Research Article

USE OF LIVESTOCK GUARDING DOGS IN ITALY: FROM HISTORY TO MODERNITY

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1. Introduction

The use of livestock guarding dogs (LGDs) in Italy dates back to Roman times, as recorded by Varro in his "Res Rusticae" in the second century BCE and Columella in his "Res Rustica" in the first century CE. These authors described flocks of sheep associated with large, white dogs that were fearless in the presence of predators and thieves.

LGDs continued to be part of the pastoral system into modern times, particularly in central Italy, where transhumance was common for transferring sheep in the mountains during summer periods. The most commonly used dog breed was a large sized mastiff named in the 1950s "Abruzzo-Maremma Shepherd Dog" by the National Dog Club. The Maremma part of its name was given in consideration of the work done by dog lovers in that area of Tuscany, where they started raising them for other purposes, setting the standards for show dog evaluation of the breed. Transhumance is still practiced in some areas of Italy, but most flocks are now transported by truck. Still, the Maremma is the most commonly used LGD breed when stock is left grazing in pastures or overnight in corrals. In the mountains of central Italy, where the wolf (Canis lupus) was never fully eradicated even when its population reached a minimum in the 1970s

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(Zimen and Boitani, 1975) such customs have never been lost. However, the socio-economic conditions and historical events in other parts of Italy resulted in the disappearance of LGDs.

The wolf population has increased since its protection in 1972, expanding into areas where it had been absent for decades and the tradition of flock protection was lost. The return of the wolf to such areas has been associated with damages to unprotected livestock and the need to implement prevention measures was evident to many livestock owners. In this context, a number of initiatives have taken place in different areas of Italy, contributing to the correct application in modern days of the ancient practice of using LGDs and to evaluation of their effectiveness with the assumption that dog behaviour with the sheep and the owner is an indicator of its ability to provide good services (Breber, 1988). Here we describe activities implemented through three LIFE projects in three areas of Italy, where different aspects of LGD management were tackled.

2. The LIFE COEX Project

The LIFE COEX project (LIFE04NAT/IT/00144) ran from October 2004 to September 2008 and included different areas of intervention in Portugal, Spain, France, Italy and Croatia. The main aim of the project was to implement damage protection measures to mitigate conflicts involving wolves and brown bears (Ursus arctos) in particular sites in the project countries, through specially designed interventions. In Italy, the intervention actions included the implementation of electric fences and livestock guarding dogs in Abruzzo National Park.

2.1. Project area: Abruzzo National Park

The area covered by the Abruzzo National Park (PNALM) is in the central Apennines, and extends for 507 km^2. The area is typically mountainous, with elevations ranging from 400 to 2,285 m. Snow cover generally extends from mid-December to March, but with great annual variability. The park is characterised by the significant presence of large ungulates and the two largest carnivores in Italy: the wolf and brown bear. Although the area has been protected since 1922, human activities are present both in the core protected areas and its buffer. Activities include livestock husbandry, forestry, tourism and some agriculture, mainly in the lowlands. Wildlife protection is a priority for the park, together with the maintenance of traditions and seeking ways for integrating economic opportunities for local communities. There are estimated to be seven wolf packs in the park (LIFE COEX, 2008) and their impact on livestock production activities is managed by the Park Administration through incentives for damage prevention measures and ex-post payment for losses (Latini et al., 2005).

2.2. Methods

LGD pups were acquired with project funds from local livestock owners who used adults for guarding their flocks. LGD recipients were selected according to a set of criteria that included: location in areas where depredations had been recorded previously; presence of other LGDs in the holding; willingness and capacity of the owner to raise the LGD (e.g. extent of time dedicated to farming activity, motivation); and the adequacy of conditions for raising the dog (e.g. risks for the survival of the dog, flock management, sanitary conditions). Once a request was received a first personal interview was made and, if selected, the livestock owner was required to sign an agreement that engaged him in a series of commitments for adequately raising the dog. Food and veterinary care were provided by the project until dogs reached 12 months of age and the new dog owner committed to providing two pups of the first litter (after the dogs had reached maturity) for free to other livestock owners who had contacted the project staff and met the established criteria. A total of eight LGDs were donated in the project area, as many livestock owners already had their own dogs or did not want to undertake the commitment to have a dog to look after. Each LGD delivered was visited on a monthly basis by the project staff and park personnel (a veterinary) in order to check health status and to detect any problems reported by the owner.

