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Are These Big White Dogs Worth the Expense? The Challenge of Determining the Costs and Benefits of Livestock Guardian Dogs

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Abstract
Livestock guardian dogs are used by sheep and goat producers throughout the West to protect livestock from predators. Recent analysis of data from the UC Hopland Research and Extension Center suggests that the costs of keeping dogs may outweigh the benefits of death loss prevention. However, this analysis omits several key economic benefits associated with using livestock guardian dogs. We offer an alternative framework for evaluating benefits, as well as for identifying potential cost savings. We also suggest a framework for incorporating simple economic analyses into an objective case study approach. We identify key drivers (economic and management) that may increase the economic efficiency of using livestock guardian dogs. Finally, we suggest future needs for research into the economics of nonlethal livestock protection tools, including livestock guardian dogs.

Keywords: Livestock guardian dogs, livestock protection tools, predator protection, livestock-wildlife coexistence

Introduction

Livestock guardian dogs (LGDs) have been used to protect livestock from predators for thousands of years. In North America, these dogs are used most frequently by sheep and goat producers (Coppinger et al. 1988; Gehring et al. 2011; VanBommel and Johnson 2012; USDA-APHIS 2015), although some beef cattle producers in the Northern Rocky Mountains and the Upper Midwest have used LGDs successfully to protect cattle (USDA-APHIS 2010; Gehring et al. 2010), and chicken producers in California have also successfully used LGDs (Macon and Whitesell 2021).

Despite the widespread and increasing adoption of LGDs as a livestock protection tool, the costs and benefits of using LGDs in production settings are not well understood. This lack of analysis is partly due to the complexity of evaluating these tools objectively and independently; developing case-control studies that account for all environmental, operational, and management variables is virtually impossible (Ecklund et al. 2017). Furthermore, ethical and economic considerations make designating an unprotected "control" group of livestock to test the effectiveness of a specific livestock protection tool untenable. Consequently, we have suggested a case study approach to documenting the effectiveness of specific tools (including LGDs) (Macon and Whitesell 2021).

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A recent evaluation of data from the University of California's Hopland Research and Extension Center (HREC) concluded that the costs of using LGDs (including acquisition and maintenance costs) exceeded the benefits (in terms of cost of sheep not lost to predators) over the 7-year useful life of the dogs (Saitone and Bruno 2020). At HREC, Saitone and Bruno (2020) show that net expected return over seven years (2013-2017) was -$14,671. In other words, the cost of buying and keeping the dogs exceeded the value of livestock saved by more than $14,000 over seven years. In light of this contrary empirical evidence suggesting that costs outweigh benefits, then, why do livestock producers continue to use LGDs?

Understated Benefits versus Overstated Costs

While the costs of LGDs outstrip the benefits they provide in Saitone and Bruno (2020), the authors concede that "the benefits associated with LGDs in this study are likely understated" (p. 107). We agree. Specifically, LGDs reduce indirect losses associated with depredation (including reduced weight gains, lower conception rates, and increased labor – see Ramler et al. 2014). Further, in real-world production settings, ranch-raised ewe lambs may have greater future value due to their local adaptation to management and forage conditions. Finally, LGDs may provide additional benefits through an impact on sheep behavior. Webber et al. (2015) suggest that sheep grazing with LGDs will travel greater distances than those grazing without LGD accompaniment, potentially indicating protected ewes may be exposed to more and more varied grazing opportunities.

On the cost side of the equation, Saitone and Bruno may overstate the costs of the dogs, primarily because they assume a linear relationship between livestock numbers and the number of dogs required for protection, as well as the labor required to care and feed each dog. In production settings however, the dog: livestock ratio varies, as do labor costs. Finally, producers who have greater success in bonding LGDs with livestock can lower their LGD acquisition and development costs.

Indirect Benefits from LGDs

While direct predator losses are relatively easy to quantify (the market value of a dead ewe and the future value of the lambs she would have produced are reasonably straightforward), the indirect impacts associated with predator-induced stress are less understood. These indirect impacts are likely related to the types of predators in the environment (coursing predators, like coyotes and wolves, may create a different level of stress than ambush predators, like mountain lions). Research in the Northern Rocky Mountains suggests that these indirect losses may be more economically significant than direct losses (Ramler et al. 2014). While that work was conducted with beef cattle, sheep producers likely suffer similar indirect losses in environments where canine predators are of concern. Additional work is needed to quantify the economic impacts of lower weight gains, lower conception rates, and increased labor; that research will provide a clearer picture of the benefits provided by LGDs when these indirect impacts are reduced or eliminated.

