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Assessment of a specifically developed bullet casing gun for the stunning of water buffaloes

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ABSTRACT

Water buffaloes and cattle differ considerably with respect to the anatomy of the head. As a result, captive bolt stunners often fail to reliably produce adequate loss of consciousness in water buffaloes and, thus, do not fulfill animal welfare requirements. The goal of the present study was to assess and validate a new stunning device for water buffaloes meeting animal welfare and occupational safety requirements. The newly designed bullet casing gun uses .357 Mag/10.2 g hollow point bullets and has additional safety features. Its effectiveness and usability were assessed under practical conditions in an abattoir as based on widely accepted criteria. Stunning resulted in deep unconsciousness in 19 out of 20 water buffaloes. One 9-year old male did not immediately collapse. Except for very old bulls, the device presented herewith provides a means to stun water buffaloes of both sexes effectively and reliably while keeping occupational hazards to a minimum.

1. Introduction

Water buffaloes were first introduced into Switzerland in 1996 to allow for the domestic production of genuine mozzarella. Since then, the number of animals has increased continuously with the result that approximately 350 animals are slaughtered every year for stock management and meat production (Dr. A. Briner, Federal Food Safety and Veterinary Office FSVO, personal communication).

The Swiss animal welfare legislation (Tierschutzgesetz, 2014; Verordnung des BLV über den Tierschutz beim Schlachten, 2014) stipulates deep concussion as a prerequisite for bleeding and further slaughtering. Concussion is usually accomplished by producing severe brain damage with penetrating devices in order to produce deep unconsciousness. Conscious perception is linked to the cerebral cortex. Prior to reaching the primary cortex areas, however, all the sensory information but olfaction is relayed in the thalamus. Damage to the thalamus thus is an effective way to prevent conscious perception making this region of the diencephalon an effective target for stunning. Beyond, the brainstem holds integration centers for cardiovascular system control, respiratory control and pain sensitivity control and is involved in alertness and awareness. Therefore, instant onset of apnoea is considered as a main criterion for loss of consciousness (Verhoeven, Gerritzen, Hellebrekers, & Kemp, 2015; Zeman, 2001). The role of the brainstem in consciousness, however, is primarily permissive as the reticular formation acts in relaying sensory information to the thalamus from where it is projected to the sensory cortex.

Irrespective of the close relatedness of the two species, water buffaloes have distinctive anatomical head features compared to cattle (Schwenk et al., 2016). Therefore, standard captive bolt stunners such as Schermer KR (Schermer GmbH, Ettlingen, Germany), Blitz-Kerner (turbocut Jopp, Bad Neustadt, Germany) or Mod. 2000 (Isler, Winterthur, Switzerland) with corresponding cartridges fail to produce loss of consciousness and, consequently, stunning procedures commonly used for cattle often are not effective in water buffaloes. This is

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basically due to the width of the frontal sinus, the skin thickness and the hardness of the bone plates which together prevent captive bolts with a length of 90 mm from reaching the cranial cavity (Alsafy, El-Gendy, & El Sharaby, 2013; Kamel & Moustafa, 1966; Moustafa & Kamel, 1971; Saigal & Khatra, 1977; Schwenk et al., 2016). Swiss legislation, therefore, stipulates the use of devices with a bolt length of more than 120 mm. However, even stunners with a bolt length of 121 mm (Cash Magnum 9000S, Accles & Shelvoke, Sutton Coldfield, UK) or 125 mm (Schermer KL, Schermer GmbH, Ettlingen, Germany) together with corresponding cartridges are often ineffective and, thus, are not adequate for the purpose of stunning water buffaloes (Glardon et al., 2017; Schwenk et al., 2016). Our own attempts to improve the situation by doubling the bolt length to 180 mm and using customized stronger propellant charges have failed to resolve the issue satisfactorily and hence were abandoned. The excessive energy consumption by the rubber rings being required to retract the bolt goes at the expense of the energy being available for the stunning itself. To increase the propellant energy further does not resolve the problem as the recoil will make it impossible to secure the bolt gun which will be dislodged from the head (Glardon et al., 2017; Schwenk et al., 2016). The retraction of the bolt, however, is important as it produces further damage to the brain due to a suction-effect (Gibson et al., 2012) and it is necessary to disconnect the stunning device from the head (Glardon et al., 2017). The option of poll shooting with a captive bolt (Gregory, Spence, Mason, Tinarwo, & Heasman, 2009) has also been considered but does not comply with Swiss legislation (Verordnung des BLV über den Tierschutz beim Schlachten, 2014). For these reasons, various handguns such as 44 Rem. Mag. Smith & Wesson Mod 629 revolver, a .357 Mag. Ruger GP 100 double action revolver or a Swiss army pistol SIG P220 are currently being used by butchers. Though these weapons are dependable and effective in many cases, their handling is unadapted to the setting and they bear an obvious risk of misuse. Therefore, stunning by firing free bullets with handguns from a distance does not meet other requirements such as occupational safety and applicability and a legally underpinned standard procedure for the stunning of water buffaloes taking into account the exigencies of both animal welfare and work safety is undoubtedly needed.