The selection of dogs to be evaluated was driven essentially by the willingness of the owner to participate in the study. The behaviour of dogs aged over 24 months was evaluated according to the protocol used by Coppinger and Coppinger (1980). The three parameters considered as proxies for the assessment of LGD behaviour were: trustworthiness, attentiveness and protectiveness. Attentive dogs stay close and follow the flocks' movements, trustworthy dogs do not disrupt the flock or injure livestock, and protective dogs display guarding behaviour in the presence of strangers/predators and interrupt potential attacks. These parameters were assessed through direct observations of the dogs during grazing periods. Each dog was observed for three sessions of four hours each (Mancini, 2006). The observer was always in a non-intrusive position, such as sitting at the edge of the pasture or walking at a distance of at least 100 m from the dog if the flock was moving. For measuring attentiveness, the location of the LGD with respect to the flock or the shepherd was recorded according to Coppinger et al. (1983), using three types of observational measures: i) sidedness (side of the flock relative

to the shepherd); ii) orientation (if dogs approached the flock or the shepherd); and iii) proximity (distance of the dogs to the flock and the shepherd as estimated by direct sight. A sidedness score was determined as the percent difference in the number of times the dog stopped on the same or the opposite side of the flock relative to the shepherd. An orientation score was determined as the percent difference in the number of times the dog approached the shepherd or the flock. For further information on the methodology used see Mancini (2006). The average distances of each dog from the shepherd and the flock were also computed. A Spearman correlation test was then used to assess correlation between the different parameters assessed and a Mann-Whitney test was conducted to compare differences between males and females.

For measuring trustworthiness towards the animals in the flock a set of behavioural categories were considered (Cruz, 1999) while observing the dogs, such as: agonistic, neutral contact, investigation, play, and allo-grooming. As for protectiveness, behaviours (e.g. alertness, approaching, barking) displayed in response to unexpected events (e.g. loud noises, non-familiar objects/individuals) were recorded. Behaviour frequencies were registered for each dog.

A total of 15 LGDs were evaluated in the period from mid-August to end of November 2006: two of them adults from the LIFE COEX project and the rest from other livestock owners and aged between 24 and 48 months. There were 11 males and four females from nine farms. The sex ratio depended on the willingness of owners to take part in the project and does not reflect the presence of LGDs in the area. A total of 45 observation sessions were made in the field during the period June–November 2006, usually in the early morning or mid-afternoon.

Finally, a questionnaire was completed by 15 dog owners to assess their personal perceptions regarding the three basic behaviour components for LGDs, as described earlier, and their dogs' overall performance. Each behaviour was explained and the owners rated them according to a four-point scale, ranging from Excellent/Very Satisfied to Bad/Unsatisfied.

2.3. Results

On average, the distance of LGDs from the flock was shorter than from the shepherd (mean LGD-Flock score=2.53±0.37 SD; mean LGD-Shepherd=2.14±0.41 SD; Fig. 1), but never higher than 90 m. Furthermore, a direct correlation between the LGD-sheep distance score and sidedness of the LGD with respect to the shepherd was detected ($r=0.78$, $p<0.001$), indicating that dogs usually approached the flock from the side opposite to the shepherd. Similarly, a significant corre-