The loss of an individual animal also represents the loss of that animal's future genetic potential, as well as the loss of years of investment by the producer (Naughton-Treves et al. 2003). Lambs, calves, and kids generally learn grazing preferences from their mothers (Howery et al. 2010). These learned behaviors help producers adapt their flocks (or herds) to their specific environments. In addition, the spatial/temporal memories of livestock to specific geographic locations improve the grazing and reproductive efficiency of ranch-raised replacement females compared to outside genetics (Launchbaugh and Howery 2005). While the economic benefits per individual animal may be marginal, the cumulative effects suggest that the future value of a ewe killed by a predator may be greater than simply the market value of the offspring she will never have. In other words, a ewe's future contribution to flock genetics (and thus, her value) depend on weaning rate and longevity. For example, a ewe that weans an average of 1.5 lambs per year and that remains in the flock until eight years of age contributes more value than a ewe with a lower weaning rate or shorter lifespan. These factors go well beyond a simple calculation of the ewe's net present value.

During the study period analyzed by Saitone and Bruno (2020), breeding ewes could graze on less than 50% of available rangeland at HREC due to historic losses due to coyotes in specific pastures, suggesting that predator pressure directly affected stocking rate and grazing efficiency. On the other hand, Webber et al. (2015) found that ewes and lambs that graze on extensive rangelands in Idaho with LGDs traveled greater daily distances than unprotected sheep. The authors hypothesize that ewes and lambs that travel greater distances are more likely exposed to more and varied foraging opportunities, resulting in more efficient pasture use. In other words, LGDs may allow producers to increase stocking rate; even a 25% increase in forage access can have a significant impact on enterprise profitability, provided additional LGDs are not required. Table 1 demonstrates the potential increase in stocking rate (and grazing efficiency) resulting from using LGDs where sheep grazed unprotected previously.

Table 1: Potential Increase in Grazing Efficiency Associated With LGDs on a Theoretical 1000-acre Annual Rangeland Sheep Operation in California.

	Total Rangeland Acres	Grazable Acres	Typical Carrying Capacity (annual rangeland)	Total Ewes Grazed
Ranch A (No LGDs)	1000 ac	500 ac	1 ewe / 3 ac	167 ewes
Ranch B (2 LGDs)	1000 ac	625 ac	1 ewe / 3 ac	208 ewes

Cost Factors

While maintenance and feeding costs (including veterinary costs, labor for feeding dogs, and dog food costs) are significant in Saitone and Bruno (2020), perhaps the most important factor driving the cost side of this analysis is the optimal ratio of dogs to livestock. While evidence at HREC suggested that one LGD is required for every 100 breeding ewes, our case studies suggest much greater variation in real-world settings (Macon and Whitesell 2021) – see Table 2 (dog: sheep ratios range from 1:50 to 1:1,200). Producer decisions regarding the ratio of dogs to livestock are driven by time of year (e.g., sheep may be more vulnerable in late winter due to a lack of native prey), stage of production (e.g., lambing ewes may require more dogs than dry ewes because they are likely more vulnerable), grazing environment (e.g., extensive rangeland versus alfalfa stubble or irrigated pasture), and predators present on the landscape. See Table 2 below. Of course, the number of dogs required for an individual operation drives both the capital and operating costs associated with using LGDs.

Table 2: Sample Ratios of LGDs to Livestock From California Case Studies (Macon and Whitesell 2021).

	Livestock Type (Number)	Stage of Production	Pasture/Rangeland Type	Number of LGDs
Ranch 1	Laying hens (4,500) Beef cattle (120)	Egg production All stages (gestation, lactation, dry)	Coastal grassland	4
Ranch 2	Ewes (100)	Lambing	Oak woodland	2
Ranch 3	Ewes (1200)	Dry ewes (non-lactating, mature ewes)	Sagebrush steppe and mountain meadow	1

Labor costs associated with LGDs also vary greatly by operation type and management system. In a permanently fenced operation (like HREC), distance from headquarters and access to grazed pastures will drive the labor costs up associated with feeding and caring for dogs. In more intensively managed systems, where electric fencing and frequent livestock movement require daily attention, the marginal additional labor associated with dogs is part of the overall labor requirements of the operation. Similarly, in open range herded operations, where a herder camps with the sheep 24/7, feeding and caring for LGDs requires little if any extra labor.

As Saitone and Bruno (2020) note, bonding success and longevity are key components to calculating the capital costs associated with LGDs. Capital costs include the cost of acquiring a dog, as well as the development costs associated with raising a puppy to working maturity (typically 18-24 months of age). A long-term study of LGDs suggests a 45% loss rate caused by re-homing due to behavior problems or mortality (Lorenz et al. 1986), suggesting that improving bonding success and reducing mortality are critical economic considerations. Producers cull LGDs for a variety of reasons, including unwillingness to stay with livestock, harassing or killing livestock, or public liability concerns. LGD mortality rates are driven by a variety of factors, including direct conflict with predators, proximity to public roads, and trespassing on neighboring properties (Lorenz et al. 1986). Below, we compare the total capital costs associated with LGD acquisition and development in an operation with a 45% dog loss rate versus an operation with a 15% dog loss rate. Of course, a lower total capital cost results in a lower annual depreciation expense. See Table 3 below.

