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CASE STUDY

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TISSUE DAMAGE IN JAPANESE QUAIL (*COTURNIX JAPONICA*) CAUSED BY PNEUMATIC WEAPON IN IMAGING AND BALLISTIC STUDIES

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ABSTRACT

The widespread availability of legal pneumatic weapons is commonly abused to hurt animals. Determining the shotgun based on animal injuries is complex and requires the knowledge of gunshot wounds and animal tissues. In this study, a detailed gunshot wound analysis was conducted on bird carcasses. An attempt was made to examine damaged soft and hard tissues in Japanese quail. A ballistic device of low energy was used. It was found that the shot of an average velocity of 83 $m \cdot s^{-1}$ thoroughly penetrates a bird carcass of an average mass of 205.5 g. A head or a neck shot with the same velocity can lead to immediate death. The shot velocity of 110 $m \cdot s^{-1}$ generates enough energy to move a carcass. These prove how dangerous the weapon is when used to harm small animals. Further studies may contribute to creating a model of bird injuries produced by various shots and result in strict law on possession of low-energy pneumatic weapons in Poland.

Key words: pneumatic weapon, birds, Japanese quail

INTRODUCTION

Birds and small mammals are often accidentally or deliberately killed by poachers. The knowledge of gunshot wounds found in small and large animals is still insufficient. The focus of ballistic and anatomical studies is mainly on broadening the database on injuries of soft and hard tissues damaged by low-energy pneumatic weapons. There are artificial substitutes used in studies such as gelatine and soap. Unfortunately, they can only be used as a simulator since they do not replicate the behaviour of live tissues [Smędra-Kaźmirska et al. 2013, Appleby-Thomas et al. 2018]. Despite of many imperfections and limitations, the methodology of ballistic studies on animal injuries is still being developed and improved [Appleby-Thomas et al. 2018]. It is worth mentioning that the science on determining the cause of animal deaths in criminal cases is called veterinary medicine [Markiewicz et al. 2018]. It is sporadic for veterinarians to see a gunshot wound in various animal species [Houszka 2005].

Nowadays, thanks to available information and human awareness, the interest in protecting companion, wild, and stray animals is vastly growing. Moreover, there is an increase in convictions in cases of violation of animal rights. Many reforms in legal organisations are currently being introduced [Kruk 2018]. One of the examples is the decree from 2012 by the administrative court in Olsztyn on animal welfare and stray animals on premises of the parish [NSA 2012]. Another example is the de-

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cree of the administrative court in 2014 on the prevention of homelessness in one of the parishes and the implementation of the care scheme for stray animals [NSA 2014]. These positive changes are creating a brighter future for animals. In recent years, most of the proceedings concerning illegal animal killing were discontinued. The main reasons for overruling decisions and discontinuance were the inability to identify the offender or the circumstances of the offence [Pankowski et al. 2018]. This thesis is mostly true as the post-mortem examination code of practice, ballistic analysis and broadly defined comparative anatomy mostly concern humans. The legal system in Poland allows the possession of pneumatic weapons without legal permits. The only condition is that the energy of a fired projectile cannot exceed 17 J [Dz. U. 2017].

The legal age for purchasing and possession of firearms is different in countries of the European Union. For instance, it is the legal age of 18 in Sweden and Norway, while the citizens of Germany and France can purchase a firearm from the age of 21. Germany is a country with very strict licence and possession laws. It is still easier to buy an airgun there compared to Poland. From all European countries, the Czech Republic least strict law which allows the unrestricted sale of airguns (pneumatic weapons) including a springer. Only the high-energy ones are registered during the purchase. However, the accessibility of firearm without a licence is similar to Poland [Dragan et al. 2017].

To this day, there are only a few institutions and not enough research investigating the causes of death in animals [Okoń et al. 2014]. One of the rare studies is the article analysing the death of a common buzzard which is a protected species. It was found that the shot was fired from a hunting weapon. The bullet was analysed by a ballistics expert and a simulation of the shot was performed to determine its trajectory and position of the bird. Unfortunately, identification of the criminal was impossible [Pankowski et al. 2018]. Another example of an animal shooting is the death of a cat that was shot by an airgun. During the analysis, two different types of pellets were found in the cat's body. It was possible to identify the weapon, however, not the shooter [Markiewicz et al. 2018]. Therefore, this study is particularly important to enforce stricter laws as well as to reduce the number of animals harmed by airguns.

