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Case Report

Unusual case of automutilation in a free-ranging grey wolf (*Canis lupus*)

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ABSTRACT

In Germany, all information about the Central European Lowland Wolf population is aggregated by the Federal Documentation and Consultation Centre on Wolves (DBBW). The dataset on wolves found dead was an important source of supplementary information for this study in particular. In January 2020, our examination of a wolf cadaver revealed a vertebral fracture that caused a complete severance of the spinal cord. Furthermore, the presence of a canid claw in the stomach of the specimen indicated that we encountered a rare case of automutilation in a wild animal, which was subsequently confirmed when the genetic analysis determined that the claw belonged to the examined wolf.

1. Introduction

The grey wolf (*Canis lupus*) was extinct in Germany for approximately 150 years and has been returning since the late 1990s as a result of the animal's strict protection status [16]. Since then, the species has continued to expand its range in Germany; in the monitoring year 2018/2019, 105 wolf packs, 40 pairs of wolves and 11 resident individuals were documented by the Federal Documentation and Consultation Centre on Wolves [6]. The agreement of all federal states on the standardized handling of reference data in 2009 laid the foundation for the nationwide monitoring of the wolf population. Since 2006 a standardized examination scheme of dead wolves has been utilized by the Leibniz Institute for Zoo and Wildlife Research (IZW) in Berlin.

In January 2020, a male wolf from Lower Saxony was sent to the IZW. The animal was found dead approximately 300 m away from the nearest road. A traffic accident was suspected as the cause of death; however an illegal killing could not be excluded either. During necropsy, we found the toe of a canid in its stomach, which phenotypically matched the wolf itself. At the hind limbs a total of four toes were missing, which suggested a case of automutilation.

Automutilation is a known problem amongst wild animals kept in human captivity and is generally attributed as a symptom of a captivity-related behavioral disorder [10]. However, in free-ranging animals there are only a few documented cases. The self-injuring behavior may have several causes:

In Lahore, Pakistan, automutilation was observed in African lions at both, single and group enclosures. According to the authors, the frequency of this behavior was reduced with increasing availability of space as well as increasing quality of enclosure equipment [10].

Some of the described causes of self-injurious behavior in pets, especially dogs, are generally conceivable for wild animals like the wolf: In the context of a viral infection with rabies or pseudo-rabies, behavior such as biting, intensive licking or rubbing occurs [15]. Furthermore, the infestation with ectoparasites such as lice [14] or allergic reactions to flea saliva can lead to licking, rubbing and finally to injuries as well [3].

Sensory polyneuropathies are known to be a hereditary cause of automutilation in various breeds of dogs, whereas the affected animals intensively lick and gnaw on their distal limbs, resulting in extensive wounds and possibly autoamputations [5].

Moreover, automutilation has been observed acutely in cases of trauma-induced paresis or paralysis [11], and it has also been described as a long-term complication following disc prolapse surgery [1].

In summary, there are various infectious, traumatic, hereditary and psychogenic causes for automutilation in animals. Here, we present a rare case of automutilation in a free-ranging wolf. Based on this case, we

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show the comprehensive pathological methods, which are standardly used within the framework of the German wolf monitoring program for all wolves found dead, to receive information about the population's health status.

2. Methods

The methods, used to illuminate the circumstances of this suspected automutilation followed the standard concept and examination procedures of the German program for monitoring of dead found wolves.

2.1. Computed tomography

The initial investigation of the submitted wolf comprised a screening for fractures and other pathologies, detection of projectile particles as well as age determination using computed tomography (CT) scanning (Appendix A).

2.2. Necropsy

In a second step, necropsy was performed. To this end, the carcass of the wolf was measured, dissected and all organs macroscopically examined. Any phenotypic characteristics as well as pathological gross lesions observed at necropsy were documented in detail in a descriptive written report and by taking high-quality photographs.

During the necropsy, we took representative samples of all internal organs, which were fixed in 4% buffered formalin. All endo- and ectoparasites were transferred into 70 % ethanol. Samples of all organs, hair, bones, muscles, feces, stomach contents, bile, urine and blood were frozen at – 80 °C until further processing.

2.3. Further investigations

For histological examination, the formalin-fixed organ samples were routinely processed as described (Appendix B).

In the Senckenberg Research Station Gelnhausen, muscle tissue samples obtained during necropsy of all dead wolves were genetically examined using standardised protocols for genetic identification and characterisation essentially as described. In the case of suspected automutilation, the canine claw from the stomach was cleaned externally and additionally analysed (Appendix C).

