivated by wolf predation on cattle.

Figure 33: A wolf found dead after consuming an illegal poisoned bait in the core area of Tzoumerka NP in October 2019 (photos: D. Vavylis and L. Badikou/HOS).

3.5 Satisfaction levels regarding ELGA

Compensation paid for wildlife damages is one of the most widespread financial tools to mitigate human-wildlife conflicts (Ravenelle and Nyhus 2017). The common sense under any compensation system is to relief livestock farmers from related economic losses and subsequently increase public acceptance of carnivores (Linnell and Cretois 2018).

In Greece the compensation scheme is uniform for the whole country and is managed by the Hellenic Farmers Insurance Organization (ELGA), a public organization. Farmers are obliged by law to insure their livestock and pay for the insurance premium in an annual basis. When damage is caused by wild carnivores (wolf, bear), or even by stray dogs, the affected farmer must file a claim for compensation to ELGA, accompanied by an inspection fee, within 48 hours of the incident. An inspector from ELGA performs an in-situ assessment and decides if the farmer will be compensated or not (Skartsi et al. 2014, Giannakopoulos et al. 2017). According to ELGA's Regulation, the minimum level of damage eligible for compensation is 200€, corresponding to 2-3 sheep/goats or one calf older than 10 days killed per attack (ELGA 2011). ELGA also covers livestock deaths caused by other natural causes (i.e. hail, flood, lighting strike, landslide etch) and diseases (i.e. anthrax, listeriosis, paratuberculosis etch).

We surveyed farmers' satisfaction level for ELGA's compensation system. Results are presented separately cattle and sheep/goat farmers (Fig. 34). Response rate was 90% for cattle and 89% for sheep/goat farmers. **Most sheep-goat farmers** (78%) **were not satisfied** with the compensation system. 50% of those farmers were very disappointed ("not at all" class) while 28% were only partially satisfied ("a little" class). An overall 22% of sheep-goat farmers were satisfied in a "moderately" (19%) or in a full degree ("a lot" class-3%). Similarly, majority of **cattle farmers** (65%) **were not satisfied** with the compensation system. 35% of those farmers were very disappointed ("not at all" class) while 30% were only partially satisfied ("a little" class). An overall 35% of cattle farmers were satisfied in a "moderately" degree.

Overall, **satisfaction levels were low for both types of farmers**, but were **relatively higher for cattle farmers** than sheep/goat farmers. The latter is linked to the higher overall damage coverage of cattle depredations from ELGA, i.e. cattle are much more easily discovered and retreated compared to sheep and goats, while the damage threshold (200€) per attack is easily covered and most cattle damages are subject to compensation according to ELGA regulation.

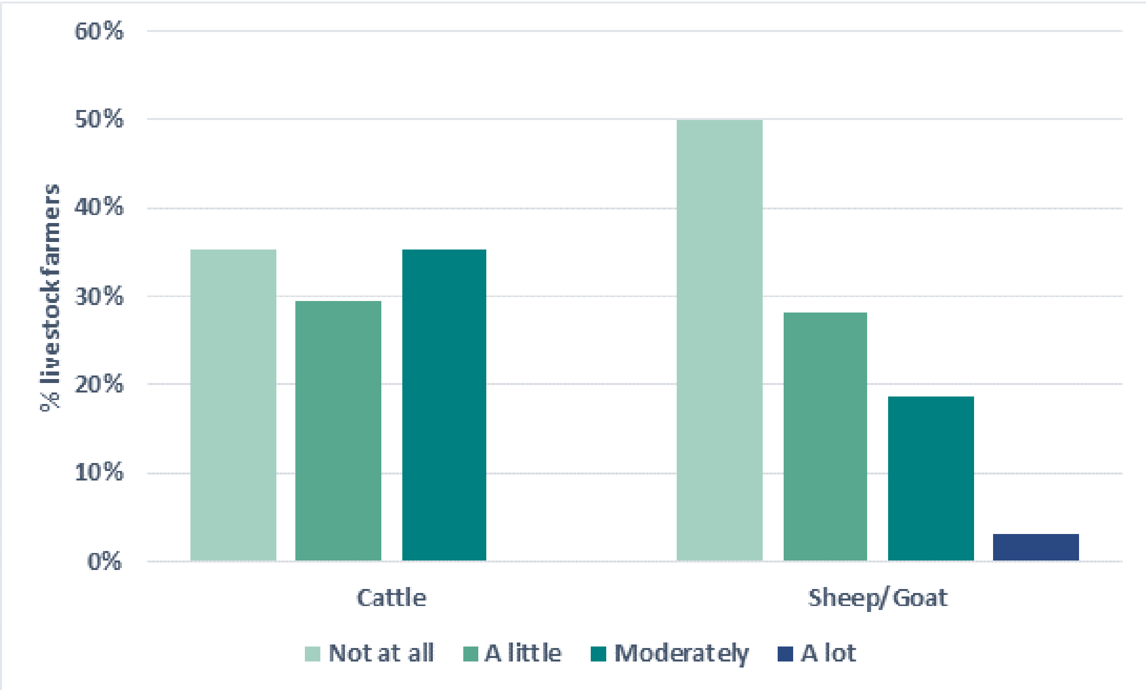

Figure 34: Percentage distribution of farmers according to their satisfaction levels regarding ELGA's compensation system in Tzoumerka NP in the 4 relevant classes, for both cattle (n=17) and sheep/goat farmers (n=32).