MATERIAL AND METHODS

The bird specimens examined in the study were female Japanese quails *Coturnix japonica* f. *Phasianidae* obtained from the museum collections of the Institute of Veterinary Medicine SGGW in Warsaw. There were 40 specimens used in the study, including 16for the ballistic investigation and 24 for imaging. The following measurements were taken: maximum length (measured from the base of the skull to pelvic bone), maximum width (measured in the widest area of chest when placed on the side) measured by a calliper with the Vernier scale, and mass of birds using an AXIS AD2000 scale with two decimal places 0.01 g.

24 Japanese quails were examined with a CT scanner GE CT 660 Optima. The produced images were 3D edited in RadiAnt DICOM Viewier in DICOM-PACS browser (www.radiantviewer.com, accessed 18.04.2019). According to the local law, the approval from the Local Ethics Committee was not required as the study examined dead animal bodies.

There were four types of pellets of different shapes used in the study: Walther High-Power cal. 4.5 mm (WH), Hammerli Field Target cal. 4.5 mm (HF), Umarex Cobra cal. 4.5 mm (UC), and Kovohute Round Balls cal. 4.5 mm (KR). They were all brand new and had no defects or any signs of previous use. The average length and mass were established for each type of pellets. The length was measured by an electronic calliper purchased from Corona. The precision of the device is two decimal places 0.01. The mass was measured using the AS 110.R2 scale obtained from RADWAG. The readings had only one decimal place 0.1 mg. There was an average number calculated from 10 measurements chosen randomly from all the measurements for each type of pellet (n = 10). The diameter for each shot was 4.5 mm as determined by the manufacturers.

RESULTS

Morphological studies

The average weight of all the examined quails was 205.47 $\pm$20.70 g, the average length was 225.3 $\pm$1.50 mm, while the average width of the chest area was 56.2 $\pm$0.52 mm. The biggest specimen was 260 mm in length and 76 mm in the chest area. The smallest specimen was 205 mm in length and 60 mm in width. The dimensions were done with a traditional calliper.

Ballistic studies

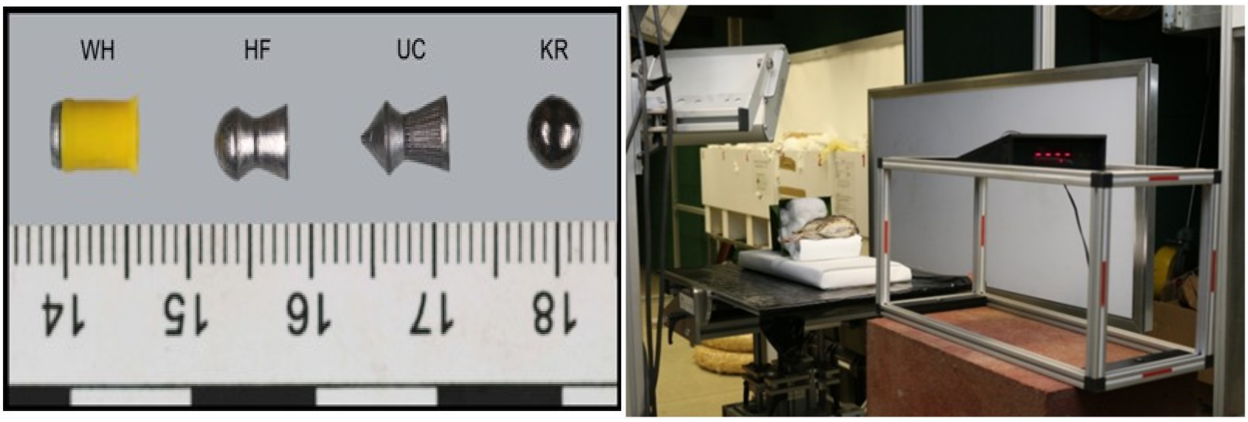
From all the measurements, the largest were Umarex Cobra pellets (cal. 4.5 mm) of 7.00 mm. While the smallest were Kovohute Round Balls (cal. 4.5 mm) of 4.50 mm. The former was also the heaviest type of pellets with the average mass of 0.569 g. Hammerli Field Target (cal. 4.5 mm) was slightly lightest with mass of 0.568 g. The lightest was Walther High-Power (cal. 4.5 mm), with the average mass of 0.354 g (Table 1).

The ballistic investigation was based on the controlled shots to the specimens. The carcasses were placed on their side on a platform. There was a bullet trap placed right behind them. It was equipped with a filter stopping

Table 1. Types of pellets used in the study, technical data; average values for n = 10

Name[1)]	Length, mm	Mass, g	Material[2)]
UC	7.00 ±0.01	0.569 ±0.1	Pb
HF	5.93 ±0.01	0.568 ±0.1	Pb
KR	4.50 ±0.01	0.544 ±0.1	Pb
WH	6.85 ±0.01	0.354 ±0.1	SiP

[1)]For explanations see MATERIALS AND METHODS.
[2)]Pb – lead, SiP – steel in a plastic cover.



