OPEN ACCESS
Advances in Animal and Veterinary Sciences

Research Article

Clinical Evaluation and Pathological Findings of Air Rifle Shot in Slow Lorises (*Nycticebus* spp.) At The Animal Rehabilitation Center of Yayasan Inisiasi Alam Rehabilitasi Indonesia (YIARI) Bogor Regency

Hanita Fadhilla[1], Shafia Khairani[1,2*], Ahmad Fitrah[3], Wendi Prameswari[4], Nur Purba Priambada[4], Indri Saptorini[4], Imam Arifin[4]

[1]Veterinary Study Program, Faculty of Medicine, Universitas Padjadjaran, Jatinangor, Indonesia, 45363; [2]Department of Biomedical Sciences, Faculty of Medicine, Universitas Padjadjaran, Jatinangor, Indonesia, 45363; [3]Department of Radiology, Faculty of Medicine Universitas Padjadjaran/Dr. Hasan Sadikin General Hospital, Bandung, Indonesia, 40161; [4]Yayasan Inisiasi Alam Rehabilitasi Indonesia, Jl. Curug Nangka, Sinarwangi RT 004/RW 005, Kelurahan Sukajadi, Kecamatan Tamansari, Bogor, Jawa Barat, Indonesia, 16610.

Abstract | Indonesian slow lorises (*Nycticebus* spp.) are threatened due to habitat loss and illegal trade. Despite their protected status, slow lorises are often hunted using air rifles. This study aims to evaluate the effects of air rifle wounds in slow lorises, identify hot spot areas for improved habitat protection, and develop standard operating procedures for veterinarians in rehabilitation centers. From 2015 to 2022, 16 individual cases of air rifle shot to slow lorises were documented by Yayasan Inisiasi Alam Rehabilitasi Indonesia (YIARI), accompanied with radiology results and anatomical gross pathology examination. Medical records were evaluated based on lesions, clinical findings, radiological findings, surgical or conservative management (treatment), and survival rates. Results showed that twelve slow lorises did not show clinical conditions, while others experienced ballistic wounds and swelling of the lymphoglandula axillary. Radiology results from 16 cases revealed there were 29 pellets identified in the regions of the head (28%), the neck (7%), the shoulder (14%), the forelimb (10%), the thorax (21%), the abdomen (3%), the pelvis (10%), and the hindlimb (7%). Surgery was performed to remove 16 pellets, with 9 being subcutaneous and 7 intramuscular. Other pathology gross anatomy findings include encapsulated pellets, entry wounds, and damaged palate tissue. Based on the findings, the impact of air rifle use is harming the welfare and population of slow loris, also probably other wildlife. Thus, we recommend that the government improves habitat protection and law enforcement, especially, with regards to air rifle hunting.

Keywords | Air rifle pellet, Air rifle wounds, Indonesia, Medical records, Necropsy, Slow loris

Received | December 06, 2023; **Accepted** | February 05, 2024; **Published** | April 26, 2024
***Correspondence** | Shafia Khairani, Faculty of Medicine, Universitas Padjadjaran, Jatinangor, Indonesia, 45363; **Email:** shafia@unpad.ac.id
Citation | Fadhilla H, Khairani S, Fitrah A, Prameswari W, Priambada NP, Saptorini I, Arifin I (2024). Clinical evaluation and pathological findings of air rifle shot in slow lorises (*Nycticebus* spp.) at the animal rehabilitation center of Yayasan Inisiasi Alam Rehabilitasi Indonesia (YIARI) Bogor regency. Adv. Anim. Vet. Sci., 12(6):1126-1135.
DOI | https://dx.doi.org/10.17582/journal.aavs/2024/12.6.1126.1135
ISSN (Online) | 2307-8316

INTRODUCTIONS

The Slow loris (*Nycticebus* spp.) are small nocturnal primates, which are protected in Indonesia according to Regulation of the Ministry of Environment and Forestry of the Republic of Indonesia No. P.106/MENLHK/SETJEN/KUM.1/12/2018. With population numbers estimated to be in decline, all slow loris species are considered threatened according to the International Union for Conservation of Nature (IUCN) with Javan

Slow Lorises Critically Endangered, the Greater Slow Loris as Endangered, and the Philippine Slow Loris as Vulnerable (Nekaris *et al*., 2020a; Nekaris *et al*., 2020b; Nekaris *et al*., 2020c). Meanwhile, included in Appendix I in the Convention on International Trade in Endangered Species (CITES) all international commercial trade in slow lorises is forbidden (Nekaris and Nijman, 2007). The trade of slow loris is a major threat to these species, where they are traded domestically and internationally for pets, traditional medicine, and meat consumption (Nekaris *et al*., 2013; Nekaris and Starr, 2015; Miard *et al*., 2017; Uprety *et al*., 2021). In addition to the conservation implications, the consumption of bushmeat from wild animals can pose a significant risk of zoonotic disease transmission and microbiological contamination, which could become a public health threat (Temmam *et al*., 2017).

In Java, there has been an increase in slow loris trade in markets over the last 25 years (Nijman *et al*., 2017). Many slow loris are sold in pet markets and online platforms, with an average of 43 Javan Slow Loris are offered per months in online forums (YIARI, 2017; Nekaris and Nijman, 2019). One of the tools used in hunting is an air rifle, which can cause injuries to slow loris (Prameswari *et al*., 2019; Permana *et al*., 2020).

An initial medical evaluation is required for slow lorises who arrive at the rescue center to determine their condition (Čižmářová *et al*., 2022). Clinical findings that can be found in air rifle cases include haemorrhage, organ damage, bone fractures, and embolism (blockage in artery caused by a foreign body) (Bradley-Siemens *et al*., 2018). In a study by Tanrisever *et al*. (2017), dogs affected by air rifle wounds had clinical symptoms in the form of lameness, effusion, and hemorrhage. Entry, exit, and intermediate wounds are specific types of lesions that indicate projectile injuries, and recording these wounds is essential for determining their prognosis, evaluation, and treatment (Bradley-Siemens and Brower, 2016; Stefanopoulos *et al*., 2017; Shrestha *et al*., 2022).