Effectiveness of compensation schemes is under major criticism as they have some severe dysfunctions or negative side effects. In particularly: a) it is not always possible to determine accurately the real cause of livestock deaths, which may also cause disputes with the official inspector, b) prompt retrieval of killed livestock after a carnivore attack -as to accurately diagnose cause of death and account for the actual number of livestock killed- is in many cases impossible and c) they may instead reward and encourage a more passive mentality rather than motivate farmers to adopt an energetic proactive approach and invest in effective mitigation strategies (Bulte and Rondeau 2005, Nyhus et al. 2005, Boitani et al. 2010, Linnell and Cretois 2018).

It is generally recommended revision of compensation schemes to improve their effectiveness (Boitani et al. 2010). One fundamental improvement is **to directly associate compensation systems with preventive measures enforced** (Marucco and Boitani 2012, Ravenelle and Nyhus 2017). Moreover, compensation systems should also prioritize in assisting farmers to apply those measures correctly (Álvares et al. 2014), especially in areas where carnivores have been absent for a period of time (Marucco and McIntire 2010).

4. COMPARISON WITH OTHER PROTECTED AREAS IN GREECE

The outputs of Tzoumerka NP survey were compared with other recent surveys throughout Greece (**Table 9**). Surveys were conducted in different periods, with different sampling design, not using the same semi-structured questionnaires, and in one case served a different purpose without targeting exclusively livestock farmers (regional study). Results are presented for the four cases studied in comparative basis, but the analysis aims at presenting the first overview of the important issue of livestock depredation by wolves in Greece, rather than reach safe comparative conclusions among case studies.

Table 9: Description of the four case studies in terms of sampling period and sample size (number of livestock farmers interviewed).

Case study		Tzoumerka NP	Prespes NP	Oiti NP	Regional study
Reference period for depredation data		2016-2018	2015-2016	2011-2012 and 2014-2015	2003-2012
Sample size		55	37	44	220
Sample size per farm type	***Sheep/goat farms***	36 (65%)	26 (70%)	36 (82%)	N/A
	Cattle farms	19 (35%)	11 (30%)	8 (18%)	

4.1 Farmers experiencing wolf predation on their livestock

In **Fig. 35**, percentage of livestock farmers with livestock losses caused by wolf predation is presented amongst the four different studies mentioned. The majority of livestock farmers in all four study areas have experienced livestock losses during the reference periods.

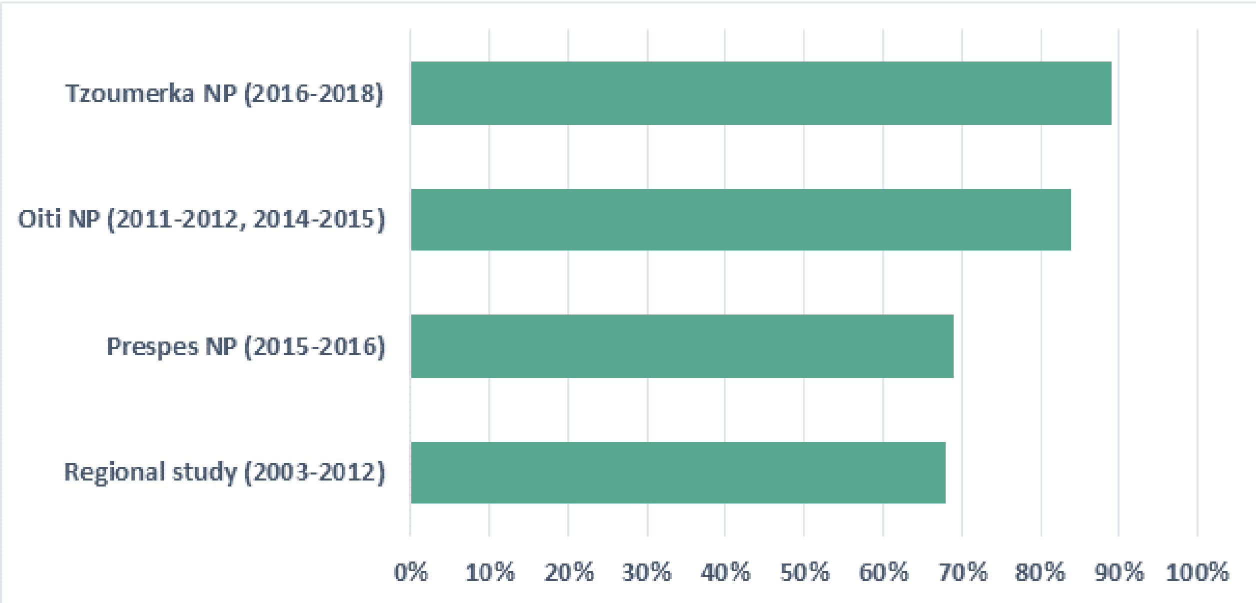

Figure 35: Percentage of farmers that experienced wolf-caused livestock losses in a) Tzoumerka National Park (present study), b) Prespes National Park (Iliopoulos and Petridou 2017), c) Oiti National Park (Iliopoulos et al. 2015, Iliopoulos and Petridou 2012) and d) Regional study (Skartsi et al. 2014).