Besides, the wolf was subject of routine testing for the rabies virus (RABV) [4], Canine distemper virus, Aujeszky's disease virus (ADV, Suid herpesvirus 1) [19], Canines adenoviruses 1 and 2, Hepatitis E virus, Dirofilaria *sp.*, *Trichinella spp.* and resistant *Escherichia coli* by various cooperating partners.

3. Results

3.1. Computed tomography

We found an oblique fracture completely through the vertebral body of the 6th lumbar vertebra with dorsoventral offset of the caudal fragment accompanied by a completely severed spinal cord. On the right hind limb, the digit II, III and IV were missing the claws, phalanges distales, phalanges media in whole or in part as well as the associated pads. On the left hind limb the claw, phalanx distalis and media and pads of digit II were missing. The right elbow joint was a completely mineralized callus. Within the callus, we found numerous metal dense particles (Appendix A).

3.2. Necropsy

Macroscopic examination revealed that the carcass was already autolytic; the winter coat was extremely wet and polluted with sand.

Presence of permanent teeth with signs of abrasion as well as mature testicles were clear signs that the animal was an adult wolf. The animal was in a good nutritional condition.

The entire left eye, the inner structures of the right eye, parts of the tongue, anus, rectum, the largest part of the colon, prostate, bladder as well as parts of the pelvic muscles were missing. We found no bleeding in these areas, but irregular blurred edges of the surfaces.

The absence of parts of the toes was confirmed during the necropsy as previously described in the computed tomography results. The remaining bone stumps showed score marks.

The right elbow joint was altered by a massive arthritis and callus formation, causing a complete stiffening of the joint. A single metal splinter of ammunition was isolated from the medial side of the joint. The muscles of the right front limb were slightly atrophic, and the right paw was smaller in length and width compared to the left. The hair underneath the right front paw was severely elongated.

In the thoracic cavity, we found approximately 100 mL of partially coagulated blood. The lungs showed moderate acute bleeding. The *Lobus quadratus hepatis* was completely separated from the rest of the liver, and it was laid together with the gallbladder cranial of the diaphragm in the thorax. Since we discovered a small tear in the esophageal hiatus and no evidence of a rupted diaphragm, the liver lobe likely entered the thoracic cavity through the hiatus.

The stomach content weighed 104 g, and it mainly consisted of hair and plant parts. From the stomach, we isolated the claw with phalanx distalis and media as well as the corresponding pad (Fig. 1).

3.3. Further investigations

The genetic examination of muscle and toe samples of the wolf showed a 100 % sequence identity and confirmed that the toe in the stomach originated from the wolf itself.

Reconciliation of the genetic data with our database as well as with the genetic database of the German wolf monitoring program, identified the examined wolf as 'GW421m'. Since 2016, the animal had previously lived reproductively active as the breeding male of the wolf pack 'Visselhövede' in Lower Saxony, where he was first recorded and genetically identified in May 2015. 'GW421m' was born between 2012 and 2014 in the 'Klepzig' wolf pack in Brandenburg. Thus, the genetic analyses confirmed the adult status of the wolf.

Tests on canine distemper, rabies and pseudorabies were negative, and histologically there was no sign of inflammation in the brain.

4. Discussion

The discovery of the toe in the wolf's own stomach is the first documented case of automutilation in a free-ranging wolf in Germany.

In the monitoring year 2019/2020, 126 wolves were found dead. 11

Fig. 1. The toe of a canid taken from the wolf's stomach.

of them were killed illegally, and seven showed old non-lethal gunshot wounds [8].

In this case, the callus around the bullet particles on the right elbow was completely mineralized, which implies that the injury must have taken place at least three months before the eventual death.

It is highly probable that the wolf died because of blunt trauma, consistent with a traffic accident, which is suggested by the ruptured liver lobe, the vertebral fracture and the bleedings in the lung. Likely, the ultimate cause of death was a shock and cardiovascular failure due to blood loss. Before succumbing to his death, the wolf managed to move 300 m away from the accident site and appears to have severed and consumed its own toe.