Taking whole-body radiographs is important to support the examination of slow loris shooting cases, as there is limited information regarding the causes of injuries observed during physical examination. Radiographs can show the characteristics of the shape and density of the projectile, the location of the projectile in the body, see the condition of the bone fracture, and help determine the trajectory of the projectile in the body (Bradley-Siemens and Brower, 2016).

We found very few reports or studies that provide detailed information on clinical examinations and radiography results of slow loris shooting cases in recent years. Therefore, this study aims to present the findings from clinical evaluations as supporting evidence to the examinations and pathological findings in cases of air rifle wounds caused by air rifle in slow lorises. We also aim to identify locations when and where law enforcement and local governments should increase habitat protection to reduce illegal poaching. We also aimed developed Standard Operating Procedures (SOPs) for managing veterinarian actions for slow loris entering rehabilitation centers.

MATERIALS AND METHODS

Study population

The study population included three species of Indonesian slow lorises: the Javan Slow Loris (*Nycticebus javanicus*), the Greater Slow Loris (*Nycticebus coucang*), and Philippine Slow Loris (*Nycticebus menagensis*) were included. This study included radiography and pathology gross anatomy documentation of air rifle shooting cases in slow lorises between 2015 – 2021 at Yayasan Inisiasi Alam Rehabilitasi Indonesia (YIARI), Bogor.

Study variables

The variable used for this study included species, age, sex, lesion, clinical findings, radiograpical findings, treatment, and outcome. These variables were taken based on the methods of Tanrisver *et al*. (2017).

Inclusion and exclusion criteria

The included data must contain documentation of pathology gross anatomy and radiological examination results in the medical records. Data was excluded if documentation of gross anatomical pathology has poor image quality and is in black and white. Data was also excluded if radiographs were illegible or could not be interpreted. More details are listed in Table 1.

Photomicrography

The radiography examination was performed under Genoray Port X-II portable dental x-ray with Agfa ORTHO CP-GU M 24 x 30 cm or Fuji Medical X Ray Film Super HR-U 24 x 30 cm and then captured by a Canon 700D camera for digitalization of radiography image. Pathology gross anatomy findings were captured using a Nikon J5 camera and personal phone.

Data analysis

The data was processed using Microsoft Office Excel 2019 program and then discussed descriptively.

RESULTS AND DISCUSSION

A total of 492 medical records at the YIARI rehabilitation center between the period of 2015-2022 were examined. A total of 51 individual cases involving shooting incidents

Table 1: Criteria inclusion and exclusion for data selection.

No.	Inclusion criteria	Exclusion criteria
1.	Medical record in 2015 – 2022.	There was no documentation of anatomical pathology and radiological examination results.
2.	Javan Slow Loris (*Nycticebus javanicus*), Greater Slow Loris (*Nycticebus coucang*), and Philippine Slow Loris (*Nycticebus menagensis*).	Anatomical pathology documentation with poor image quality (too low resolution) and in black and white.
3.	Slow lorises shot by an air rifle.	Radiographs that are illegible or cannot be interpreted
4.	Medical records contain documentation of pathology gross anatomy and radiological examination results.	

were found: 49 cases were based on radiology results and 18 were based on pathology gross anatomy results. Data selection was carried out based on inclusion and exclusion criteria, resulting in 16 individual cases of data, which are detailed in Table 2.

The slow lorises included in the research subject is the Javan slow loris, which came from Bandung, Bogor, Ciamis, Cianjur, Cirebon, Jakarta, Bandung Regency, West Bandung Regency, Kuningan, and Majalengka (Figure 1). The greatest number of slow lorises came from Bogor, with three individuals, and Ciamis, with three individuals. Previous research (Munds *et al.*, 2008; Winarti, 2008; Widiana *et al.*, 2013; Nekaris *et al.*, 2014, 2017) has indicated that these areas are the habitat of the Javan slow loris.

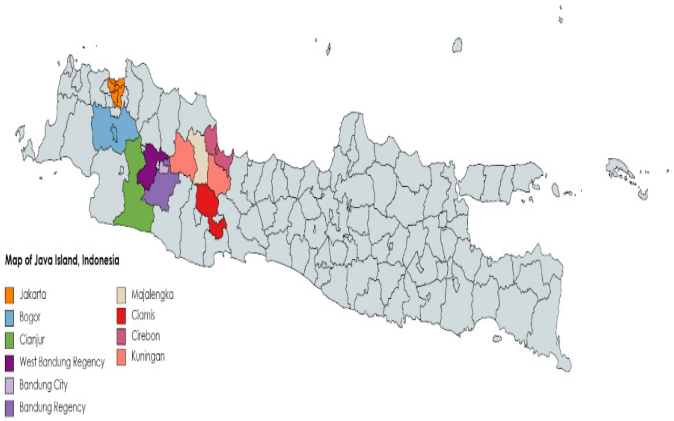

Figure 1: The area from which the slow lorises were rescued.

Clinical evaluation from radiography imaging

Radiology reports from the period 2015-2022 revealed 49 cases of slow lorises being shot by air rifles. Only 16 cases were selected based on predetermined inclusion and exclusion criteria. The data presented in Table 2 includes clinical findings, anatomical pathology, and radiology. Data shows that 12 slow lorises who entered the rehabilitation center did not show any clinical condition, while 4 others experienced conditions in the form of ballistic injuries, swelling of the lymphoglandula axillary, tooth fractures, and upper respiratory tract infections (URTI).

Radiography imaging (Figure 2) is differentiated into eight regions, head, neck, shoulder, forelimb, thorax, abdomen, pelvis, and hindlimb, based on previous research (Diogo et. al., 2014, 2018; Casteleyn *et al.*, 2023a, b).