4.2 Mean Percentage Annual Losses per farmer

To compare severity of wolf depredation on livestock farms amongst those three National Parks we estimated the standardized index MPAL, i.e. Mean Percentage Annual Loss (MPAL) for each farmer, type of livestock farm (cattle, sheep-goat) and study area: Tzoumerka NP (3 years), Prespes NP (2 years) and Oiti NP (4 years) (**Fig. 36**). Average farmer losses in Prespes NP (mean MPAL=1.2%) seem to be lower compared to Tzoumerka NP (mean MPAL = 2.3%) and Oiti NP (mean MPAL=2.4% MPAL) where farmers suffered similar amounts of losses.

Differences between Prespes NP and the two other study areas are more prevalent for cattle farms: in Prespes NP cattle farmers had almost zero losses, in contrast to Tzoumerka and Oiti NPs where farmers lost annually 2.4% and 3.0% respectively of their herd. Mean annual losses **concerning sheep/goat seem to be similar among the three study areas**, i.e. MPAL ranges from 1.6% in Prespes NP (lowest value) to 2.3% in Oiti NP (higher value). Nevertheless, high standard deviations for MPAL index reveal also a **very high variability of individual farmer losses in all three study areas** (**Fig. 36**).

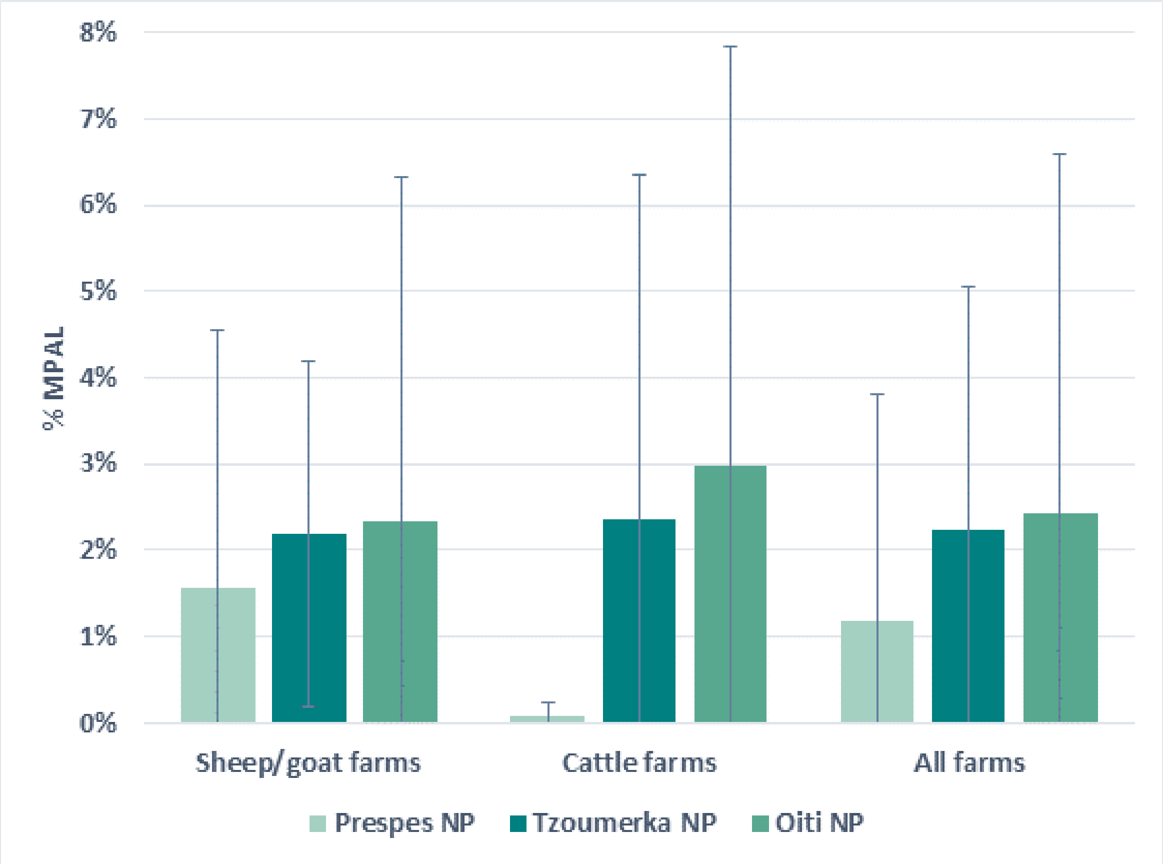

Figure 36: Mean Percentage of Annual Losses (MPAL), as claimed by farmers, in three study areas: a) Tzoumerka National Park, b) Prespes National Park and c) Oiti National Park, presented for all types of farms and for sheep/goat and cattle farms (Error bars: SD).

4.3 Severity of losses

To compare severity of wolf-human conflicts amongst the three national Parks we first estimated %MPAL expressed in Animal Units for each farmer and then we calculated, percentage of farmers falling into each of the four loss classes per area: a) 0% (no losses) b) 0-1% (small losses), c) 1-5% (moderate losses) and d) ≥5% (large losses) (Iliopoulos et al. 2009).

Comparisons among parks are presented in Figure 37. The most **prevailing loss class for all three national parks is the "moderate" one (1-5%)** with percentage of farmers classified in this category ranging from approximately 40% to 50% of local sample sizes.