Although there are reports of infections with distemper, rabies [13] and pseudorabies in wolves [2], we did not find any histological evidence of encephalopathy. Because laboratory testing did not detect any pathogen related viral antigen, RNA or DNA, we excluded these infections as the primary cause for the observed automutilation. Besides, an infestation with ectoparasites could not be detected at the time of the examination. Ticks and fleas leave the host with the onset of *algor mortis*. However, we found no evidence for general dermatopathy, chafing and licking of the entire carcass including the remaining toes. Those would be expected in case of a generalized ectoparasite infestation [14] or an allergic reaction [9]. The presence of dysesthesias due to a hereditary polyneuropathy could not be excluded entirely, but the intactness of the remaining paws in this case, the good nutritional condition and the absence of general chronic muscle atrophy contradicts a hereditary polyneuropathy as an explanation for the automutilation.

The possibility that the wolf began to consume his paws due to hunger cannot be excluded either; it is likely that the wolf did not feel deep pain in its hind limbs anymore, and was unable to hunt due to its paralysis [20]. As not every hunt is successful, wolves are able to cope with not eating daily. The wounds of the hind limb showed blurred edges while the visible bone fragments showed small score marks, which are suspected to be tooth scratches. Also, there were no signs of scar formation or tendencies of healing. Nevertheless, the fact that we found only one of the five gnawed off toes in the digestive tract as well as the good nutritional condition of the animal points against this hypothesis.

A common cause of automutilation in wild animals cared for by humans is psychogenic disorder. Under unfavourable housing conditions, inadequate behavioural and foraging enrichments and missing anticipatory activity, both boredom and stress are known to induce stereotypical behaviour [17]. Such stereotypes occur less frequently in more semi-natural enclosures, as it has been shown in big cats [18]. Therefore, a psychogenic cause for automutilation in free-ranging animals is considered highly unlikely.

The other missing toes could not be found. Possible explanations are that the toes were separated during the accident or the wolf had bitten them off at a different place and/or digested them. Also, the toes might have been removed by scavengers before. It is unlikely that a wild boar or fox, for example, could have bitten off the toes after the wolf's death in the same way the wolf did. However, dental marks were only detected clear on the bone stumps. The absence of the eyes and organs of pelvic region instead of missing parts of the entire carcass is more in accordance with scavenging birds than with mammals.

In our opinion, the automutilation is comparable to the cases from the study by Aikawa et al., 2012 [1], in which several dogs with high-grade neurological dysfunctions after surgical treatment of disc prolapse began to gnaw and mutilate their hind limbs, tails or genitals. The authors cite Shermann et al. [17] as a possible explanation for their cases, who suggested that automutilation occurs in animals with an insensibility or paraesthesia as well as in bored or stressed animals. In regard to this wolf, a psychogenic cause of the automutilation by this stress situation can only be speculated. The fact that it suffered from paraesthesia and paraplegia due to the spinal cord dissection and therefore dysfunction of the lumbosacral plexus cannot be denied.

Aside from the cause of death and the last hours of the wolf's life, we received information about the general health condition of this wolf. Combined with the data from all necropsies and further investigations, we obtain an overview of the population's health status, parasite infestations [12] and viral infections [7]. Despite its injured fore limb due to shooting, the wolf was in a good nutritional condition. It showed no conspicuous behaviour in the neighbourhood of human settlements. Both facts indicate either a sufficient food supply by its pack or a persisting own hunting success regardless of its former gunshot injury.

This necropsy in combination with the results from the monitoring project reveals useful information about the life and death of wolves in Germany. It is an excellent example of how the lives of individual wolves can be randomly endangered by humans, but also how they can be intentionally influenced at times.

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Declaration of Competing Interest

The authors report no declarations of interest.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.fsiae.2021.100019.

References

[1] T. Aikawa, H. Fujita, S. Kanazono, M. Shibata, Long-term neurologic outcome of hemilaminectomy and disk fenestration for treatment of dogs with thoracolumbar intervertebral disk herniation: 831 cases (2000–2007), J. Am. Vet. Med. Assoc. 241 (2012) 1617–1626, https://doi.org/10.2460/javma.241.12.1617.

[2] M.G. Amoroso, D. Di Concilio, N. D'Alessio, V. Veneziano, G. Galiero, G. Fusco, Canine parvovirus and pseudorabies virus coinfection as a cause of death in a wolf (Canis lupus) from southern Italy, Vet. Med. Sci. 3 (2020) 600–605, https://doi.org/10.1002/vms3.270. Epub 2020 April 16.