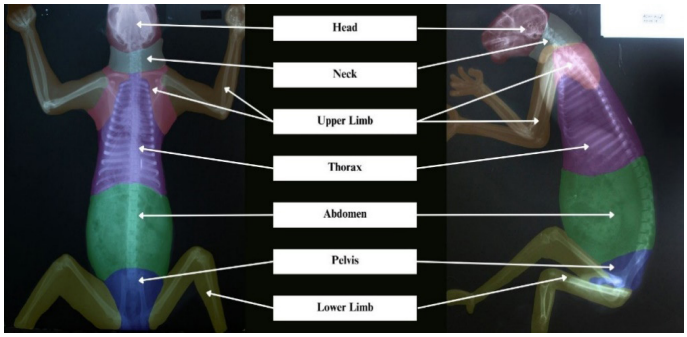

Figure 2: Anatomy region in slow loris radiography (YIARI, 2019).

A total of 29 pellets were identified from the radiology results from 16 cases were 8 pellets were present in the head region, 2 pellets in the neck region, 4 pellets in the shoulder region, 3 pellets in the forelimb region, 6 pellets in the thorax region, 1 pellet in the abdomen region, 3 pellets in the pelvis region, and 2 pellets in the hindlimb region. Schematically, the locations of the pellets are shown in Figure 3. Most pellets were identified in from the radiology results of individual 012P2022 with a total of 5 pellets lodged in the head, neck, and pelvis regions. Most of the pellets lodged in the shoulder, thorax, and abdomen regions were in the dorsal part of the body.

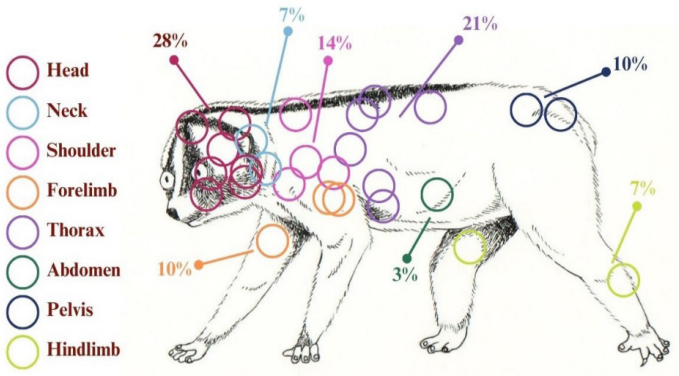

Figure 3: Schematic representation of pellet location findings.

Table 2: Cases of air rifle shootings in slow lorises that have radiography and anatomical pathology reports.

No.	Code name	Species (NJ/NC/NM)	Age (I/J/S/A)	Sex (M/F)	Location	Lesion	Clinical findings	Radiology findings			Treatment	Outcome
								Pellet amount	Pellet location	Fracture		
1.	01A20	NJ	A	F	Bandung	Pellet intact in subcutaneous left forelimb	-	1	Left forelimb	-	Op. and Cons.	Alive
2.	02B20	NJ	A	F	Ciamis	Entry wound in abdomen	Ballistic wound	1	Pelvis	-	-	Alive
3.	03C20	NJ	A	F	Bogor	Pellet intact in subcutaneous right forelimb	-	1	Right forelimb	-	Op. and Cons.	Alive
4.	04E22	NJ	A	F	Bandung Regency	Pellet intact and encapsulated in intramuscular left hemithorax	Swollen axillary lymph nodes	1	Left forelimb	-	-	Dead
5.	05H19	NJ	A	F	Bogor	1 pellet intact in subcutaneous head	-	3	Head and abdomen	-	Op. and Cons.	Alive
6.	06I22	NJ	A	F	West Bandung Regency	-	Broken teeth	1	Head	Fractured teeth	-	Alive
7.	07J20	NJ	A	M	Ciamis	Pellet intact in subcutaneous head	-	1	Head	-	Op. and Cons.	Alive
8.	08K18	NJ	A	F	Ciamis	Pellet intact in subcutaneous left hindlimb	-	1	Left hindlimb	-	Op. and Cons.	Alive
9.	09L18	NJ	A	M	Bandung	1 pellet intact in both subcutaneous head and left hindlimb	-	3	Head, thorax, dan left hindlimb	-	Op. and Cons.	Alive
10.	10M19	NJ	A	M	Majalengka	Entry wound in head (pallatum)	Upper respiratory tract infection (URTI), Abrasion wound in forehead, ballistic wound	2	Head dan left forelimb	-	Op. and Cons.	Dead
11.	11P15	NJ	A	F	Jakarta	Pellet intact in intramuscular left forelimb	-	1	Shoulder	-	-	Dead
12.	12P22	NJ	A	M	Cirebon	1 pellet intact in subcutaneous abdomen	-	5	Neck, thorax, vertebrae, dan pelvis	-	Op. and Cons.	Alive
13.	13R20	NJ	A	M	Cirebon	1 pellet intact in both subcutaneous thorax and right forelimb	-	4	Neck, shoulder, thorax, and right forelimb	-	Op. and Cons.	Alive
14.	14S17	NJ	A	F	Bogor	1 pellet intact in both subcutaneous neck and thorax	-	2	Head dan thorax	-	Op. and Cons.	Alive
15.	15S19	NJ	A	F	Kuningan	Pellet intact in subcutaneous thorax	-	1	Thorax	Fracture vertebrae 8-9	Op. and Cons.	Dead
16.	16S20	NJ	A	M	Cianjur	Pellet intact in subcutaneous head	-	1	Head	-	Op. and Cons.	Alive

NJ: *Nycticebus javanicus*, NC: *Nycticebus coucang*, NM: *Nycticebus menagensis*, I: Infant, J: Juvenile, S: Sub-adult, A: Adult, M: Male, F: Female.

Pellets lodged in dorsal part of the body (back, thigh, or backside) may be a result of the slow loris's body position when sleeping in trees. Slow lorises have a tendency to roll up into a ball-like position covering the front of their head and extremities. This would result in the caudal part of the head and the entire dorsal part be more exposed to pellets from air rifle hunters (Figure 4). The perceptible visualization of the slow loris back can quickly become a shooting target for hunters.

