Retz, Stefanie; Schiffer, Katrin Juliane; von Wenzlawowicz, Martin and Hensel, Oliver

Stunning effect of different rifle-bullets for slaughter of outdoor cattle

The slaughter method via gunshot implies a stunning of cattle by means of a targeted shot from a rifle and is as an alternative to regular slaughter at abattoirs. This method is only permitted under restricted circumstances and if the cattle is held on a pasture all the year. However, there is a considerable lack of specifications regulated by law concerning calibre and bullet-type. In this study, four different calibres, two bullet-types and two different shot placements were investigated with respect to their stunning efficiency. All of the calibres exhibited an entry-energy over 400 J and provided sufficient stunning potential. Yet, only calibre .22 Magnum caused no exit of the bullet out of the scull, which provides higher safety conditions for man and cattle.

received 13 August 2014
accepted 21 Oktober 2014

Keywords
Outdoor cattle, rifle shooting, stress-free slaughter, stun quality

Abstract
Landtechnik 69(6), 2014, pp. 296–300, 4 figures, 1 table, 9 references

The perennial outdoor keeping of cattle confronts the herd management with different requirements than keeping cattle inside the barn does. The relationship between man and animal is clearly less profound and outdoor-cattle generally keep a higher distance towards humans than e.g. dairy cows do. Especially when it comes to slaughter, stress-induced meat quality impairment (e.g. DFD-meat) is well known. Transportation, waiting time at the abattoir as well as restraining of the head before stunning can lead to strain and do not support animal welfare [1, 2, 3].

Slaughter via gunshot on the pasture

The on-farm slaughter method via gunshot directly on pastures provides an alternative to regular stunning methods at abattoirs, where a captive bolt is generally used in order to stun the animal. The animals gets stunned and killed immediately on the pasture by a targeted shot from a hunting rifle. The withdrawal of blood on-site follows promptly. Then, the carcass gets transported in a suitable transportation vehicle to the closest possible slaughter house for further processing. According to the "Tierschutz-Schlachtverordnung" ("regulation on the protection of animals at slaughter or killing", Annex 1 to section 12 Article 3 and 10) in Germany this slaughter method can be applied [4]. However, it is only permitted to stun or slaughter cattle via gunshot if the cattle is reared on pasture all year round. Contrary to the decree (EG) No. 853/ 2004 (Annex III Section I Chapter IV Number 2 Letter b) [5] and after amending section 12 of the "Tierische Lebensmittel-Hygieneverordnung" ("regulation on hygiene regarding production, treatment and sale of certain foodstuffs from animal origin") in November 2011 [6] it is permitted to slaughter grazing cattle on the farm of origin prior to transport the carcass to the abattoir. A permit to slaughter on the farm must be requested at the responsible authority.

Projectile Requirements

According to the supranational regulation on the protection of animals at the time of killing (VO EG No. 1099/ 2009) the projectile's caliber and the impact energy of the targeted bullet shot need to provide an efficient stunning potential to provide instant death [7]. However, there are no further specifications regulated by law concerning caliber and projectile apart from mentioning the position of the shot, the power and calibre of the cartridge and the type of the projectile as key parameters. This lack of specification often leads to uncertainty.

Hunting weapons are ideal for stunning and slaughtering cattle via gunshot [8]. The cattle has to be induced into an immediate state of complete unconsciousness and loss of sensibility. Therefore, the animal receives a shot to the head, and not to the body as it is practiced in hunting. The aim of using