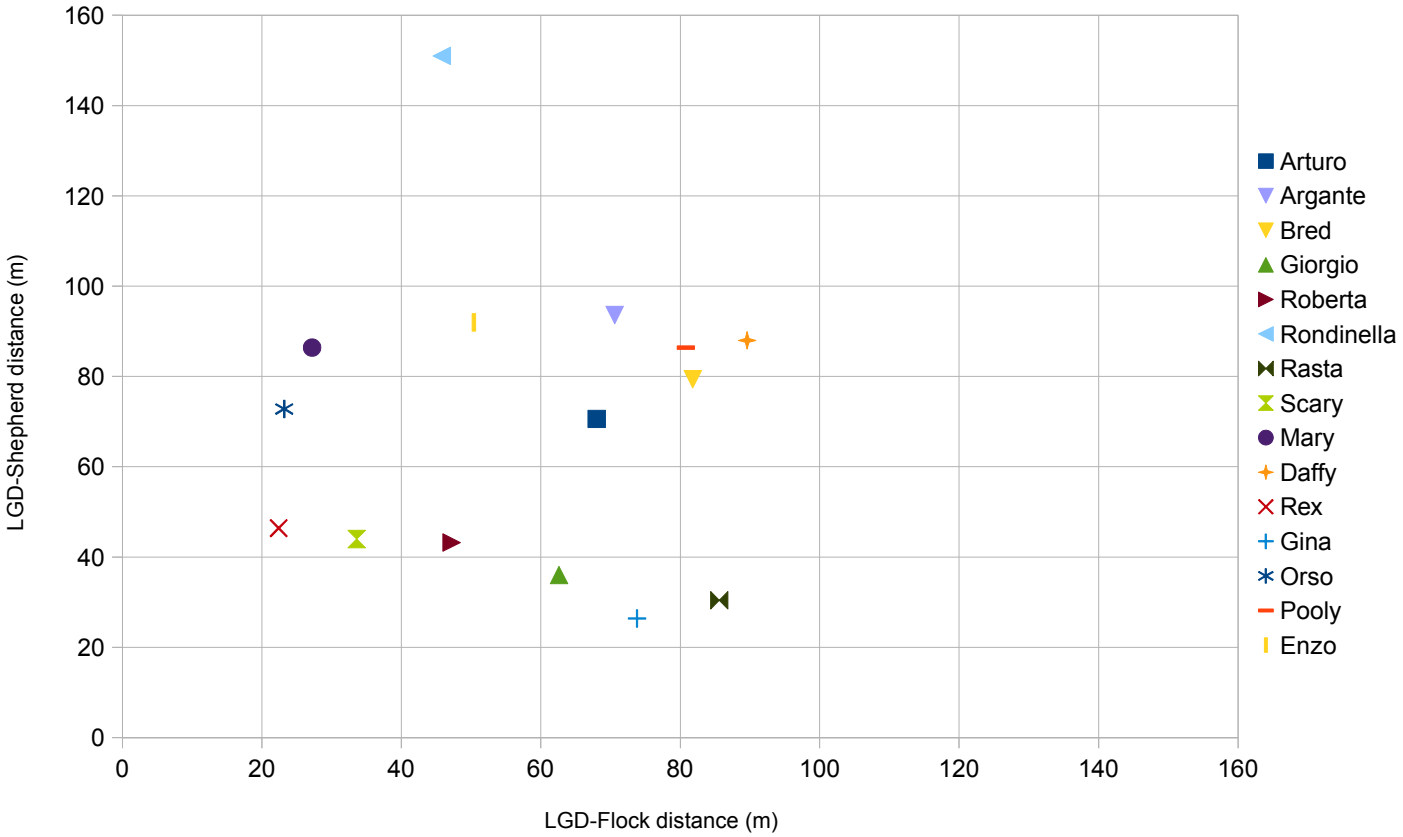

Fig. 1. Distance from the flock and from the shepherd of the 15 LGDs observed in PNALM during the LIFE COEX project.

lation was found between the score of relative distance between LGDs and flocks and the score for orientation ($r=0.56$, $p<0.05$), indicating that approaches of LGDs to flocks were not random. The correlation between the distance of the LGD to the shepherd and the frequency of allo-grooming exhibited towards the sheep was also positive ($r=0.63$, $p<0.05$), suggesting LGDs approaching the flocks were attached to the sheep, following them actively instead of the shepherd. The differences among the two sexes were significant in respect to the distance from the flock: females were on average closer to the flock than males (mean distances: females=4.8m ±0.4, males=14.7m±0.3; $Z=-2.35$, $p<0.05$). This can be explained by the fact that males display a higher frequency of protective behaviours (e.g. approach and alert to the presence of intruders, investigate any strange stimuli around the flock) than females ($Z=-1.98$, $p=0.047$). However, care should be taken when considering these results due to the small sample size and the male-biased sex ratio.

LGD owners were generally satisfied with their dogs. Most dogs (93%) were rated as good-excellent in attentiveness to the flock (only one male was rated as sufficiently attentive) while all were reported as good-excellent for protection of the flock and excellent for trustworthiness. The level of satisfaction with the overall performance of LGDs was good-very good for all owners (Fig. 2). Thirteen LGD owners reported having assisted in cases when dogs chased predators such as wolves or bears trying to attack their flocks. Seven male dogs (67% of all males) were reported to have killed wildlife (hares *Lepus europaeus*, roe deer *Capreolus capreolus*, foxes *Vulpes vulpes*) on many occasions and were observed feeding on them.