Hunting time may also be a factor influencing the number of pellets found the head region. The nocturnal slow loris possesses a tapetum lucidum, a biologic reflector system common in the eyes of many vertebrates, which functions to enhance visual sensitivity at low light levels (Ollivier *et al*., 2004; Beltran *et al*., 2007). When light is shone in

the eyes of an animal with a tapetum lucidum such as a slow loris, the eyes glow a golden yellow color due to the presence of riboflavin crystals (Pirie, 1959; Beltran *et al*., 2007). These glowing eyes can act as a target for hunters who hunt at night with torches (Figure 5).

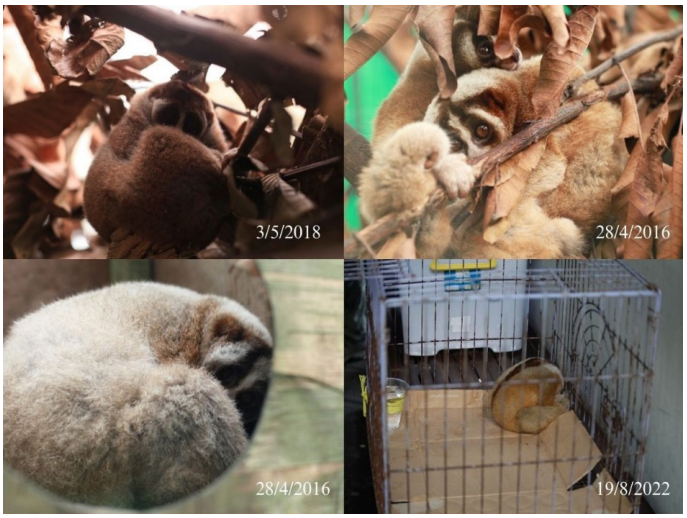

Figure 4: The rounded shape of the slow loris when sleeping (YIARI, 2016; 2018; 2022).

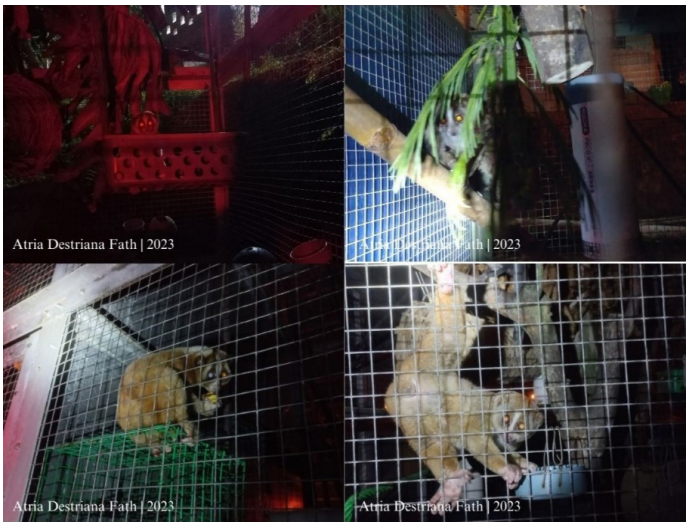

Figure 5: The slow lorises eyes are reflective due to the presence of the tapetum lucidum.

It is hoped that the findings of this study will help aid the Nature Resources Conservation Agency (BKSDA) and other conservation institutions in the conservation of slow lorises, primarily with regards to the identification and medical treatment of air rifle wounds in rescued slow lorises. If a potential air rifle wound, is found in slow loris, it is reasonable to suspect that the animal may have been shot. Further examination, such as a radiological examination, is needed to confirm the pellet's presence and the condition of the body, potentially causing organ damage and fracture.

The slow lorises rescued identified with air rifles wounds during this study originated from several different areas in West Java (Figure 1). Hunting protected animals with air rifles is strictly prohibited and indicates that additional habitat protection and socialization on the legal use of air rifles in these areas is required. Camera traps can also be used for indirect monitoring to expand the monitoring area and increase efficiency. It is hoped that increased patrols and law enforcement will reduce illegal wildlife poaching crimes.

Pathology findings

Pellets that enter the body can remain embedded in various types of tissue, as shown by gross anatomical pathology results in the form of intact pellets in subcutaneous tissue (Figure 6), intact pellets in intramuscular tissue (Figure 6), and entry wounds (Figure 8). Medical records from YIARI show that from 29 pellets identified, 16 could be removed through surgery, with nine being subcutaneous and seven intramuscular. The pellets were taken from 12 individuals with the following codes: 01A20, 03C20, 05H19, 07J20, 08K18, 09L18, 10M19, 12P22, 13R20, 14S17, 15S19, and 16S20.

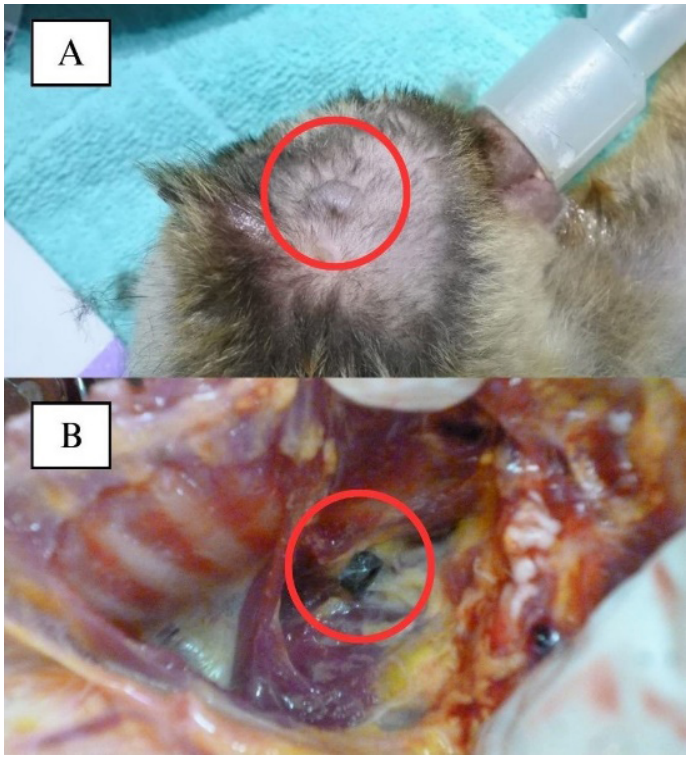

Figure 6: Intact pellet in the subcutaneous part of the head of individual 07J20 (A) and an intramuscularly intact pellet in the left forelimb of individual 11P15 (B) (YIARI, 2015; YIARI, 2022).