An important percentage of farmers experiences severe losses (≥5% MPAL) in all three areas, ranging from 11% in Prespes NP to 16% in Oiti NP. It is also worth mentioning that an **important percentage of farmers in Prespes NP** (31%) **had no losses** (%MPAL=0), which was two-fold and three-fold higher than in Oiti NP (16%) and Tzoumerka NP (11%).

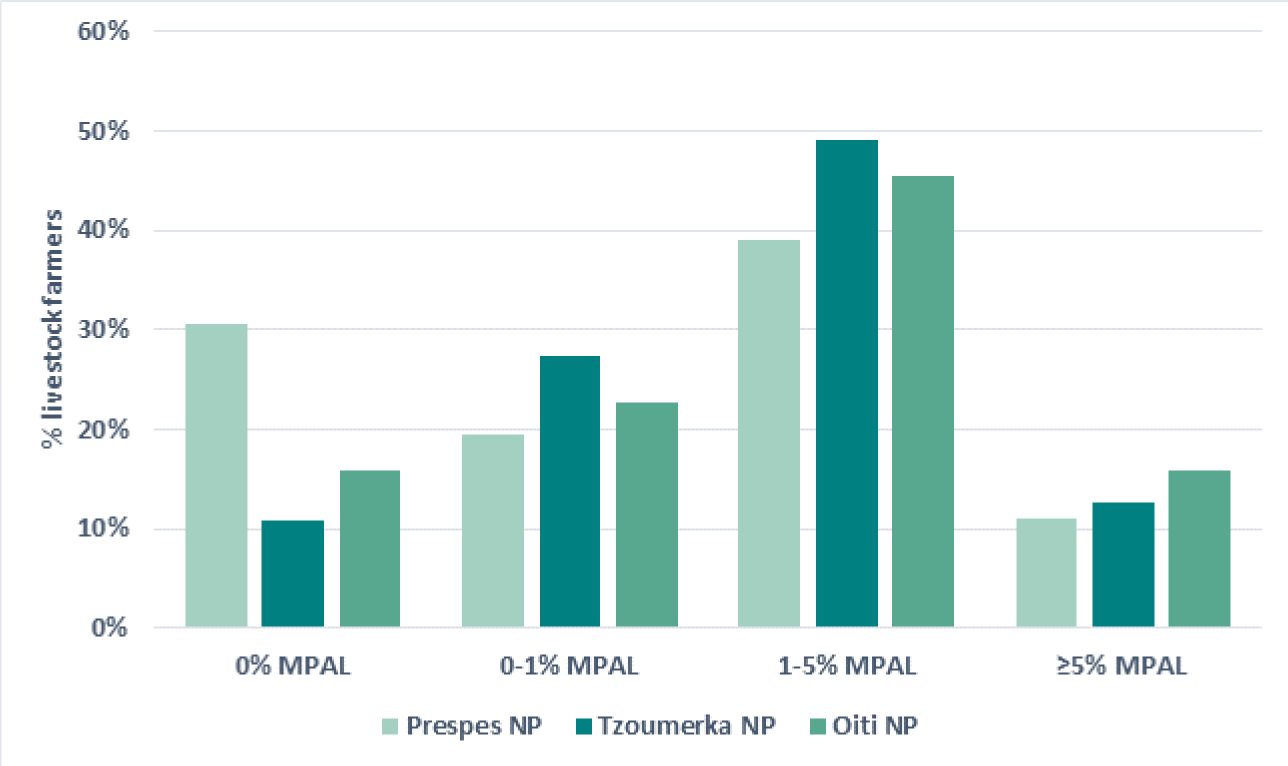

Figure 37: Percentage distribution of farmers according to severity of annual livestock losses caused by wolves, in the 4 severity classes of %MPAL, for three study areas: a) Tzoumerka NP, b) Prespes NP and c) Oiti NP. Classes of MPAL: 0% (no losses) b) 0-1% (small losses), c) 1-5% (moderate losses) and d) ≥5% (large losses).

Given that livestock farmers were asked to classify losses in 4 classes of magnitude (small, medium, large and very large) a similar quantitative analysis could not be performed for the regional study. **Wolf attacks at the regional study were mostly perceived as having a medium** (28%) **to small** (23%) **impact (Fig. 38**). However, an important percentage of farmers, reaching just over 16% of the sample size, considered wolf attacks to have a large and very large impact. The latter percentage is similar and comparable to >5% MPAL class that ranged from 11 to 16% in the rest of the study areas (Fig. 37).

