Effect of ammunition on the escape distance of game in Germany

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BACKGROUND

Non-lead hunting ammunition is an alternative to bullets that contain lead. The use of lead ammunition can result in severe contamination of game meat [1], thus posing a health risk to consumers [2]. Lead bullets are also a source of contamination for birds of prey when they feed animal carcasses that contain toxic lead bullet fragments [3]. Therefore, the reduction of lead exposure of consumers and the environment through the substitution of lead with non-lead ammunition is recommended. However, an animal welfare concern has been raised regarding the killing efficiency for non-lead ammunition.
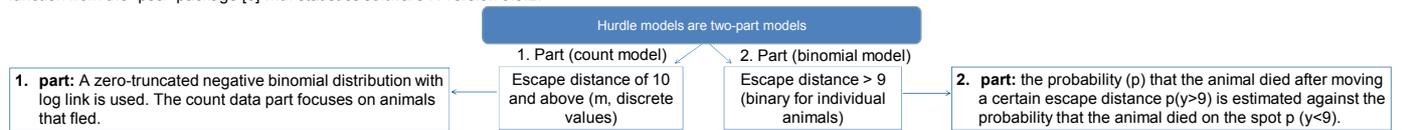
Aim

In the context of the research project "Safety of game meat obtained through hunting (**LEMISI**) the influence of the bullet material (lead or non-lead) on the observed escape distances of roe deer and wild boar was investigated. Escape distance was used as the measure for the killing efficiency of bullets on game animal and was estimated by the hunters. As the bullet material (lead vs. non-lead) cannot be regarded as the sole cause of the varying escape distance lengths, interactions with the location of the shot placement, hunting method, shooting distance, bullet type and age and sex of the animals were also examined.
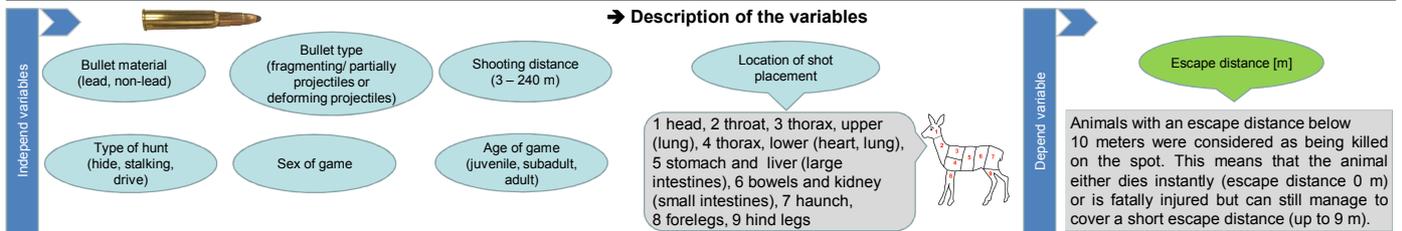
Methods

➜ Statistical methods

Conditional inference trees [4] were used to identify interactions between the potential explanatory variables. Subsequently, we used hurdle models [5] to study the important interactions and factors due the observed zero inflation. A considerable number of animals died on the spot or could not escape due the wounds received. The hurdle regression was carried out with the "hurdle" function from the "pscl" package [6] with statistics software R version 3.3.2.

Hurdle models are two-part models

1. Part (count model)	2. Part (binomial model)
Escape distance of 10 and above (m, discrete values)	Escape distance > 9 (binary for individual animals)

1. part: A zero-truncated negative binomial distribution with log link is used. The count data part focuses on animals that fled.

2. part: the probability (p) that the animal died after moving a certain escape distance p(y>9) is estimated against the probability that the animal died on the spot p (y<9).

➜ Description of the variables

Independ variables

- Bullet material (lead, non-lead)
- Bullet type (fragmenting/ partially projectiles or deforming projectiles)
- Shooting distance (3 – 240 m)
- Location of shot placement
- Type of hunt (hide, stalking, drive)
- Sex of game
- Age of game (juvenile, subadult, adult)

1 head, 2 throat, 3 thorax, upper (lung), 4 thorax, lower (heart, lung), 5 stomach and liver (large intestines), 6 bowels and kidney (small intestines), 7 haunch, 8 forelegs, 9 hind legs

Depend variable

Escape distance [m]

Animals with an escape distance below 10 meters were considered as being killed on the spot. This means that the animal either dies instantly (escape distance 0 m) or is fatally injured but can still manage to cover a short escape distance (up to 9 m).