The air rifle shoot case in individual 04E22 showed the occurrence of fibrous encapsulation of the pellet (Figure 7). Li and Zreiqat (2019) described the fibrous encapsulation process can occur when foreign objects enter the body as one of the body's defense mechanisms. The healing process will be initiated by monocytes and macrophages

after inflammation occurs, which then enter the stage of granulation tissue formation that originates from the proliferation of fibroblast cells and vascular endothelial cells. Components in granulation tissue, together with multinucleated macrophages (foreign body giant cells), trigger a process called a foreign body reaction. This foreign body reaction process is the initial stage of the fibrous capsule formation process. Fibroblasts will form a vascular and collagenous fibrous capsule surrounding the foreign object. This encapsulation limits interactions between foreign objects that enter the body and the surrounding tissue.

Figure 7: Encapsulated pellet in individual 04E22 (YIARI, 2022).

Figure 8: Entry wound in abdomen individual 02B20 (YIARI, 2020).

Ballistic wound findings were only seen in individual 002B2020 (Figure 8). The wound is round and appears to have healed with the tissue being closed. The small size of the wound makes it difficult to identify the presence of the wound. The time between the shooting and when slow loris entered the rehabilitation center also became a challenge to identify the presence of a ballistic wound because the wound would have been healed in the meantime. The visible wound appears to be an entrance wound because it is circular, indented, and small in diameter (Bradley-Siemens and Brower, 2016). This is also supported by radiographic results in the lateral view, where the pellet is depicted pointing dorsocaudally (Figure 9).

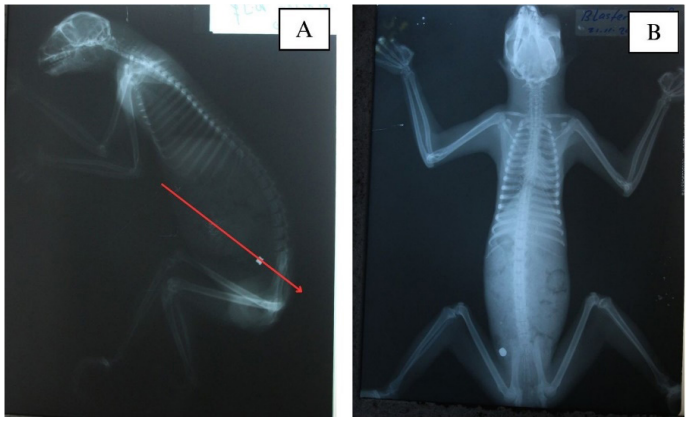

Figure 9: Radiographic results of lateral (A) and dorsoventral (B) views of individual 02B20. It can be seen that the pellet is pointing from the ventral to the dorsocaudal (YIARI, 2020).

Air rifle wounds from air rifles can cause tissue damage and be one of the causes of disease, such as in individual 10M19. The medical record stated that 10M19 experienced symptoms of snoring and had discharge from his nose, which was then diagnosed as upper respiratory tract infections (URTI) due to an air rifle wound with a prognosis of dubious. However, the individuals did not survive. Damage to the palate (Figure 10) can increase the risk of URTI (Thomas and Bomar, 2023). In general, damaged to the palate can makes it easier for pathogens to enter the respiratory system.

Figure 10: Necropsy documentation of head region individual 10M19 (YIARI, 2019).

Treatment

Inspection and palpation were important during initial screening to help assess the patient's condition (Widodo *et al*., 2011). Removal surgery was performed on pellets that were visible on inspection or identified during palpation. Pre- and post-operative X-rays are required (Figure 11). An X-ray was taken before to surgery in order to aid

identify and locate pellets. An X-ray was taken following surgery to help identify any pellets fragments that were still in place. If the pellet is embedded in too-deep, non-palpable tissue, it cannot be extracted.

Figure 11: Radiography image that was taken before (up) and after (down) surgery in individual 09L18.

Figure 12: Surgical removal of a pellet lodged in the subcutaneous left lower extremity of individual 08K18 (YIARI, 2018).

Removal was carried out by making an incision in the area where the pellet was estimated to be present based on inspection and palpation (Figure 12). After that, sutures were performed on the incision area. Medications such as synulox®, metacam®, and tramadol® were then given. Synulox® is a drug containing amoxicillin and clavulanic acid, an antibiotic that prevents post-operative infections and works well as a treatment for skin and soft tissue infections (Plumb and Pharm, 2011). Metacam is a drug that contains meloxicam and is an NSAID (nonsteroidal anti-inflammatory drug) that functions to reduce inflammation and relieve pain (Rivere and Papich, 2017). Tramadol as an analgesic contains Tramadol HCL and is a drug that works in synergy with NSAIDs (Carpenter and Marion, 2018).

Meloxicam and tramadol HCL can be used as pre-emptive analgesics before surgery, potentially reducing nerve pain by reducing IL-6 levels and preventing the release of PGE-2, a mediator in spinal and peripheral sensations (Abass *et al*., 2014). This combination can also reduce hyperalgesia, an increased sensitivity to pain. A study by Teixeira *et al*. (2013) found that dogs given meloxicam in combination with tramadol showed an earlier decrease in postoperative pain scores compared to tramadol alone or with dipyrone. However, further research is needed regarding the appropriate dosage and effectiveness of the combination in primates. The importance of combining these two drugs also needs to be considered, considering the study by Teixeira *et al*. (2013), which also showed that using tramadol only at intervals of 8 hours after surgery effectively controlled pain during the initial 24 hours.