Table 1

Overview of used calibers and bullets

Kaliber *Caliber*	Einschussposition *Shot placement*	Geschoss/*bullet* Hersteller, Art *Manufacturer, type*	Durchmesser *Diameter* [mm]	Gewicht *Weight* [g]	V_0–V_{100} [1)] [m s^{-1}]	E_0–E_{100} [1)] [J]	Rasse *Breed*	n
9.3 x 62	frontal	PPU, Teilmantel/*semi metal jacket*	9,3	18,5	695-600	4470-3360	Dt. Angus	4
.30-06	frontal	RWS, bionic yellow, bleifrei/*lead-free*	7,6	10,0	885-760	3915-2880	Dt. Angus	5
.30-06	frontal	RWS, bionic black, bleifrei/*lead-free*	7,6	10,0	885-760	3915-2880	Dt. Angus	6
.30-06	lateral	RWS, bionic black, bleifrei/*lead-free*	7,6	10,0	885-760	3915-2880	Dt. Angus	6
.30-06	frontal	Barnes, TTSX, bleifrei/*lead-free*	7,6	10,9	850-790	3940-3360	Dt. Angus	2
.22 Hornet	frontal	PPU, Teilmantel/*semi metal jacket*	5,6	2,9	770-550	865-460	Dt. Angus	5
.22 Hornet	lateral	PPU, Teilmantel/*semi metal jacket*	5,6	2,9	770-550	865-460	Dt. Angus	5
.22 Magnum	frontal	CCI, Hohlspitz/*hollow-point*	5,6	2,6	580-400	440-210	Galloway	4

[1)] V_0–V_{100} ist die Geschwindigkeit des Geschosses an der Laufmündung und nach 100 m Entfernung. E_0–E_{100} ist die Energie des Geschosses an der Laufmündung und nach 100 m Entfernung/*V_0–V_{100} is the velocity of the bullet at the muzzle and after a distance of 100 m; E_0–E_{100} is the energy of the bullet at the muzzle and after a distance of 100 m.*

a bullet shot is to inflict severe and irreversible damage to the brain. The damage is visible in pronounced bleedings and the destruction of the brain tissue. A short-term pressure increase within the cranial vault when the bullet hits and penetrates the skull is crucial. If the bullet contains too much energy, it is likely to exit the skull. As a result, bullet splinters could enter the carcass, leading to a reduction in meat quality. Bullets containing lead are especially critical. A bullet that exits the skull is a hazard to man and cattle standing close by. The optimal projectile can be determined by analyzing the parameters “impact of destruction” and “minimal invasive bullet reaction”.

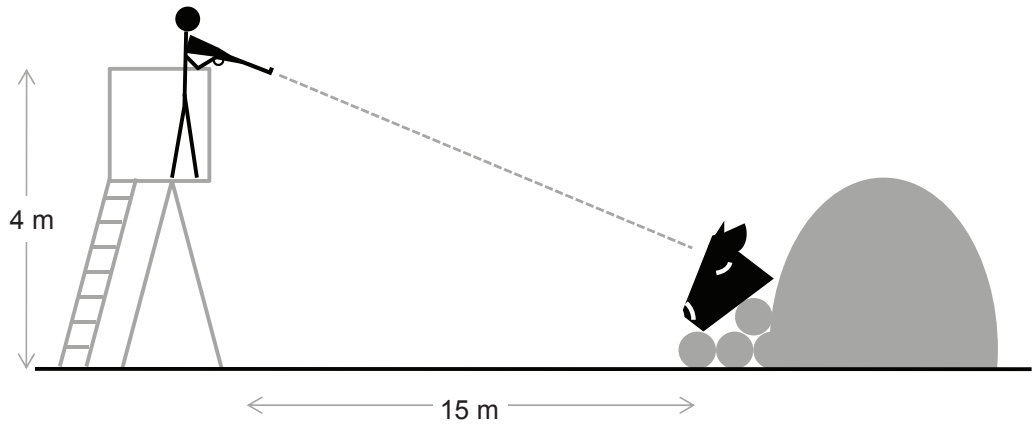
The advantage of soft point bullets compared to full metal jackets is that they expand their surface when they hit the target and release more energy into the tissue. This is vital for a sufficient destruction in the brain if the bullet remains in the skull.

A study of the University of Kassel, Department of Agricultural Engineering [9] investigated which amount of energy is necessary to penetrate a bovine skull successfully in order to induce serious and irreversible damage to the brain at the same time trying to keep the risk for man and cattle as low as possible.