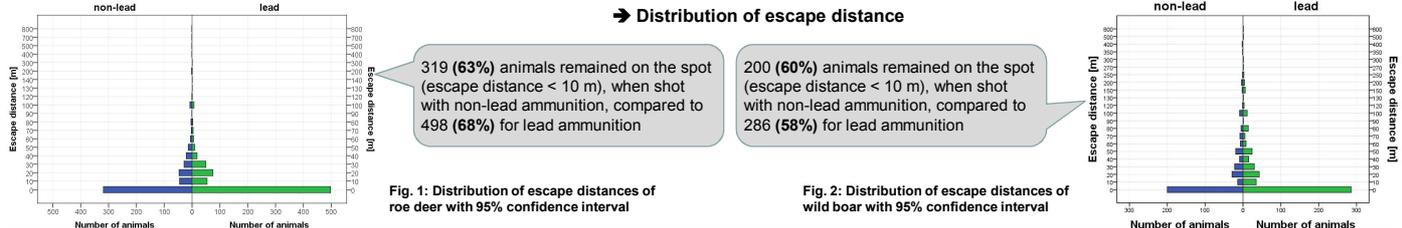## Results

➜ Study population

n = 1,234 shooting records
(504 killed with non-lead and 730 with lead ammunition)

n = 825 shooting records
(333 killed with non-lead and 492 with lead ammunition)

➜ Distribution of escape distance

319 **(63%)** animals remained on the spot (escape distance < 10 m), when shot with non-lead ammunition, compared to 498 **(68%)** for lead ammunition

200 **(60%)** animals remained on the spot (escape distance < 10 m), when shot with non-lead ammunition, compared to 286 **(58%)** for lead ammunition

Fig. 1: Distribution of escape distances of roe deer with 95% confidence interval

Fig. 2: Distribution of escape distances of wild boar with 95% confidence interval

➜ Multivariable hurdle model

Tab. 1: Results of the hurdle model for roe deer; dependent variable: escape distance

Condition	Significant part of the hurdle model	Two groups that differ significantly in the target variable	Effects on the escape distance
Hits in the forelegs, gastrointestinal tract, haunch, throat, thorax or head	Count	Thorax or head vs. Forelegs, gastrointestinal tract, haunch or throat	90th percentile 60 m, median 20 m, max 500 m. Longer escape distances (90th percentile 122 m, median 30 m, max 800 m)***
Hits in the forelegs, gastrointestinal tract, haunch or throat	Binomial	Shooting distance ≤ 100 m vs. Shooting distance > 100 m	Around 70% of the animals remained on the spot. Around 40% of the animals remained on the spot**
Hits in the thorax or the head	Binomial	Hide hunting or stalking vs. Drive hunting	Around 69% of the animals remained on the spot. Around 53% of the animals remained on the spot***
Hits in the thorax or the head and hunting method is drive hunting	Count	Shooting distance ≤ 60 m vs. Shooting distance > 60 m	90th percentile 40 m, median 20 m, max 100 m. Longer escape distances (90th percentile 200 m, median 30 m, max 500 m)***
Hits in the thorax or the head and hunting methods hide hunting or stalking	Binomial	Juvenile vs. Subadult, adult	Around 82% of the animals remained on the spot. Around 67% of the animals remained on the spot***

Tab. 2: Results of the hurdle model for wild boar; dependent variable: escape distance

Condition	Significant part of the hurdle model	Two groups that differ significantly in the target variable	Effects on the escape distance
Hits in the forelegs, gastrointestinal tract or haunch	Count	Juvenile vs. Subadult, adult	90th percentile 80 m, median 20 m, max. 150 m. Longer escape distances (90th percentile 200 m, median 50 m, max. 800 m)***
Hits in the forelegs, gastrointestinal tract or haunch	Binomial	Juvenile vs. Subadult, adult	Around 50% of the animals remained on the spot. Around 30% of the animals remained on the spot**
Hits in the thorax, head or throat	Binomial	Thorax vs. Head or throat	Around 58% of the animals remained on the spot. Around 90% of the animals remained on the spot***
Hits in the thorax	Binomial	Juvenile vs. Subadult, adult	Around 65% of the animals remained on the spot. Around 52% of the animals remained on the spot**
Hits in the thorax	Count	Juvenile vs. Subadult, adult	90th percentile 76 m, median 20 m, max 200 m. Longer escape distances (90th percentile 100 m, median 40 m, max 400 m)

**p<0.01, *** p<0.001

Conclusion

The length of the escape distance in this study was not significantly influenced by the use of lead or non-lead ammunition with either roe deer or wild boar. Other parameters play a more decisive role, like location of the shot placement, shooting distance (only roe deer), age of the animals and the hunting method (only roe deer). Non-lead bullets already exist which have an equally reliable killing effect in comparison with lead ammunition [7].

Reference

[1] Müller-Graf C, Gerofke A, Martin A, Bandick N, Lahrssen-Wiederholt M, Schafft HA, et al. Reduction of lead contents in game meat: results of the 'Food safety of game meat obtained through hunting' research project: Food safety and security. Game meat hygiene - Food safety and security: Wageningen Academic Publishers; 2017. p. 201-12.
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