3. The LIFE MEDWOLF Project

The LIFE MEDWOLF project (LIFE11NAT/IT/069), implemented from September 2012 to November 2017, focuses on the conflict between livestock raising activities and wolf presence in areas of Portugal and Italy where the wolf had been absent or at very low densities for decades but has made a comeback in the last two decades, bringing about high levels of depredations to unguarded livestock. The project area in Italy is the Province of Grosseto, where interventions included the allocation of livestock protection infrastructures and livestock guarding dogs, associated with an intensive networking activity among livestock producers from different areas to establish a long-term relationship among users of damage prevention measures. The project is characterised by the cross-sectorial participation of environmental and livestock producer associations as active partners.

3.1. Project area: Province of Grosseto

The Province of Grosseto is part of Tuscany Region, in central Italy, and covers over 4,000 km^2. It is dominated by a Mediterranean-like environment and extends from the Mediterranean coastline to the peak of Mount Amiata (1,738 m). Wild ungulates are present at high densities and livestock production, particularly sheep, is a keystone of the local economy. The province has the lowest density of human presence in Italy and is known for the production of Pecorino Toscano cheese targeted by tourists for its eno-gastronomic productions. There were 1,200 registered sheep farms in 2015 with about 200,000 sheep (BDN, 2015). Claims for damages to livestock production by wolves increased

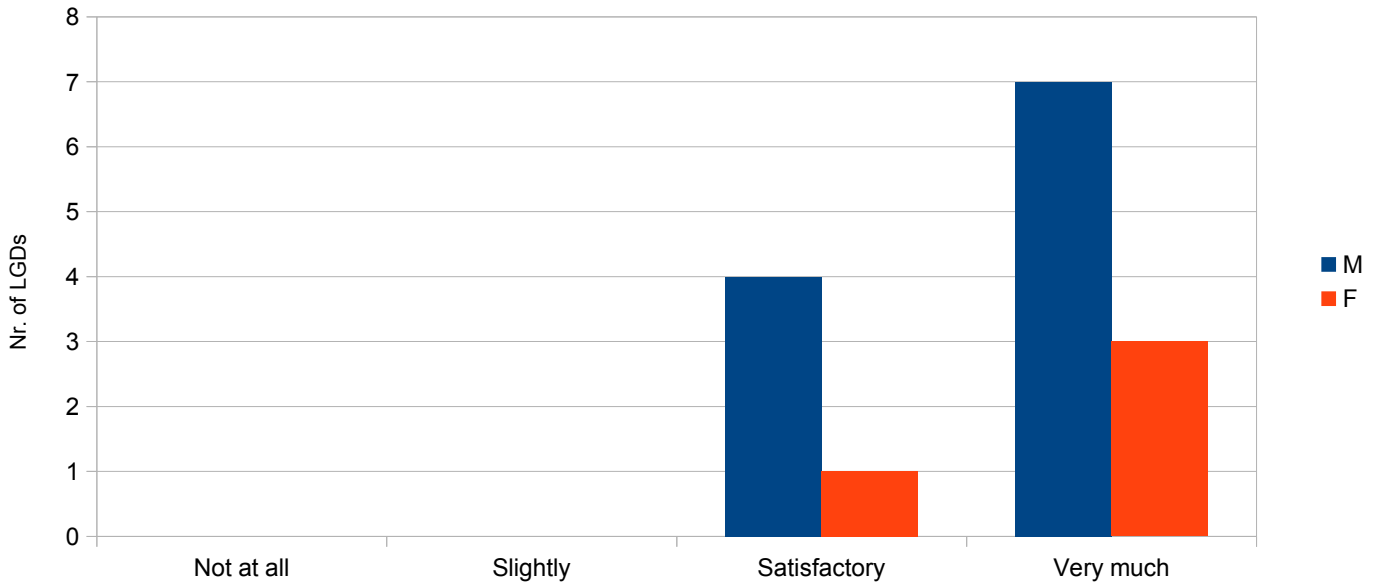

Fig. 2. Degree of satisfaction of 15 LGD owners who completed a questionnaire.

since 1995, when the regional law for damage compensation came into force (Banti et al., 2005). Compensation was paid directly until 2005, when an insurance-based system came into force. The efficacy of the new system in mitigating conflicts was so poor that in 2014 the regional government renewed direct compensation payments (Marino et al., 2016). There were estimated to be at least 12 wolf packs in Grosseto in 2015 (Marco Apollonio, pers. comm.).