Animals, material und methods

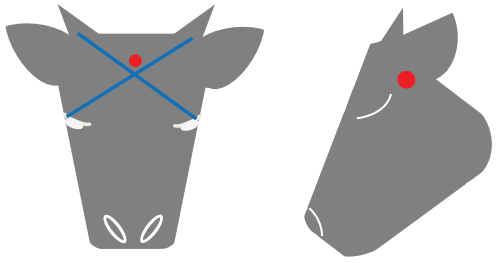
In 2012 37 bovine skulls of German Angus (n = 33, of these 14 bulls and 19 cows) and Galloway (n = 4, all ox) were collected from two farms in northern Germany. The cattle was held outdoor all year. Electrical stunning was used prior to slaughter and the collected skulls were frozen at the abattoir. By using electrical stunning the skulls stayed unmarked by bullet holes. The skulls were thawed at room temperature approximately 48 hours prior to the treatment. The mean age of the animals was 20 ± 10 month with a range from 7 to 44 month. One cow was already ten year old, but the skull was similar to the others. The high inhomogeneity of the examined cattle was inevitable due to the varying slaughter management systems of the cooperating farmers.

Fig. 1



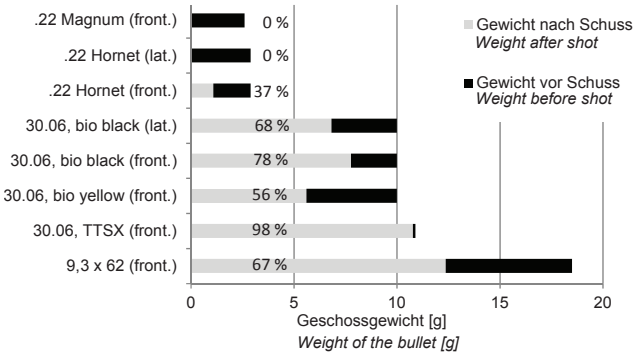
Shooting stand for the shooting of the heads

Fig. 2



Optimum shot placement, frontal and lateral

Fig. 3



Weight of retrieved bullets after shooting and percentage of exited material

Fig. 4

Bullet 30.06 TTSX after shooting (Photo: S. Retz)

The skulls were shot at with different rifles in order to test varying calibers and bullet types. The choice of caliber was based on the experience of gunmen who had worked with gun shots on cattle before. The different calibers were 9.3 x 62 and 30.06 (big bore) as well as .22 Hornet and .22 Magnum (small bore) (**Table 1**). All calibers used were soft point bullets. The caliber 30.06 was differentiated in deformation bullets (bionic black, Barnes TTSX) and fragmenting bullets (bionic yellow). It was only possible to shoot at the Galloway skulls with the caliber .22 Magnum due to permit and operational reasons.

The defrosted skulls were positioned on sandbags in front of a bullet trap made out of sand in a 90° angle to the shooter (**Figure 1**). The shooter stood on a 4 m high platform. The distance between the muzzle and the skull was 15 m. From this distance it is realistic to shoot cattle for certain. The skulls were frontally shot on the optimal point of entry. This point is 2 cm above the intersection point of eyes and horn attachment (**Figure 2**). The mean thickness of the cranial bone at the frontal point of entry was 1.4 ± 0.5 cm. In addition, skulls were shot from the side with the calibers .30-06, bionic black and .22 Hornet. This was performed in order to test the practicability and accuracy of the alternative point of entry.

The optimal point of entry was marked on each skull with paint before the shot. After each shot the deviation of the bullet's entry to the prior marked point was analyzed and it was assessed whether the bullet had stayed in or exited the skull. The bullet splinters that exited the skull were collected from the bullet trap, cleaned and weighed. If the bullet stayed in the skull, the penetration depth was measured with the means of a probe. Afterwards, the skull was opened and examined on tissue damage by an expert veterinarian.

Based on the prior experiments with the bovine skulls, cattle were stunned and killed by a bullet shot on the same farms. Five German Angus were shot with the caliber 30.06 and 13 Galloway with the smallest caliber .22 Magnum and slaughtered subsequently. The stunning efficiency was assessed right away using the method of Atkinson and Algers [2]. Evidence for a good stunning efficiency is the absence of respiration, the lack of eye movement and reflexes and the absence of directed motor functions. These skulls were examined by an expert veterinarian as well.