A B

Fig. 1. (A) Bullets used in the study, UC – Umarex Cobra cal. 4.5 mm, HF – Hammerli Field Target cal. 4.5 mm, KR – Kovohute Round Balls cal. 4.5 mm, WH – Walther High-Power cal. 4.5 mm; (B) The platform used in the study

the gunshot penetrating the bird carcasses. In front of the platform, there was an EMC-500 gate measuring the velocity of the gunshot. Next to it, there was a support stand stabilising the weapon placed 1.5 m away from a specimen (Fig.1 B).

The shots were fired from an airgun CROSMAN mod.P1377BR, calibre 4.5 mm, produced in the USA. There were 16 birds used in the study, four quails for each type of pellet. The shots were fired in series dependent on the amount of released air in the gun. The first quail was shot after releasing the air once (one compression), the second after two compressions, the third after three compressions and the fourth after four compressions. The velocity of pellets was dependent on the number of compressions. The numbers are shown in Table 2.

The shots with one compression gave the most diversified results: $\pm 7.61 \text{ m} \cdot \text{s}^{-1}$ for HF HF, $\pm 8.72 \text{ m} \cdot \text{s}^{-1}$ for KR. Given the mass and the velocity of pellets, it is possible to calculate their kinetic energy as shown in Table 3.

The shot energy of pellets with the mass of 0.5 g and the velocity of 80 $\text{m} \cdot \text{s}^{-1}$] was calculated using the following equation:

$$E = \frac{1}{2} \cdot 0.0005 \cdot 80^2 = 1.6 \left[\frac{kg \cdot m^2}{s^2} = J \right]$$

There were twelve shots for each type of pellets and forty-eight shots fired to sixteen quails in total.

Imaging done by CT scanner

The examined birds were analysed with a CT scanner after the shots were fired. The following bones were damaged during the controlled gunshots: ulna, radius and a base of humerus. The shoulder bone was also damaged at the level of extremitas caudalis. After penetrating soft and hard tissues, the pellets were stopped in the area of dorsal muscles and adjacent shoulder muscles. There were also numerous bone fragments found in all previously mentioned bone structures (Fig. 2).

DISCUSSION

During forensic analysis, it is important to remember that an injury is a damage done to a tissue, an organ or a certain body area caused by external factors. An injury is not a bruise, a scrape, a wound or a fracture as these are scathes. It is important to determine the type of weapon during forensic examination [Okoń et al. 2014]. The factors affecting the size of injuries are velocity and force of impact of the bullet penetrating the tissue and its kinetic

Table 2. Average gunshot velocity for different numbers of compressions

Gunshot name	1 compression, m · s^{-1}	2 compressions, m · s^{-1}	3 compressions, m · s^{-1}	4 compressions, m · s^{-1}
UC	48.50 ± 1.47	82.37 ±0,76	100.20 ±0.79	111.77 ±0.90
HF	48.33 ±7.61	82.97 ±0.64	101.13 ±1.27	112.50 ±1.91
KR	48.33 ±8.72	81.70 ±4.29	100.33 ±1.14	113.27 ±0.81
WH	63.63 ±1.29	86.07 ±0.15	110.30 ±0.30	134.23 ±4.92

Table 3. The average energy of pellets dependent on the number of compressions

Shot name	1 compression, J	2 compressions, J	3 compressions, J	4 compressions, J
UC	0.67 ± 0.04	1.93 ±0.04	2.86 ±0.05	3.55 ±0.06
HF	0.67 ±0.22	1.95 ±0.03	2.91 ±0.07	3.60 ±0.12
KR	0.65 ±0.24	1.82 ±0.19	2.74 ±0.06	3.49 ±0.05
WH	0.72 ±0.03	1.31 ±0.00	2.15 ±0.01	3.19 ±0.24