3.2. Methods

The project foresaw the allocation of 20 LGDs of the Maremma breed to selected livestock breeders in Grosseto. Recipients were initially selected according to three main criteria: damages previously suffered (in 2011-2013); location of the holding with respect to a risk map elaborated by the project team using data on wolf damage claimed in the years 2011-2013; size of the holding in terms of number of heads (minimum 50 heads). We only focused on sheep producers as the preliminary data gathered on wolf damages indicated the majority of them occurred to sheep. The preliminary list of potential beneficiaries was analysed and direct interviews were made in order to verify that proper conditions were in place for raising dogs, namely confirming the interest and willingness of the potential recipient to devote care and time to the pups, following instructions provided by project staff, and the stock management in the holding.

After the final selection of beneficiaries was made, pups were delivered in the presence of a technical expert from Abruzzo Region, where LGDs are traditionally used. An agreement was signed with the beneficiary, committing them to follow project procedures including a fixed protocol for correcting dog behaviour when necessary and managing dog breeding according to a plan agreed with project staff. The collaboration further assessed the potential to involve the livestock breeder in a network of producers aimed at sharing experience through meetings and communication events.

After the dog was delivered visits were made daily for the first week followed by once a month for behaviour and health condition checks. LGDs aged >24 months were selected for fitting with GPS collars. They were monitored regularly from November 2015 to July 2016 during daily grazing to estimate their positions relative to flocks using Tractive® GPS Pet Tracking collars (Tractive GmbH, Austria), under the assumption that LGDs should stay close to the flock in order to protect it. GPS collars were fitted both to

LGDs and one member of the flock (Fig. 3). The selection of the sheep to be fitted with GPS collar was made with the livestock owner who knew which individuals were more dominant and so would represent the movements of the entire flock. GPS monitoring was performed for 20-day sessions at each farm during which GPS collars recorded positions every 15 minutes during movement and every 60 minutes during rest. Batteries were charged every other day by the livestock owner and data were logged automatically on a daily basis. The period when the flock was closed in the stable was excluded in order to assess only the interactions between dogs and sheep on pastures. Data were analysed considering the intensity of location distribution and the overlap between locations of dogs and sheep represented by the Utilization Distribution Overlap Index (UDOI) (Fieberg and Kochanny, 2005).

3.3. Results

In response to a public call, a total of 201 expression of interest in the damage prevention measures provided by the project were received by project partners. Of these, only a few were interested in receiving LGDs, as farmers had neither knowledge nor experience of having such dogs, which were thus perceived

as a burden and essentially a cost they did not want to bear. In order to overcome this initial reluctance, a process of awareness raising and information provision was initiated. Alliances with those few farmers who already had LGDs were established and they were asked to provide information to others during two workshops organised by project staff. These activities allowed the delivery of the first eight LGDs in July 2014. Once these first pups were established in holdings, word of mouth was the most effective means of raising awareness and an additional 12 pups were delivered from December 2014 to May 2015. All pups given in 2014 and 2015 were selected from a working dog breeding cooperative in Abruzzo Region: a farm where working dogs from different farms were bred and selected for sale. There were eight males and 12 females. Until the age of 2.5 months they were raised at eight different sheep farms in Abruzzo Region, who adhered to CIRCA dog breeding cooperative.

All LGDs were vaccinated prior to delivery (repetition was made in due time according to a veterinary protocol) and health checks were made monthly for the first two years of age by a veterinarian contracted by the project. Three LGDs died due to car accidents and health problems (i.e. gastroenteritis). Three had to be transferred to new holdings in the project area after the accidental death of the livestock owner

Fig. 3. GPS collar fitted LGDs with their flock in Province of Grosseto.

(n=2) and due to problems with the original beneficiary (n=1), who was not interested in keeping them according to the project protocol. Fifteen LGDs were fitted the GPS collars (Fig. 4). The distance between dogs and sheep averaged 92±116 m and they tended to use the same areas, with a high degree of overlap of their 95% Utilization Distribution area (UDOI=2.19, Zingaro et al., 2016). The range of distance depends on several variables, particularly the dogs' age and land cover, namely artificial area, forest, heterogeneous area (as described in the CORINE Land Cover). Dog-sheep distance increased in correspondence to wooded areas, while it decreased in the presence of artificial surfaces. Older dogs (over 2 years of age) kept closer to sheep than younger ones (Zingaro et al., 2018).