Results and discussion

It was observed that all caliber except the .22 Magnum (0 % bullet exits) caused a 100 % exit of the bullets, if shot frontally. The mean depth of penetration of the caliber .22 Magnum was 12.1 ± 1.9 cm. The bullet was always retrieved in the caudal region of the cranial bone nearby the canal of the spinal cord. If the skull was shot from the side with the small caliber .22 Magnum no bullet splinters exited the skull and with the larger caliber 30.06, bionic black 43 % bullet splinters exited the skull. If the bullet fragments left the skull, a large part of the projectile's mass could be found outside of the skull (**Figure 3**). The heaviest bullet fragments retrieved from the bullet trap belonged to the caliber 9.3 x 62 with an average of 12.4 g of the 18.5 g original weight. The highest percentage with 98 % of the exiting bullet mass was found in the deformation bullet 30.06 TTSX. The bullet's head had fully expanded but nearly stayed in one piece when it exited the skull (**Figure 4**). The fragmenting bullet 30.06 bionic yellow had the least weight losses with 56 % in the caliber category 30.06. The smallest caliber with exiting bullet fragments was the .22 Hornet. It exhibited the least weight loss (37 %) after an exit with an average of 1.1 g of the original 2.9 g. The safety for man and cattle is principally higher if no bullet and bullet fragments exit the skull at all. Weight losses potentially greater than 6 g of bullet splinters

containing lead in the carcass are considered risky in terms of food hygiene.

All frontally tested calibers featured massive destruction of brain tissue at the examinations of the skulls. The tissue destructions were less expressed with the caliber .22 Magnum but it always completely penetrated the brain. The bullet remained in the cranial cavity leading to the assumption that it released its complete energy to the brain. Based on the amount of energy at the muzzle E_0 = 440 J, at a distance of 15 m (E_{15}) this means a complete release of estimated E_{15} = 440 J to the skull. These accelerating forces inside the skull lead to extensive traumata of the brain. As specified by the manufacturer, a captive bolt disposes an amount of energy of about 300–600 J, depending on the animal that is about to be stunned. However, the velocity of the bolt is below 100 m/s. For adult cattle with a live weight between 450 and 900 kg an energy of approximately 400 J has been proven sufficient for stunning. This shows that the calibre .22 Magnum is in the range for sufficient stunning. In the case of old and heavy bulls and in the case of doubt a slightly bigger load should be used. The bigger calibre .22 Hornet features a higher velocity at the muzzle and therefore an amount of energy of approximately 800 J at the point of entry. That is why, in this study, the bigger calibre showed exits of the bullets from the skulls. However, it remains unclear how much energy was actually transferred to the brain and how much energy was lost through the exit of the bullet.

It has to be considered that an exceedance of the shooting distance of 15 m leads to a higher loss of energy which can cause an inefficient stunning effect. In this case, an adjustment of the calibre to the distance has to be carried out. The shorter the shooting distance, the higher the precision of the shot, though.

In this study, the type of the projectile (deformation or fragmenting bullet) did not have any effect on the impact of destruction of the brain.

In four out of six cases the lateral shots with the calibre 30.06, bionic black resulted in “failed” shots. This means, the brain was only insufficiently or not at all damaged. In these cases, the risk of an inadequate stunning would have been very high. With the calibre .22 Hornet three out of four lateral shots proved to be insufficient. Both calibres showed that a precise lateral shot that penetrates and damages the brain is much harder to achieve than using a frontal shot. The aiming at the lateral optimal point of entry is more difficult than aiming at the intersection point of eyes and horn attachment. Additionally, the anatomy of the brain provides, laterally seen, a rather flat shaped surface compared to the frontal view.