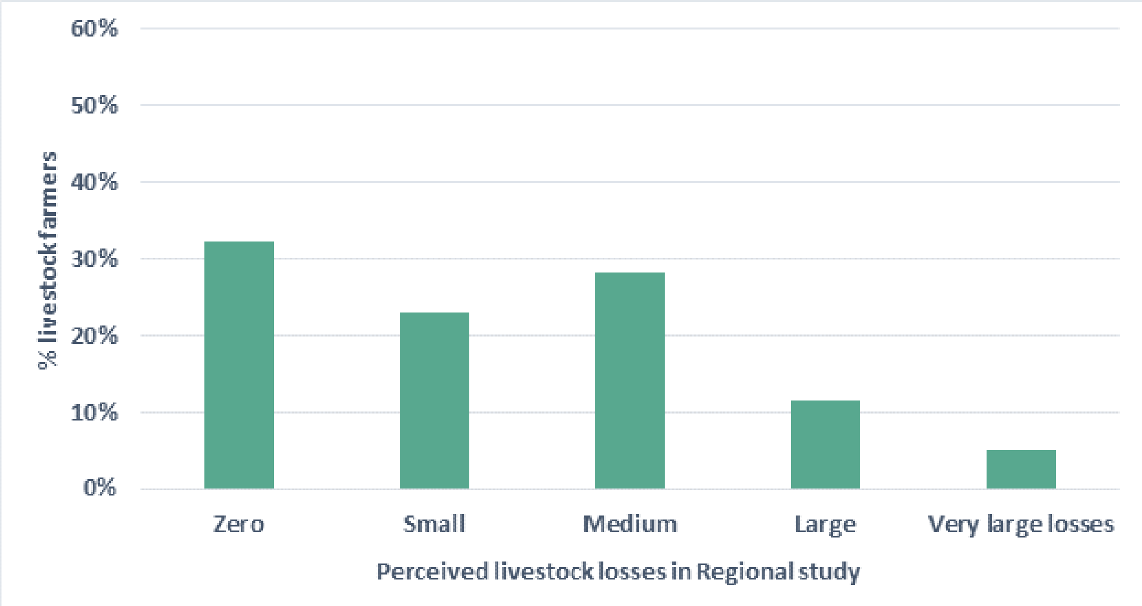

Figure 38: Magnitude of livestock losses caused by wolves, as perceived by livestock farmers in the Regional study: a) small b) medium, c) large, d) very large. Zero losses were added for comparison reasons.

4.4 Satisfaction of farmers regarding compensation system

We compared satisfaction levels regarding ELGA's compensation system. Comparisons were made only between the present study and the regional study as satisfaction levels were assessed in a similar way only for those two study areas.

Response rate of farmers was 89% in Tzoumerka NP and 68% in the regional study. **Farmers in both studies** (74% and 62% respectively) **were not satisfied with the compensation system** and classified it as either completely inadequate ("not at all" class) or partially inadequate ("a little" class) (**Fig. 39**).

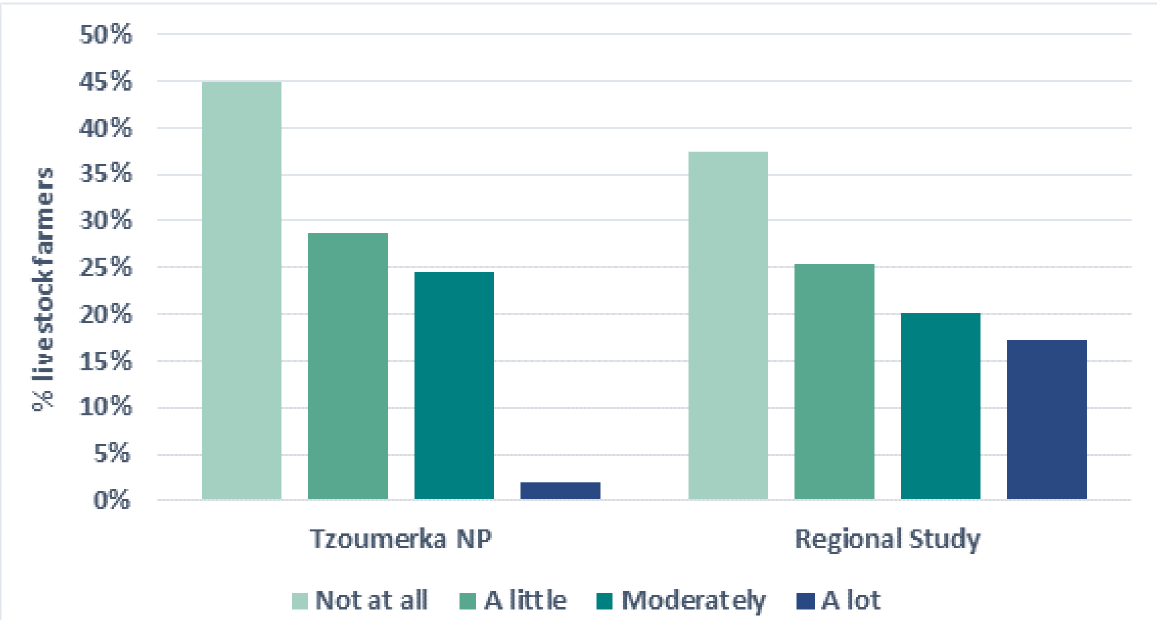

Figure 39: Satisfaction levels of livestock farmers regarding ELGA's compensation system for: a) Tzoumerka NP, n=49 and b) Regional study, n=145.

4.5 Livestock surveillance

Intensity of livestock surveillance in Tzoumerka, Prespes and Oiti national Parks was classified in three classes (see also chapter 3.3.1):

a. **"Never":** livestock herd grazes mostly unattended during daytime, without a shepherd's presence.
b. **"Partly"**: livestock herd is partially attended by a shepherd during daytime grazing.
c. **"Always":** livestock herd is constantly attended by a shepherd during daytime grazing in pastures.