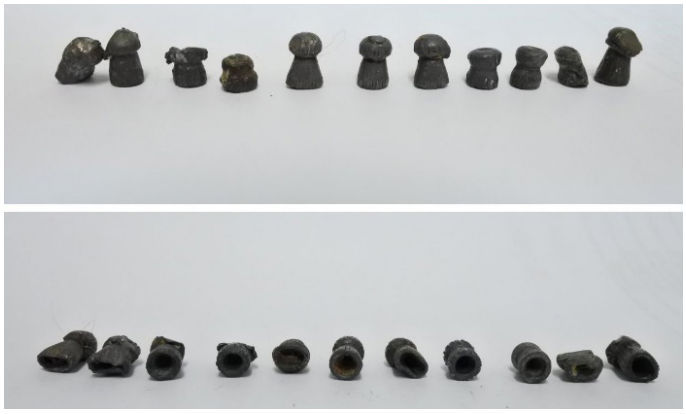

Figure 13: Some pellets were removed through surgery and stored in the medical record file (YIARI, 2018).

The pellets that were taken out during operation are generally already deformed. This is because pellets made from lead (Pb) are soft and easy to shape so that when a pellet collides with the body, the pellet will experience deformation due to the transfer of kinetic energy from the projectile to body tissue (Coupland, 1999; Kerkhoff *et al*., 2019). Based on the pellets that were taken and recorded in the medical record, all of the pellets were identified as diablo pellets with a size of 0.177 (4.5 mm), which are better known to the local people in Indonesia as peluru mimis (Figure 13).

Based on the Republic of Indonesia State Police Regulation Number 1 of 2022 concerning Licensing, Supervision and Control of Firearms in articles 13 and 102, it is stated that air rifles are considered to be security equipment, and are classified as non-organic police/TNI firearms used to carry out the duties of the police, PPNS, security guards and police officers, sports and martial arts. Ownership of these weapons by the general public is used for sporting purposes under the supervision of Indonesian Shooting Association (Perbakin). Article 76 further explains that holders of firearms for sporting purposes are prohibited from using or firing firearms outside training, competition, and hunting locations. The permits and obligations of air rifle owners are explained in articles 142 to 150.

The owner of an air rifle must meet the requirements regarding skills, physical health, and psychological health. The many conditions that must be met in these regulations should make it difficult for the public to obtain and use air rifles. The free use of air rifles for hunting wild animals shows that law enforcement still needs to be stricter in regulating the sale and ownership of air rifles. Possession of illegal firearms can be subject to criminal sanctions following Article 1 paragraph (1) of Emergency Law No. 12 of 1951 with the threat of a maximum temporary prison sentence of 20 years, life imprisonment, or death penalty. Criminal provisions for hunting protected wild animals are also outlined in Article 40 of Law No. 5 of 1990. The existence of regulations that emphasize the ownership, use, and prohibitions on hunting of protected wild animals should be the basis for law enforcement by law enforcement agencies.

CONCLUSIONS AND RECOMMENDATIONS

The increase of slow lorises hunted using air rifles has contributed to decreased population numbers in the wild. A total of 51 individual cases involving shooting incidents were documented by Yayasan Inisiasi Alam Rehabilitasi Indonesia (YIARI) from 2015 to 2022. Sixteen individual cases of air rifle shot to slow lorises were accompanied with radiology results and anatomical gross pathology examination. A total of 28 pellets were identified, with most of the pellets were found in the head region (28%), meanwhile in the other regions: the neck (7%), the shoulder (14%), the forelimb (10%), the thorax (21%), the abdomen (3%), the pelvis (10%), and the hindlimb (7%). Apart from that, the pathological findings from air rifle wounds were found to be intact pellets in subcutaneous, intact pellets in intramuscular, entry wounds, and encapsulated pellets. Treatment that can be carried out to treat slow lorises are removal surgery and conservative management using medication.

Even though air rifle pellet wounds or retention pellets inside slow lorises body mostly did not show significant health problems, concern about their welfare needs action from the government and rehabilitation centers. The government and law enforcement officials, especially the Directorate General of Environmental and Forestry Law Enforcement and local governments, should improve habitat protection. Strict action must be taken against the sale and ownership of air rifles by legal authorities because, currently, people appear to be freely using air rifles to hunt wild animals. Law enforcement agencies must also carry out criminal action against poachers to provide a deterrent effect.

ACKNOWLEDGEMENT

We would like to thank Universitas Padjadjaran through Undergraduate Program and Yayasan Inisiasi Alam Rehabilitasi Indonesia (YIARI) that have support this research. We also would like to thank Richard Moore (Yayasan Inisiasi Alam Rehabilitasi Indonesia (YIARI), Bogor) for assistance in writing and comments on the manuscript.

NOVELTY STATEMENT

The author has researched the clinical evaluation and pathological findings in slow lorises with gunshot wounds for the development of standard operational procedures for wildlife protection in Indonesia. This study is published for the first time.

AUTHOR'S CONTRIBUTION

HF, AF, and SK concept the research. HF conducted the research under supervision. WP, NPP, IS, IA, AF, SK and HF wrote the manuscript. SK, AF, WP, NPP, proofread. All authors discussed the results and contributed to the final manuscript. All authors approved for submitting.

Ethic approval

This study's ethical clearance was approved by the research ethics committee in the Faculty of Medicine, Padjadjaran University, Indonesia. The clearance number was: 1053/UN6.KEP/EC/2023. This study was conducted from July until August 2023 at Yayasan Inisiasi Alam Rehabilitasi Indonesia (YIARI), Bogor. A permit to carry out research has been issued by YIARI the with number l20/YIARI-BGR/VII/2023.

Data availability

The data set use to support the findings of this study are included within the article.

Conflict of interest

The authors have declared no conflict of interest.