Dog-sheep distances and UDOI can be a good proxy to a dog's attentiveness to the flock, as defined by Coppinger and Coppinger (1980), with attentive dogs having higher overlap scores and staying closer to the flock. Attentiveness may provide good indications of a dog's efficacy in protecting flocks since, according to Coppinger et al. (1988), it is the most important component for a successful guarding dog, since the mere presence of a dog may disrupt predatory behaviour and thus reduce predation.

With increasing confidence, the number of farmers willing to have LGDs also increased and the experience gained by all of them was made available to others through the network established within the DifesAttiva organisation (see Vielmi and Salvatori, 2017). This resulted in an additional 20 LGDs transferred to 12 new holdings in the period from December 2015 and November 2016 through the newly established networking association DifesAttiva.

4. The LIFE MIRCo-lupo Project

The LIFE MIRCo-lupo project (LIFE13/NAT/IT/000728), implemented from January 2015 until the end of March 2019, aims to reduce the impact of stray and wandering dogs on the Italian wolf population in two Appennino tosco-emiliano and Gran Sasso–Laga National Parks. Free ranging dogs create or perpetrate hybridization problems (Godinho et al., 2011; Pacheco et al., 2017; Verardi et al., 2006) but they can also represent a sanitary issue for wolves living in the same environment (Ciucci, 2013). Dogs and wolves share susceptibility to several infectious diseases (Kreeger, 2003). If dogs are not correctly managed and do not undergo prophylaxis including anti-parasitic treatments and vaccines they can spread pathologies and negatively

Fig. 4. GPS collars being fitted to LGD and sheep by the livestock owner.

influence wolf population fitness (Di Sabatino et al., 2014; Guberti et al., 2004). The project aims to improve the management practices of farm working dogs in the project area and consists of two main actions: i) a preparatory action for monitoring management in terms of the level of supervision and health status of the canine population used as working dogs in farms or LGDs in sheep-goat farms; and ii) a concrete action including health treatments (vaccines and anti-parasitic treatments) and, when missing, compulsory registration of dogs in the official canine registry as extraordinary actions.

4.1. Project area: Tosco Emiliano Apennine National Park

Appennino Tosco-Emiliano National Park (Parco Nazionale dell'Appennino Tosco-Emiliano, PNATE) was established in 2001 by the unification of two regional parks (Parco Regionale del Gigante and Parco Regionale dei Cento Laghi). It covers 262 km^2 and includes parts of four provinces in two different regions: Parma and Reggio-Emilia in Emilia-Romagna and Massa Carrara and Lucca in Tuscany. PNATE and its adjacent territory contribute to the production of several typical products, including Parma ham and Parmigiano Reggiano cheese. A small part of the local economy is still represented by sheep and goat farms. This kind of livestock is mainly bred for milk (to produce pecorino cheese) but also for meat; farmers typically use local breeds (e.g. Massese sheep) which are suitable for both.

In the north-central Apennines the use of LGDs is becoming common since the return of the wolf a couple of decades ago. PNATE, through its Wolf Apennine Center (WAC), has provided assistance to farmers who requested it after having acquired an LGD from other farmers in the area, by either connecting farmers with LGDs or providing technical support for dog behaviour and management. Eight wolf packs are estimated to occupy the entire park territory (LIFE EX-TRA, 2013)[1]. There are 196 registered livestock raisers and many of them use dogs either for guarding or herding livestock. Although it is mandatory by law (L.N. n. 281/1991), LGDs are often not identified with microchips and, consequently, not included in the National Dog Registry database. This poses management problems such as control of the dogs that may roam freely, representing a vector for diseases and/or crossbreeding with wolves (Ciucci, 2012).