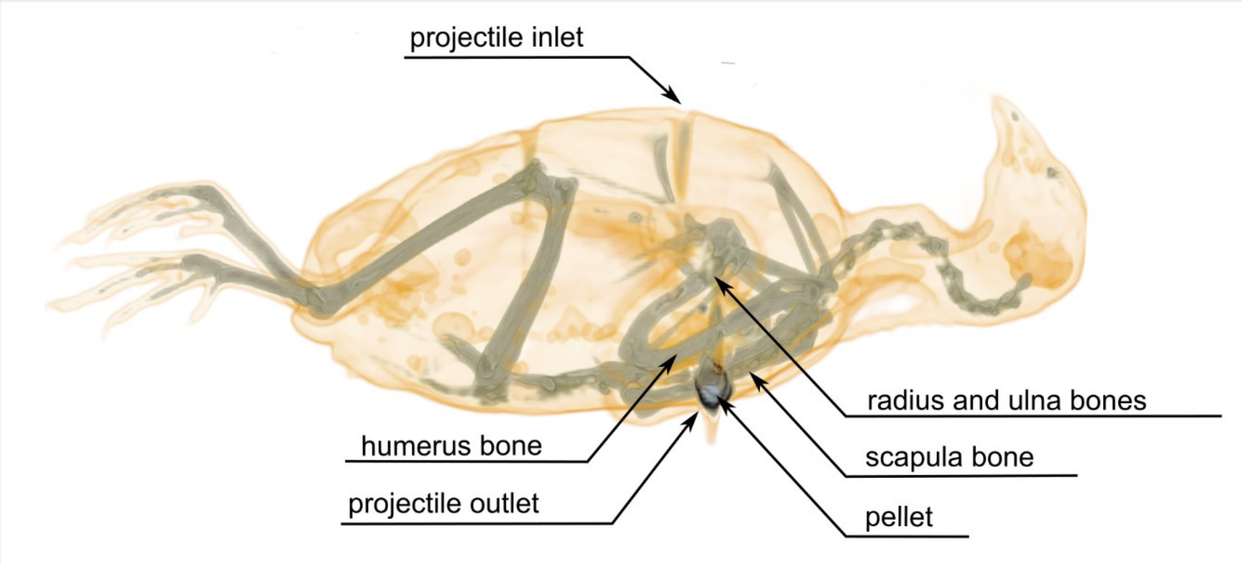


Fig. 2. 3D reconstructions of quail in the research sample

energy. A gunshot wound is caused by a bullet damaging the tissue. The factors affecting the wound are the diameter, shape and velocity of a bullet. It is also affected by its plasticity and the material of the damaged material, in this case, it is an animal's body [Jamroziak 2016].

Writing a comprehensive ballistic report is of great importance, therefore it is crucial to perform a necropsy and examine a body with a CT scanner. Tomography can be helpful in determining the trajectory of a bullet [Makhlouf et al. 2013]. This procedure is routine in many countries and very often provides more information than necropsy. The post-mortem examination is crucial for the analysis of tissues and internal organs. The latest research presents new applications of a CT scanner which makes is useful in both human and veterinary medicine [Ampanozi et al. 2017]. It can be used in determining the cause of death [Pankowski et al. 2018]. Furthermore, it may also be used to examine the body of an animal that was deliberately harmed. Its huge advantage is that it is quick, safe and non-invasive [Ludwiniak et al. 2017]. It is commonly used to examine shotgun wounds. It was crucial in the case of a young individual who was administrated to a hospital after being shot in the neck from an airgun [Juźwik et al. 2019]. The lack of strict laws on purchasing these weapons can lead to shots that required a more advanced analysis [Trnka et al. 2008].

In post-mortem examination for the ballistics, there are other methods used for more detailed analysis including magnetic resonance imaging (MRI) and micro CT. These are more expensive and only a small part of facilities has the access to them. Usually, there are no requirements to use these techniques, therefore they are not as common as a CT scanner and necropsy [Markiewicz et al. 2018]. There is literature about the latter one based on the research in which this method was examined. During the experiments on wounds, the amount of gunshot residue was determined. They can be characterised by the loss of fluids, contractibility and result in changes in microscopic and macroscopic images. There were human tissues used in the study, which were burnt from different distances. Detailed tissue analysis was possible thanks to the micro CT technique. It can be assumed that its popularity will continue to grow [Fais et al. 2013].

Methods used in the forensic and ballistic sciences in the context of animals are rapidly developing. The number of research and publications is growing, presenting revolutionary techniques and methods in these areas. The models of tissue damage are created and matched to certain weapons to determine a criminal.

An example of an innovative study is a comparative description of thoracic walls in pigs and human corpses. There were two types of shots fired and both soft and hard tissues were analysed. The bone mineral density and number of fractured ribs were examined. It was found that the motor activity of the chest area in pigs was larger, however, the injuries were more severe in the human body. Pig bones were more elastic and less fragile. The bone mineral activity is higher for human corpses, and it was assumed that the chest area should be more resistant to pig's one [Prat et al. 2012].