Combining results from the three areas revealed that **surveillance by a shepherd during livestock grazing is a widespread prevention method in all three study areas**. Nevertheless, intensity of surveillance amongst shepherds differs between the three areas **with the highest value recorded in Prespes NP** (i.e. 97% of farms use at least one shepherd constantly full time present) followed by **Oiti NP (**87% of farms with full time surveillance) (**Fig. 40**). In **Tzoumerka NP we recorded the lowest surveillance intensity** with the prevalent surveillance intensity amongst farms to be only partial (49%).

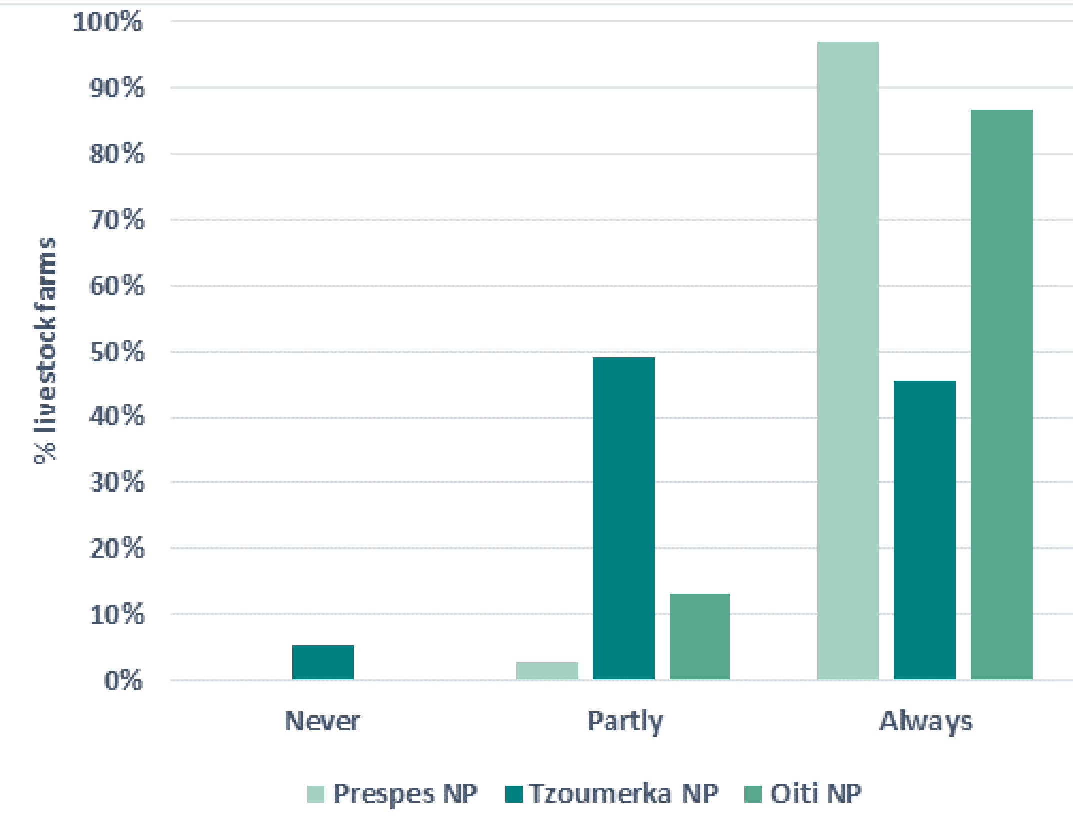

Figure 40: Percentage distribution of livestock farms amongst the three surveillance intensity classes (Never, Partly, Always), in: a) Tzoumerka National Park, b) Prespes National Park and c) Oiti National Park.

4.6 Use of Livestock Guarding Dogs

Percentage of farmers that use LGDs as a damage prevention method is compared between Tzoumerka NP, Prespes NP and Oiti NP. Combined results for each park and type of livestock farm (cattle, sheep/goat) are presented in Figure 41. **Use of LGDs is widespread in all three areas**. This is especially prevalent in sheep/goat herds, as 100% of **sheep/goat farmers** in all three areas use LGDs as a damage prevention method. On the contrary, **LGD use from cattle farms differs substantially amongst the three areas**: in Prespes NP all of the cattle farms use LGDs (100%), in Tzoumerka NP this percentage is lower (84%) while in **Oiti NP only** 67% of cattle farms use LGDs.