4.2. Methods

The selection of dogs to be treated was based on the willingness of farmers to participate and locations of farms. The work focused mainly on rural areas, particu-

[1] The LIFE EX-TRA project - Improving the conditions for large carnivore conservation – a transfer of best practices (www.lifextra.it), aimed to address the conflicts between wolf and bear conservation and human activities. It was implemented in 2009-2013 and involved seven partners from four different countries: Italy, Greece, Romania and Bulgaria.

larly summer pastures with wolves in and around PNATE. The dogs present in the holdings were screened by project veterinaries for checking their registration in the National Dog Registry (managed by the National Health System), by checking for the presence of a microchip with a microchip reader, and their vaccination history by asking the owner for the vaccination record (Fig. 5). A sample of dogs was also screened for a set of diseases that are known to be potentially transmittable to wildlife, namely canids: Leishmaniasis, Filariasis, Borreliosis, Ehrlichiosis and Herpesvirosis. The first four of these are vector borne diseases linked to temperate climates. Considering climate change, the increased movement of pet or working dogs and the new distribution areas of wolves it is of primary importance to have screening data of all pathologies which have been reported in wild wolves (Kreeger, 2003; Wallach and Boever, 1983). From a preliminary collection of medical data from local veterinarians, we decided not to focus on Parvovirus, Distemper and Toxoplasmosis as these have not been recorded in the study area for the last three decades.

4.3. Results

A total of 234 dogs at 44 farms were inspected in the period from March 2015 to April 2016. Of these, 55% were LGDs and 45% were herding dogs. LGDs were used at 91% of the farms, with the Maremma Sheepdog (87%) being the most common breed, followed by crossbred dogs (11%) and other breeds (2%). The number of LGDs per farm averaged 3.2 and ranged from one to 15, generally positively correlated to the size of the flocks. Only 12.5% of farmers reported correct vaccine prophylaxis at the time of inspection (87.5% of farmers never treated their dogs). As a correct vaccine prophylaxis it was considered a treatment with at least two shots (a first one and a recall booster shot) of a vaccine including protection for: canine distemper virus, adenovirus type 1 (hepatitis) and adenovirus type 2 (respiratory disease), canine parainfluenza virus, canine parvovirus and leptospirosis (with protection for at least *Leptospira interrogans* serogroup *Canicola* and *L. interrogans* serogroup *Icterohaemorrhagiae*). A total of 122 dogs (52%) were vaccinated thanks to the LIFE MIRCo-lupo project (with a four-strain vaccine protecting for *Leptospira interrogans* serogroup *Canicola* serovar *Portland-vere*, *L. interrogans* serogroup *Icterohaemorrhagiae* serovar *Copenhageni, L. interrogans* serogroup *Australis* serovar *Bratislava* and *L. kirscheneri* serogroup *Grippotyphosa* serovar *Dadas*). In addition, 109 dogs were treated for internal parasites with combined medication preventing infestations of nematodes (ascarids, hookworms and whipworms) and cestodes (tapeworms including *Echinococcus* spp.). Ninety-three LGDs (40%) were found to be not correctly registered and so were microchipped and registered in the national database during inspections.

A sub-sample of 50 dogs, 58% of them LGDs, was chosen for the sanitary survey. No dogs tested positive for Filariosis, Ehrlichiosis or Herpesvirosis. Only one dog, a LGD, tested positive for Leishmaniosis at a low antibody titre. Eleven dogs, including six LGDs, showed serological positivity for Borreliosis at different titres. Borreliosis, also known as Lyme disease, is a bacterial disease caused by the spirochete *Borrelia burgdoferi* which may debilitate wolves as well as dogs and represents an emerging primary zoonosis in Italy (Kreeger, 2003; Lindgren and Jaenson, 2006).

Fig. 5. LGD being checked for microchip in Appenino tosco-Emiliano National Park.

5. Discussion

Livestock guarding dogs in Italy are well known in many regions but their use in common practice is limited geographically. The high cultural diversity that characterises Italian regions and the variability in traditions and beliefs are obstacles to the application of certain practices in areas where they were have been abandoned. In such cases the work to be done is similar to that done in countries where the tradition did not exist at all (Coppinger and Coppinger, 2001; Gehring et al., 2010). This is the case in Tuscany, where in the Province of Grosseto only a few livestock owners had LGDs and the LIFE MEDWOLF project had to start with an intensive activity of persuasion and full time assistance to new owners.

In other areas, such as the Abruzzo region, the pres-

ence of LGDs is considered common practice by all livestock owners, who are used to coexist with wolves and brown bears. In Abruzzo it was easier for LIFE COEX project staff to transfer LGDs and find good quality donors from the area. There, the evaluation of LGDs, even those not provided by project staff and hence raised without supervision, indicated they had the behavioural traits considered desirable for LGDs.