REFERENCES

Abass M, Mosbah E, Rizk A, Karrouf G, Zaghloul A (2014). Synergistic efficacy of tramadol and meloxicam on alleviation of pain and selected immunological variables after sciatic nerve ligation in rats. Int. J. Vet. Sci. Med., 2(1): 14–20. https://doi.org/10.1016/j.ijvsm.2013.12.004

Beltran WA, Vanore M, Ollivet F, Nemoz-Bertholet F, Aujard F, Clerc B, Chahory S (2007). Ocular findings in two colonies of gray mouse lemurs (*Microcebus murinus*). Vet. Ophthalmol., 10(1): 43–49. https://doi.org/10.1111/j.1463-5224.2007.00491.x

Bradley-Siemens N, Brower AI, Kagan R (2018). Firearms injuries. In: Brooks J.W. (ed.). Vet. Forensic Pathol., 1. Springer; January, pp 107-127. https://doi.org/10.1007/978-3-319-67172-7_7

Bradley-Siemens N, Brower AI (2016). Veterinary forensics: Firearms and investigation of projectile injury. Vet. Pathol., 3(5): 988–1000. SAGE Publications Inc. https://doi.org/10.1177/0300985816653170

Carpenter JW, Marion CJ (2018). Exotic animal formulary, 5th ed. Missouri: Elsevier.

Casteleyn C, Gram C, Bakker J (2023a). Topographical anatomy of the rhesus monkey (*Macaca mulatta*) Part I: Thoracic Limb. *Vet. Sci.*, 10(2): 164. https://doi.org/10.3390/vetsci10020164

Casteleyn C, Robin N, Bakker J (2023b). Topographical anatomy of the rhesus monkey (*Macaca mulatta*) Part II: Pelvic Limb. *Vet. Sci.*, 10(3): 172. https://doi.org/10.3390/vetsci10030172

Čižmářová L, Příbrský F, Holubová K (2022). Rescue centres. In: Byczyk, K., Dunn, N., Příbrský, F., Tang, C. (Eds): EAZA Best Practice Guidelines for the slow loris (*Nycticebus*) species (1st ed.). European Association of Zoos and Aquaria, Netherlands. pp. 116-123.

Coupland R (1999). Clinical and legal significance of fragmentation of bullets in relation to size of wounds: retrospective analysis. Br. Med. J., 319(7207): 403–406. https://doi.org/10.1136/bmj.319.7207.403

Diogo R, Molnar JL, Smith TD (2014). The anatomy and ontogeny of the head, neck, pectoral, and upper limb muscles of *Lemur catta* and *Propithecus coquereli* (Primates): Discussion on the parallelism between ontogeny and phylogeny and implications for evolutionary and developmental biology. Anatom. Rec., 297(8): 1435–1453. https://doi.org/10.1002/ar.22931

Diogo R, Molnar JL, Rolian C, Esteve-Altava B (2018). First anatomical network analysis of fore- and hindlimb musculoskeletal modularity in bonobos, common chimpanzees, and humans. Sci. Rep., 8: 6885. https://doi.org/10.1038/s41598-018-25262-6

Indonesian Government (1951). Undang-undang darurat republik Indonesia Nomor 12 Tahun 1951 tentang Mengubah Ordonnantie Tijdelijke Bijzondere Strafbepalingen (Stbl. 1948 No.17) dan Undang-Undang R.I. Dahulu No 8 Tahun 1948

Indonesian Government (1990). Undang Undang Nomor 5 Tahun 1990 tentang Konservasi Sumber Daya Alam dan Ekosistemnya. Jakarta.

Indonesian National Police (2022). Peraturan Kepolisian Negara Republik Indonesia Nomor 1 Tahun 2022 Tentang Perizinan, Pengawasan dan Pengendalian Senjata Api Standar Kepolisian Negara Republik Indonesia, Senjata Api Non Organik Kepolisian Negara Republik Indonesia/ Tentara Nasional Indonesia, dan Peralatan Keamanan yang Digolongkan Senjata Api.

Kerkhoff W, Mattijssen EJAT, Zwanenburg EA, Oostra RJ (2019). Relationship between bullet diameter and bullet defect diameter in human calvariums. Int. J. Legal Med., 134(1): 267–272. https://doi.org/10.1007/s00414-019-02197-9

Li JJ, Zreiqat H (2019). Tissue response to biomaterials. Encycl. Biomed. Eng., pp. 270-277. https://doi.org/10.1016/B978-0-12-801238-3.99880-5

Miard P, Nekaris KAI, Ramlee H (2017). Hiding in the dark: Local ecological knowledge about slow loris in Sarawak sheds light on relationships between human populations and wild animals. Hum. Ecol., 45(6): 823–831. https://doi.org/10.1007/s10745-017-9954-x

Ministry of Environment and Forestry (2018). Peraturan Menteri Lingkungan Hidup dan Kehutanan Republik Indonesia nomor P.106/MENLHK/SETJEN/KUM.1/12/2018 tentang Jenis Tumbuhan dan Satwa Yang Dilindungi. Jakarta.

Munds RA, Collins R, Nijman V, Nekaris KAI (2008). Abundance estimates of three slow loris taxa in Sumatra (*N. coucang*), Java (*N. javanicus*) and Borneo (*N. menagensis*). Int. J. Primatol., 96: 902.

Nekaris KAI, Campbell N, Coggins TG, Rode EJ, Nijman V (2013). Tickled to Death: Analysing Public Perceptions of 'Cute' Videos of Threatened Species (Slow Lorises – *Nycticebus* spp.) on Web 2.0 Sites. PLoS One, 8(7): e69215. https://doi.org/10.1371/journal.pone.0069215

Nekaris KAI, Miard P, Streicher U (2020a). *Nycticebus menagensis*. The IUCN Red List of Threatened Species 2020: e.T163013860A17970781. Accessed on 5 May 2023.

Nekaris KAI, Nijman V (2007). CITES proposal highlights threat to nocturnal primates nycticebus: Lorisidae. J. Folia Primatol., 78: 211-214. https://doi.org/10.1159/000102316

Nekaris KAI, Nijman V (2019). Javan slow loris *Nycticebus javanicus* (É. Geoffroy Saint-Hilaire, 1812). In: C. Schwitzer, R.A. Mittermeier, A.B. Rylands, F. Chiozza, E.A. Williamson, D. Byler, S. Wich, T. Humle, C. Johnson, H. Mynott and G. McCabe (eds.). Primates in Peril: The World's 25 Most Endangered Primates 2018–2020. IUCN SSC Primate Specialist Group, International Primatological Society, Global Wildlife Conservation, and Bristol Zoological Society, Washington, DC, pp. 52-55.