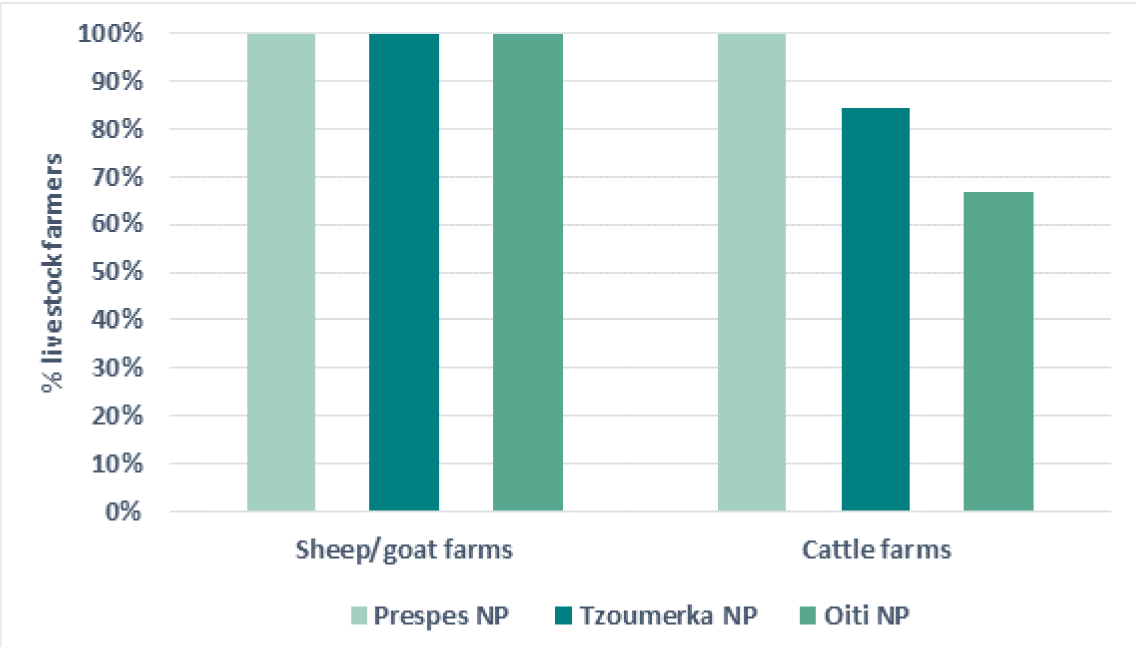

Figure 41: Percentage of cattle and sheep-goat livestock farmers that use Livestock Guarding Dogs (LGDs) in: a) Tzoumerka National Park, b) Prespes National Park and c) Oiti National Park.

4.7 Intensity of Livestock Guarding Dog use

To compare Livestock Guarding Dog intensity of use by farmers, amongst the three national parks, we calculated two indexes/scores: a) Average Number of LGDs/herd and b) Average Number of LGDs/100 livestock animals. Farmers in **Prespes NP used more dogs for livestock protection** (5.7 LGDs/herd and 2.6 LGDs/100 animals), closely followed by **farmers in Tzoumerka NP** (5.0 LGDs/herd and 2.4/LGDs/100 animals). In **Oiti NP, LGD intensity of use was the lowest amongst the three parks** (3.4 LGDs/herd and 1.7/100 animals), (**Fig. 42**).

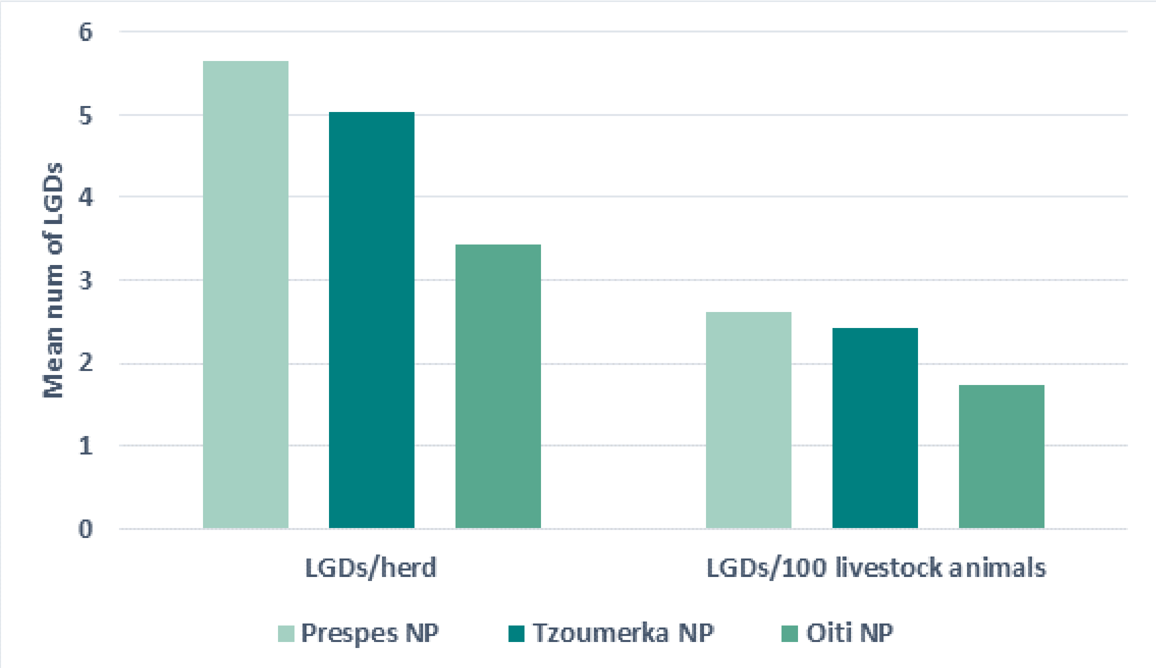

Figure 42: Average number of Livestock Guarding Dogs (LGDs) used per livestock farm and per 100 livestock animals in: a) Tzoumerka National Park, b) Prespes National Park and c) Oiti National Park.