Table 3: Total LGD Capital Cost = (Acquisition Cost + Development Cost[3]) ÷ Success Rate[4]

[3] Development costs are the normal operational costs (dog food, veterinary care, etc.) incurred until the dog is mature enough to formally protect livestock – typically this period is 18-24 months.

[4] For our purposes, success rate is the percentage of dogs that are raised to adulthood (18-24 months) and are placed in a working situation (guarding livestock).

	Acquisition Cost	Development Cost (18 months)	Success Rate	Average Capital Cost of a Working Dog	Annual Depreciation (Assume 5-year working life and $0 salvage value)
Ranch A	$400	$900	55%	$2,364	$473
Ranch B	$400	$900	85%	$1,529	$305

A Case Study Approach

The case study approach we have outlined in previous work (Macon and Whitesell 2021) offers a framework for collecting real-world data on costs and effectiveness of LGDs. Based on producer interviews and researcher observations, these case studies collect objective information on a variety of factors, including:

- *Environment:* terrain, vegetation type, surrounding land uses, and livestock protection tools (or lack thereof) on surrounding landscapes.
- *Predators present on the landscape:* certain predators often target particular livestock species or classes (e.g., ewes vs. lambs) more frequently than other predators. Additionally, seasonal prey variations and preferences may influence predator pressure in specific situations.
- *Operational characteristics:* Species and class of livestock are directly related to predator susceptibility, as can a particular operation's production calendar. Parturition (lambing or calving) can be an especially vulnerable time for many operations. Conversely, running dry (non-lactating) females without their young in extensive settings may be less risky.
- *Time of year and duration:* Seasonal availability of natural prey, vulnerability of livestock based on stage of production, and the length of time that livestock and LGDs are present on a specific landscape create variability in the predator pressure experienced by operators.
- *Costs associated with LGDs:* these costs include the full cost of acquisition (purchase price and transportation), development costs during the bonding process (including veterinary care, dog food, and labor), operating costs (for an adult working dog; veterinary care, dog food, and labor), success rate (as defined above), depreciation, and equipment costs (feeders, etc.).

While case-control studies regarding LGD effectiveness (including costs versus benefits) are difficult to conduct, we believe our case study framework will help researchers and practitioners collect objective, site-specific data (including cost data) regarding these tools. Since this framework explicitly describes factors that may influence LGD effectiveness, it will allow practitioners to better evaluate their own operation in comparison to each case study.

Future Research Questions

Based on the complicated relationships identified by Saitone and Bruno (2020) and expanded on above, we believe there are a number of questions that warrant further study:

1. Can management systems and/or equipment increase the efficiency of labor associated with LGDs? For example, can creep feeding systems eliminate the need to travel to remote pastures to feed LGDs on a daily basis? Research at Texas A&M suggests that creep feeding systems can replace the need for daily hand feeding (Costanzo, personal. communication). Are there other management benefits associated with more frequent checks of LGDs and livestock (like lower disease incidence or livestock/dog mortality rates)?
2. Are specific bonding techniques likely to lead to greater bonding success? For example, does a high degree of interaction with humans during early puppyhood impair or enhance bonding with livestock? Similarly, are puppies successfully bonded by a producer to his/her livestock more cost effective than purchasing a working-age dog bonded by someone other than the producer?
3. Can we quantify increases in carrying capacity associated with LGDs? Similarly, can we quantify the production impacts of predator-induced stress on livestock?

Table 4 provides a cost versus benefit framework for considering the economic and production impacts of our answers to these research questions.

Table 4: Drivers of Possible Cost Savings and Benefit Enhancements in LGDs on Commercial Ranching Operations.

Potential Cost Savings	Potential Benefit Enhancements
• Improve LGD success rate (e.g., successful bonding and increased longevity) to reduce capital costs. • Optimize dog: livestock ratio (keep "just enough" dogs). • Increase efficiency of feeding LGDs (to reduce feeding labor).	• Reduced livestock stress may improve reproductive performance and weight gain. • Increased travel distances during foraging may allow producers to increase stocking rate on a given unit of land. • Maintenance of locally adapted livestock genetics may increase grazing efficiency.

Conclusion

As with many producer-level management decisions, the decision regarding whether to use LGDs (or any other nonlethal livestock protection tool, for that matter) is extremely complex. Producer attitudes towards a particular tool are directly related to that producer's confidence in the tool. If a rancher thinks a LGD will work on his/her operation, he/she is more likely to stick with the dog even when problems arise. In addition, Producer A may have a greater degree of success in raising and bonding LGDs with livestock than Producer B. Environment, management system, and other factors all impact the cost: benefit ratio of using LGDs. Perhaps the most difficult consideration to measure, however, is peace of mind. While most commercial producers factor an acceptable level of predator loss into their economic decision making process, the value of peace of mind (or the absence of human stress) is difficult to quantify.

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