There are many publications investigating airguns with energy not exceeding 17 J, which can be purchased in Poland without any permits or registration. It is crucial for animal protection to demonstrate the harmfulness of these weapons. The following parameters were measured: velocity, kinetic energy, distance and type of pellets. These are the most important in forensic reports. It was shown that shots from 20 to 30 m can cause severe injuries to human bodies or even result in death [Bogiel 2014]. Therefore, it is only logical to assume that airguns with such force can be even more dangerous to small animals causing lethal injuries. Animal carcasses are commonly used in research to establish a correlation between the depth of the wound and the force of a fired shot. The results can be generalised to different species with similar anatomy. The finding on the distances and depth of gunshot wounds can be the basis of the thesis and further research.

There was research focused on the analysis of various types of pellets shot from different airguns. The following parameters: the velocity and the angle of each shot as well as the trajectory for different surfaces. The shots were fired at the gel imitating the human body. It was found that pellets shot from pneumatic weapon a of energy not exceeding 17 J penetrated the body for over 80 mm. Therefore, it could damage most of the internal organs [Ćwik and Bogiel 2016].

In this study, a low-energy airgun was used with adjustable force not exceeding 17 J. It is important to notice that it can be used as a dangerous weapon to injure or kill animals. Studies on this topic contribute to modernisation of the law on possession of airguns killing many animals. The number of reported cases is very low, however, the danger is enormous.

It was the first study focused on investigating the damaged tissues in small birds. It was proved that a bullet with an average velocity of 83 $m \cdot s^{-1}$ fully penetrates a carcass of a Japanese quail. Bone structures and soft tissues are damaged. The projectile with the same kinetic energy penetrates a body without causing immediate death. In nature, a bird who was shot has no chance to heal or survive and becomes prey. Further studies could contribute to creating a model of bird injuries from various projectile's velocities.

CONCLUSIONS

1. The highest velocities were achieved for the pneumatic weapon with Walther High-Power pellets. There were issues with Kovohute Round Balls which were unstable.
2. With an average velocity of 110 $m \cdot s^{-1}$ most of the birds were pushed off the platform which indicates that projectiles with that speed can cause loss of balance and death to live birds.
3. With the velocity of 83 $m \cdot s^{-1}$ the projectile fully penetrates a quail carcass with an average mass of 205.5 g. Bone structures and soft tissues are damaged. A projectile with this amount of kinetic energy penetrates the carcass without immediate death.
4. A head or a neck shot with a velocity of 83 $m \cdot s^{-1}$ may cause damage to the central nervous system (CNS) or immediate death.

When a Diabolo (UC shape) bullet with the mass of 0.55 g is hot from a pneumatic weapon with the following energy:

- 7.5 J the velocity is 83 $m \cdot s^{-1}$, the distance is about 64 m from the gun barrel,
- 12 J the velocity is 83 $m \cdot s^{-1}$, the distance is about 86 m from the gun barrel,
- 17 J the velocity is 83 $m \cdot s^{-1}$, the distance is about 102 m from the gun barrel.

The distances were measured using ballistic software. It shows the accessible range of certain guns. In theory, the velocity of the shot should be the same as well as the damages it causes.

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USZKODZENIA TKANEK PRZEPIÓRKI JAPOŃSKIEJ (*COTURNIX JAPONICA*) SPOWODOWANYCH PRZEZ BROŃ PNEUMATYCZNĄ W BADANIACH OBRAZOWYCH I BALISTYCZNYCH

STRESZCZENIE

Legalna w wielu krajach broń pneumatyczna często trafia w niepowołane ręce i wykorzystana do krzywienia zwierząt. Ustalenie broni na podstawie obrażeń zwierząt jest trudne, wymaga wiedzy o tym jak śrut penetruje tkanki. Przeprowadzono analizę strzałów do ptasich tuszek. Podjęto próbę określenia uszkodzeń tkanek. Wykorzystano urządzenie pneumatyczne niskiej energii. Wykazano, że przy prędkości około 83 $m \cdot s^{-1}$ śrucina powoduje przestrzelenie zwłok ptaka o średniej masie 205,5 g. Strzał z tą samą prędkością w okolicę głowy i szyi może powodować natychmiastowy zgon. Przy średniej prędkość 110 $m \cdot s^{-1}$ energia pocisku była na tyle duża, że w większości przypadków powodowała strącenie materiału. Pokazuje to, jak groźna jest taka broń, gdy użyta jest przeciwko małemu zwierzęciu. Kontynuacja badań może przyczynić się do powstania modelu uszkodzeń u ptaków na podstawie różnych prędkości śrucin i być argumentem za zaostrzeniem prawa o posiadaniu urządzeń miotających niskiej energii w Polsce.

Słowa kluczowe: broń pneumatyczna, ptaki, przepiórka japońska

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