5. CONCLUSIONS

5.1 Wolf-livestock conflicts in Tzoumerka National Park

Our study attempted to shed light on wolf-livestock conflicts on cattle, sheep and goat farms in Tzoumerka National Park, by collecting data and perceptions of 55 livestock farm owners in the Park. The main outputs of our study are the following:

- The **regeneration potential** of free-ranging livestock rearing sector seems to be satisfactory, as an important part of the sample (36%) consisted of farmers under 40 years old [see 3.1.1].
- Interviewed farmers were **very experienced in livestock farming**, as 73% of them have started to work for the family business as non-adults, while in 80% of all cases their families practiced traditional livestock farming for many generations [see 3.1.2].
- **Livestock herd size was medium to large:** sheep herds averaged 326 animals, goat herds 273, mixed herds 455 sheep and 27 goats, and cattle herds averaged 112 adult cattle and 44 calves [3.1.3].
- There was a **great variability in animal losses per farmer** ranging from 0 to 16.4% (SD=2.81%)**,** with average annual capital loss by wolf attacks reaching 2.25% [3.2].
- Annual percentage losses were **similar in sheep/goat and cattle farms.** However, losses **ranged much greater for cattle farms.** This may be associated with the large variability of cattle farmers on applying preventive measures [3.2, 3.3].
- **Most livestock farmers experience moderate losses** in their herd annually (1-5%). However, an important percentage of them (~**13%**), **experiences large losses each year**, i.e. ≥5% of their herd annually due to wolf attacks [3.2].
- **Calves were the most vulnerable prey category** averaging 6.37% of the total calf availability. **Goats were the second most vulnerable prey category** (3.36% in pure and 3.62% in mixed herds), and they were **selected against sheep in mixed herds** [3.2].
- **Livestock surveillance from a shepherd during grazing hours in the pastures was mostly partial** (42% of sheep/goat herds and 63% of cattle herds graze with a shepherd being only part-time present) [3.3.1].
- **Use of a fenced enclosure for animal protection during nighttime is practiced from most sheep/goat farmers** (86%) in **a daily basis** [3.3.2].
- **Half of cattle farmers** (53%) **do not use a fence or a fenced enclosure for cattle protection during the night**. Cattle remain in the open usually gathered in one or more resting spots. Moreover, an important percentage of cattle farmers **(42%) lets calves to overnight outside of a fenced shelter** accompanied by their mothers [3.3.2].
  - The greatest majority of **cattle farmers** (74%) **allows grazing of vulnerable young calves (<6 months) in pastures.** On the contrary, most **sheep/goat farmers** (78%) **keep**

vulnerable lambs and kids inside a fenced enclosure or permanent pen at least until age of 6 months [3.3.3].

- **Use of Livestock Guarding Dog (LGDs) is satisfactory:** all sheep/goat (100%) and most of cattle farmers (84%) use LGDs to protect their herds from carnivore attacks [3.3.4].
- Livestock farmers use on average **5 LGDs/herd** and **2.4 LGD/100 animals** [3.3.4].
- **LGDs used by farmers were self-evaluated as of good quality**: farmers scored their LGDs on average with 6.8, based on a 1-10 scale [3.3.4].
- **Nearly half of farmers have lost LGDs by poisoned baits in Tzoumerka NP during the last decade:** 22 farmers lost in total 202 LGDs during the last decade (mean=4 per farmer) [3.4].
- **Local farmers** suffered LGD poisoning inside Tzoumerka NP the most compared to transhumant farmers. However, **transhumant farmers also experienced serious losses by poisoned baits in their wintering areas**, outside the borders of the park [3.4].
- **Most farmers were not satisfied with** the national compensation system of ELGA**.** Satisfaction levels were low for both types of farmers (cattle, sheep/goat), but were **relatively higher for cattle farmers** than sheep/goat farmers [3.5].

Figure 43: Pictures of interviewed free-ranging livestock farmers in Tzoumerka National Park.

5.2 Wolf-livestock conflicts in selected areas of Greece

We summarized the main results of wolf-livestock conflicts in the three national park and the regional area in **Table 7.** Conflicts were higher for Tzoumerka and Oiti National parks and lowest for Prespes NP, while mitigation measures scored higher in Prespes NP and were medium to lowest for Tzoumerka and Oiti, on the basis of the responses of the local farmers interviewed. Although many other factors may affect depredation levels in an area, like wolf population size, overall livestock density or landscape characteristics, it seems probable that there is a **negative correlation between intensity of preventive methods and depredation levels**. Those striking differences are most probably related to different levels or quality of husbandry methods enforced between areas. Farmers in Prespes NP scored higher in all husbandry methods evaluated and especially in the intensity of surveillance and LGD use (see paragraphs 4.5-4.7). This could be related to the fact that wolf and brown bear had been never extirpated from this area contrary to Oiti and Tzoumerka, where local extinctions took place during the period from 1960 to 1990.

Table 7: Main results following comparisons amongst the three national park and the regional area

	Chapter	Research question	Tzoumerka NP	Oiti NP	Prespes NP	Regional
Livestock losses	4.2.1	% of farmers experiencing livestock losses by wolves	Highest	Medium	Lowest	Lowest
	4.2.2	Mean percentage of annual losses (%MPAL)	Medium	Highest	Lowest	N/A
	4.2.3	Severity of losses	Medium	Highest	Lowest	Lowest
Preventive measures	4.2.4	Intensity of livestock surveillance	Lowest	Medium	Highest	N/A
	4.2.5	Adoption of LGDs as a protection measure	Medium	Lowest	Highest	N/A
	4.2.6	Intensity of LGD use	Medium	Lowest	Highest	N/A
	4.2.7	Satisfaction levels from ELGA	Lowest	N/A	N/A	Medium

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