Building on an extensive ballistic analysis (Glardon et al., 2017), the goal of the present study was to assess and validate a newly developed stunning device for water buffaloes meeting all animal welfare and occupational safety requirements and to pave the way for corresponding regulations. The new bullet casing gun fires .357 Mag. ammunition and has been found to achieve the best results with 10.2 g Hollow Point HP bullets. It can be either placed against the head or positioned 5 to 10 cm away. After in-depth analysis of its ballistic parameters, the usability, effectiveness and reliability of the device were validated under practical conditions in an abattoir. Assessment of widely accepted criteria (European Food Safety Authority [EFSA], 2013; Grandin, 2002; Gregory, Lee, & Widdicombe, 2007; Verhoeven, Gerritzen, Hellebrekers, & Kemp, 2015) showed that stunning resulted in deep unconsciousness of 19 slaughtered water buffaloes including a 13 year-old female but failed in one male individual close to 10 years of age. Except for old bulls, the device presented herewith provides a means to stun water buffaloes of both sexes effectively and reliably while keeping occupational hazards to a minimum.

2. Materials and methods

2.1. Tests on water buffalo heads collected after slaughtering

The investigations of the present study included preliminary shooting tests with different ammunitions fired onto heads collected from the slaughterhouse as well as a clinical assessment of the concussion depth after using the bullet casing gun in a commercial abattoir.

All the tests were performed with a bullet casing gun which was specifically designed and built for stunning water buffaloes (Fig. 1). The device was made of two 9 mm-bore rifled gun barrels with a barrel length of 150 mm to provide a backup means for an immediate second shot in case of failure of the first attempt. As a safeguard, the device needs to be unlocked ahead of firing. The contact point on the head of the animal to be stunned was slightly lateral to the intersection of two lines connecting the upper and contralateral lower edges of the horn base.

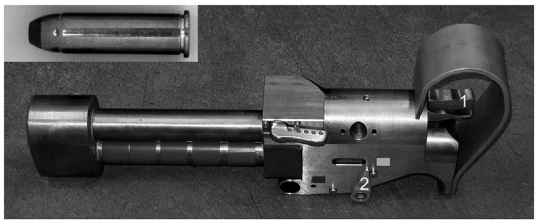

Fig. 1. Bullet casing gun and ammunition used.
The prototype with its two 9 mm-bore rifled gun barrels and protected trigger. Both barrels can be loaded with .357 Mag./10.2 g HP (inset) to provide a backup means for an immediate second shot in case of failure of the first attempt. A shifter (hidden) allows for a rapid switch between the barrels. The safety lever locks both barrels and needs to be released ahead of firing. 1: Trigger; 2 Safety lever.

The .357 Mag./10.2 g HP ammunition which was eventually used was selected as based on a previous study (Glardon et al., 2017; Schwenk et al., 2016) as well as on pilot experiments. These were conducted in order to obtain preliminary ballistic data prior to assessing the bullet casing gun on live animals in the abattoir. The heads of six water buffaloes were collected after regular slaughtering. The unskinned heads were numbered from 1 to 6 according to the animals' ages. Five heads (h1–h5) were from bulls aged 26, 28, 30, 35 and 107 months. Head six (h6) originated from a 114 month-old female water buffalo. In four out of the six heads (h1–h4), the base of the skull was cut away with a band saw and the brains were removed thus yielding forehead plates.

Targets were firmly mounted onto a box filled with Kevlar sheets (Glardon et al., 2017), and up to four shots were fired on any given forehead plate (h1–h4). Four different ammunitions were tested in order to assess whether the projectiles reached the cranial cavity (Fig. 2a). Ammunitions tested on forehead plates included

- the .357 Mag. 10.2 g Hollow Point (.357 Mag./10.2 g HP) bullets from Geco (Ruag Ammotec Group, Germany),
- the .357 Mag. 8 g Semi Jacketed Hollow Point (.357 Mag./8 g SJHP) bullets from Remington (Madison, North Carolina, USA),
- the .357 Mag. 8 g Semi Jacketed Soft Point (.357 Mag./8 g SJSP) from Union Metallic Cartridges (UMC, Madison, North Carolina, USA) and
- the .38 Special 10.2 g Semi Jacketed Soft Point (.38 Spl./10.2 g SJSP) from Geco (Ruag Ammotec Group, Germany).

After every shot, the forehead plates were inspected from the inside to determine whether the bullet had completely penetrated the skull. The two best suited ammunitions, i.e. .38 Spl./10.2 g SJSP and the .357 Mag./10.2 g HP, were then tested on the two intact heads h5 and h6. The .38 Spl./10.2 g SJSP was fired to the right half and the .357 Mag./10.2 g HP ammunition to the left half of the head, respectively. Both heads underwent computed tomography with a dual-source CT scanner with 2 × 128 slices (SOMATOM FlashDefinition, Siemens, Forchheim, Germany) to track the projectile's pathway through the brain. Data reconstruction was performed with 0.6 mm slice thickness in a soft (B30) and a hard (B70) reconstruction algorithm. Multiplanar and 3-dimensional reconstructions were performed at a multimodality workstation (LEONARDO, SynGo, Siemens Medical Solutions, Forchheim, Germany). Data were analyzed with the Osirix® software (Pixmeo, Bernex, Switzerland).