The additional examinations with the living cattle confirmed the results from the foregoing investigations. When the brain was hit properly, an efficient stunning effect could be demonstrated. The dissection of the skulls showed reliable and irreversible damage of the brain tissue displayed as massive vessel ruptures and contrecoup-bleeding (bleeding in the caudal area of the brain). In all investigated cases the calibre 30.06 caused an exit of the bullet from the skull. In the cases of the small bore .22 Magnum, every bullet remained inside the skulls. If the point of entry was right, no difference between the two calibres concerning stunning efficiency could be detected.

Conclusion

Stunning via gun shot is an effective instrument in order to slaughter cattle. The calibres 9.3 x 62, 30.06, .22 Hornet and .22 Magnum all proved to be fit to inflict an irreversible damage to the brain if the accuracy of the shot is adequate. However, the calibres with an energy higher than 400 J and a shooting distance of 15 m can cause exits of the bullet from the skull. These stray bullets and fragments can endanger adjacent animals and men. If bullet fragments enter the carcass they can cause a decrease in value. Therefore it is beneficial to use a calibre that provides, proportionate to the shooting distance, the minimum amount of energy that is recommended for captive bolts related to race, age, gender and live weight of the cattle.

References

[1] Atkinson, S.; Algers, B. (2007): The development of a stun quality audit for cattle and pigs at slaughter. In: Animal health, animal welfare and biosecurity. Aland A (ed.), Proceedings Volume 2, XIII International congress in animal hygiene, International Society for Animal Hygiene and Institute of Veterinary Medicine and Animal Sciences: Estonian University of Life Sciences, 17–21 June 2007, Tartu, Estonia, pp. 1023–1027

[2] Atkinson, S.; Algers, B. (2009): Cattle welfare, stun quality and efficiency in 3 abattoirs using different designs of stun box loading, stun box restraint and weapons. Project Report Department of Animal Environment and Health, Swedish University of Agricultural Sciences (SLU), Skara, Sweden

[3] Von Wenzlawowicz, M.; von Holleben, K.; Eser, E. (2012): Identifying reasons for stun failures in slaughterhouses for cattle and pigs in a field study. Animal Welfare 21, pp. 51–60

[4] Deutsches Bundesministerium der Justiz (BMJ) (2012): Verordnung zum Schutz von Tieren im Zusammenhang mit der Schlachtung oder Tötung und zur Durchführung der Verordnung (EG) Nr. 1099/2009 des Rates (Tierschutz-Schlachtverordnung – TierSchlV)

[5] European Union 2004 Regulation (EC) No 853/2004 of the European parliament and of the council of 29 April 2004 laying down specific hygiene rules for on the hygiene of foodstuffs. Regulation (EC) 853/2004

[6] Deutsches Bundesministerium der Justiz (BMJ) (2007/2011): Verordnung über Anforderungen an die Hygiene beim Herstellen, Behandeln und Inverkehrbringen von bestimmten Lebensmitteln tierischen Ursprungs (Tierische Lebensmittel-Hygieneverordnung – Tier-LMHV)

[7] European Union 2009 Council Regulation (EC) No 1099/2009 of 24 September 2009 on the protection of animals at the time of killing. Regulation (EC) No 1099/2009

[8] AVMA (American Veterinary Medical Association) (2013): AVMA Guidelines for the Euthanasia of Animals: Version 2013.0.1. Schaumburg, IL, USA

[9] Retz, S.K.; Schiffer, K.J.; von Wenzlawowicz, M.; Hensel, O. (2013): Stressfreie Schlachtung von Weiderindern. Erste Erkenntnisse eines Pilotprojekts. Tierärztliche Umschau 6, S. 242–243

Authors

Dr. agr. Stefanie Retz and **M. Sc. Katrin Schiffer** are staff members of the section Agricultural Engineering (head: **Prof. Dr. Oliver Hensel**) of the University of Kassel, Witzenhausen. e-mail: sretz@agrar.uni-kassel.de

Dr. vet. med. Martin von Wenzlawowicz is head of the bsi Schwarzenbek (applied animal welfare at transport and slaughter – independent veterinary expertise)

Acknowledgement

This study was financed by the Federal German Office for Agriculture and Food (Bundesanstalt für Landwirtschaft und Ernährung).