Nekaris KAI, Pambudi JAA, Susanto D, Ahmad RD, Nijman V (2014). Densities, distribution and detectability of a small nocturnal primate (Javan slow loris *Nycticebus javanicus*) in a montane rainforest. Endanger. Species Res., 24: 95–103. https://doi.org/10.3354/esr00585

Nekaris KAI, Poindexter S, Reinhardt KD, Sigaud M, Cabana F, Wirdateti W, Nijman V (2017). Coexistence between Javan slow lorises (*Nycticebus javanicus*) and humans in a dynamic agroforestry landscape in WestJava, Indonesia. Int. J. Primatol., 38: 303–320. https://doi.org/10.1007/s10764-017-9960-2

Nekaris KAI, Poindexter S, Streicher U (2020b). *Nycticebus coucang*. The IUCN Red List of Threatened Species 2020: e.T163017685A17970966. Accessed on 5 May 2023.

Nekaris KAI, Shekelle M, Wirdateti, Rode-Margono EJ, Nijman V (2020c). *Nycticebus javanicus* (errata version published in 2021). The IUCN Red List of Threatened Species 2020: e.T39761A205911512. Accessed on 5 May 2023.

Nekaris KAI, Starr C (2015). Overview: Conservation and ecology of the neglected slow loris: Priorities and prospects. Endanger. Species Res., 28(1): 87–95. https://doi.org/10.3354/esr00674

Nijman V, Spaan D, Rode-Margono E, Wirdateti J, Nekaris KAI (2017). Changes in the primate trade in Indonesian wildlife markets over a 25-year period: Fewer apes and langurs, more macaques, and slow lorises. Am. J. Primatol., 79: e22517. https://doi.org/10.1002/ajp.22517

Ollivier FJ, Samuelson DA, Brooks DE, Lewis PA, Kallberg ME, Komaromy AM (2004). Comparative morphology of the tapetum lucidum (among selected species). Vet. Ophthalmol., 7(1): 11–22. https://doi.org/10.1111/j.1463-5224.2004.00318.x

Permana S, Partasasmita R, Iskandar J, Rohmatullayaly EN, Iskandar BS, Malone N (2020). Traditional conservation and human-primate conflict in Ujungjaya village community, Ujung Kulon, Banten, Indonesia. Biodiversitas, 21: 521-529. https://doi.org/10.13057/biodiv/d210213

Pirie A (1959). Crystals of riboflavin making up the tapetum lucidum in the eye of a lemur. Nature, 183, pp. 985–986.

Plumb DC, Pharm D (2011). Veterinary Drug Handbook, 7th ed. Wisconsin: PharmaVet Inc.

Prameswari W, Priambada NP, Llano K (2019). Case report slow loris and air rifle shot in IAR Indonesia since 2015-2018. Proceedings of the 11th International Conference of Asian Society of Conservation Medicine, Bali, Indonesia.

Rivere JE, Papich MG (2017). Veterinary pharmacology and therapeutics, 10th ed. USA: John Wiley and Sons.

Shrestha R, Kanchan T, Krishan K (2022). Gunshot wounds forensic pathology. In: Stat Pearls. StatPearls Publishing.

Stefanopoulos PK, Pinialidis DE, Hadjigeorgiou GF, Filippakis KN (2017). Wound ballistics 101: the mechanisms of soft tissue wounding by bullets. Eur. J. Trauma Emerg. Surg. Off. Publ. Eur. Trauma Soc., 43(5): 579–586. https://doi.org/10.1007/s00068-015-0581-1

Tanrisever M, Karabulut E, Canpolat I (2017). The clinical and radiological evaluation of firearm injuries in dogs. IOSR J. Agric. Vet. Sci., 10: 58-62. https://doi.org/10.9790/2380-1004015862

Teixeira RC, Monteiro ER, Campagnol D, Coelho K, Bressan TF, Monteiro BS (2013). Effects of tramadol alone, in combination with meloxicam or dipyrone, on postoperative pain and the analgesic requirement in dogs undergoing unilateral mastectomy with or without ovariohysterectomy. Vet. Anaesth. Analg., 40(6): 641–649. https://doi.org/10.1111/vaa.12080

Temmam S, Davoust B, Chaber AL, Lignereux Y, Michelle C, Monteil-Bouchard S, Raoult D, Desnues C (2017). Screening for viral pathogens in African simian bushmeat seized at a French airport. Transbound. Emerg. Dis., 64(4): 1159–1167. https://doi.org/10.1111/tbed.12481

Thomas M, Bomar PA (2023). Upper respiratory tract infection. In: StatPearls. StatPearls Publishing.

Uprety Y, Chettri N, Dhakal M, Asselin H, Chand R, Chaudhary RP (2021). Illegal wildlife trade is threatening conservation in the transboundary landscape of Western Himalaya. J. Nat. Conserv., pp. 125952. https://doi.org/10.1016/j.jnc.2020.125952

Widiana A, Sulaeman S, Kinasih I (2013). Studi Populasi Dan Distribusi Kukang Jawa (*Nycticebus Javanicus*, E. Geoffroy, 1812) di Talun Desa Sindulang Kecamatan Cimanggung Sumedang Jawa Barat. J. Istek, 7(1).

Widodo S, Sajuthi D, Choliq C, Wijaya A, Wulansari R, Lelana RPA (2011). Diagnostik klinik hewan kecil. Bogor: IPB Press.

Winarti I (2008). Field research on Javan slow loris' population in Sukakerta Ciamis and Kawungsari Tasikmalaya, West Java, Indonesia. Report to IAR Indonesia. Ciapus, Bogor, Indonesia, pp. 7.

Yayasan Inisiasi Alam Rehabilitasi Indonesia (2017). Kukang dan Tantangan Konservasinya - Yayasan IAR Indonesia. Available at: https://www.internationalanimalrescue.or.id/kukang-dan-tantangan-konservasinya. Accessed 4 May 2023.