Although the use of LGDs is considered common practice, their sanitary management is not always compliant with current legislation and the threat they pose to wild canids in areas of expansion could be considerable. In such areas, the correct management of working dogs is increasing relevance: not leaving them wandering unguarded and applying sanitary care to minimise the risk of infections from the most common pathologies, including de-worming.

It is clear that although the use of LGDs is spreading and in some cases the Regional Governments are promoting their use (e.g. Regione Piemonte use RDF for covering costs of LGDs), more work needs to be done for their correct management and education. This needs to be adapted to the local cultural settings in different areas in Italy. In some cases the introduction of LGDs might be counterproductive. In the Province of Grosseto, for example, we refused to deliver LGDs to livestock owners that were too close to touristic paths and were not committed enough to work with dogs and correct their behaviour when necessary. Although there is no hard evidence that LGDs pose effective problems to tourists in the area, the perception of local people is negative (as revealed by many local newspaper articles) and intensive communication work should be done before the introduction of LGDs in the area.

It is of paramount importance that LGDs be evaluated for their effectiveness (cf. Eklund et al., 2017). A recent review (Catullo et al., 2016) showed that although LGDs have been distributed through programmes, projects and specific measures of the Rural Development Fund in Italy, only in a very few cases was there a proper evaluation of LGD behaviour with the exception of 4 out of 12 LGDs provided in the Alps in 2004 (Tedesco and Ciucci, 2005) and the 15 LGDs assessed within the LIFE COEX project reported here (Mancini, 2006). LGD effectiveness is more commonly done through interviews with dog owners to assess their satisfaction and perceptions on dog behaviour (e.g. Coppinger et al., 1988; Marker et al., 2005; Rust et. al., 2013). Although this might be a fast and simple method, a good proxy and certainly, an important factor to take into consideration when implementing conflict mitigation measures, owner perception might not reflect the actual behaviour of the dog, and complementary methods should be developed that better quantify the various effects of the interventions. Decrease of damages after the introduction of LGDs to farms is also an indicator of efficacy (Dalmasso et al., 2012; LIFE COEX, 2008), but other factors might affect such results (e.g. changes in wolf presence, wild and domestic prey density and availability, habitat characteristics). We therefore strongly support the implementation of a rigorous method for assessing LGD efficacy and evaluation of its behaviour with a progressive scientifically-based approach.

The selection of farmers to receive LGDs is crucial for the evaluation of the effectiveness of such dogs. Zingaro et al. (2016) reported that the collaboration of the LGD owner was essential for contributing to data collection and for fitting GPS collars to sheep. Tedesco and Ciucci (2005) reported that some LGDs to be evaluated were not approachable even by the sheep owner, while others were used incorrectly, staying all day inside an enclosure.

In the north-central Apennines the use of LGDs is again becoming common following the return of the wolf. The work done recently allowed for the assessment of the sanitary risk posed by dogs in and around the park. Many were not included in the national canine registry database, which poses management problems such as

control of the dogs that may roam freely, representing a vector for diseases and/or crossbreeding with wolves (Ciucci, 2012). Even registered farm dogs were seldom correctly vaccinated and treated for parasitic infestations, posing a threat to other canids (dogs and wolves) and in some cases even humans (e.g. for *Echinococcus spp.* and *Borrelia burgdoferi* infestations and for *Leptospira spp.* infections). In canids it is not uncommon that Borreliosis causes no symptoms and the infected animal becomes a carrier. The pathology represents a zoonosis (Krupka et al., 2007; Carstensen et al., 2017; D'Amico et al., 2017): humans, like other hosts, can contract the disease from ticks and, if not diagnosed in time, this can cause severe problems such as myocarditis and arthritis (Stanek et al., 1988). The spread of *Borrelia burgdoferi* in tick populations is high (Strnada et al., 2017) so it is therefore important to educate dog owners to treat them with external anti-parasite products in order to limit the spread of the pathogen in the environment. Even though parasitic prophylaxis treatments were not included in the LIFE MIRCo-lupo actions, inspections combined with serological data allowed the project veterinary technicians to discuss the importance of this kind of treatments with dog owners. In several cases owners were willing to change their approach and were given a prescription in order to use the best antiparasitic protocol.

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