[3] D.N. Carlotti, D.E. Jacobs, Therapy, control and prevention of flea allergy dermatitis in dogs and cats, Vet. Dermatol. 11 (2000) 83–98, https://doi.org/10.1046/j.1365-3164.2000.00204.x.

[4] D.J. Dean, M.K. Abelseth, P. Athanasiu, The fluorescence antibody test, in: F. X. Meslin, M.M. Kaplan, H. Koprowski (Eds.), Laboratory Techniques in Rabies, 4th edition, World Health Organization, Geneva, 1996, pp. 88–93.

[5] C.W. Dewey, R.C. da Costa, Practical Guide to Canine and Feline Neurology, 3rd edition, Wiley Blackwell, Iowa, 2015, pp. 454–455.

[6] DBBW Federal Documentation and Consultation Centre on Wolves, Görlitz, 2020. https://www.dbb-wolf.de/Wolfsvorkommen/territorien/karte-der-territorien (accessed 15 June 2020).

[7] B. Ehlers, A.E. Anoh, N.B. Salem, S. Broll, E. Couacy-Hymann, D. Fischer, A. Gedvilaite, N. Ingenhütt, S. Liebmann, M. Martin, A. Mossoun, L. Mugisha, J. J. Muyembe-Tamfum, M. Pauly, B. Pérez de Val, H. Preugschas, D. Richter, G. Schubert, C.A. Szentiks, T. Teichmann, C. Walter, R.G. Ulrich, L. Wiersma, F. H. Leendertz, S. Calvignac-Spencer, Novel polyomaviruses in mammals from multiple orders and reassessment of polyomavirus evolution and taxonomy, Viruses 11 (2019) 930, https://doi.org/10.3390/v11100930.

[8] Federal Agency for Nature Conservation, 2020. press release. Available from https://www.bfn.de/presse/pressemitteilung.html (accessed 15 November 2020).

[9] C. Griffin, B. Deboer, The ACVD task force on canine atopic dermatitis (XIV): clinical manifestations of canineatopic dermatitis, Vet. Immunol. Immunopathol. 81 (2001) 255–269, https://doi.org/10.1016/S0165-2427(01)00346-4.

[10] B.N. Khan, R. Ahmad, Z. Ali, S. Mehmood, H. Raza, M. Azhar, A. Zakir, Impact of different captive environmental conditions on behavior of african lions and their welfare at lahore zoo and safari zoo, Lahore, Pakistan J. Zool. 50 (2018) 523–531, https://doi.org/10.17582/journal.pjz/2018.50.2.523.531.

[11] B. Kohn, G. Schwarz, Praktikum der Hundeklinik, 12th edition, Ferdinand Enke, Stuttgart, 2017, pp. 1080–1081.

[12] I. Lesniak, I. Heckmann, M. Franz, A.D. Greenwood, E. Heitlinger, H. Hofer, O. Krone, Recolonizing gray wolves increase parasite infection risk in their prey, Ecol. Evol. 8 (2018) 2160–2170, https://doi.org/10.1002/ece3.3839.

[13] J. Marino, C. Sillero-Zubiri, A. Deressa, E. Bedin, A. Bitewa, F. Lema, G. Rskay, A. Banyard, A.R. Fooks, Rabies and distemper outbreaks in smallest ethiopian wolf population, Emerg. Infect. Dis. 12 (2017) 2102–2104, https://doi.org/10.3201/eid2312.170893.

[14] M.D. McGavin, J.F. Zachary, Pathologie der Haustiere, 1st edition, Urban & Fischer, München, 2009, p. 1076.

[15] K. Nieberle, P. Cohrs, Lehrbuch der speziellen pathologischen Anatomie der Haustiere, 4th edition, VEB Gustav Fischer, Jena, 1961, p. 631.

[16] I. Reinhardt, G. Kluth, Leben mit Wölfen. Leitfaden für den Umgang mit einer konfliktträchtigen Tierart in Deutschland, BfN Skripten 201 (2007) 1–180.

[17] J. Sherman, N. Olby, Nursing and rehabilitation of the neurological patient, in: BSAVA Manual of Canina and Feline Neurology, Volume 3, 2004, pp. 394–407.

[18] J. Vaz J, E.J. Narayan, R.D. Kumar, K. Thenmozhi, K. Thiyagesan, N. Baskaran, Prevalence and determinants of stereotypic behaviours and physiological stress among tigers and leopards in Indian zoos, PLoS One 12 (4) (2017), e0174711, https://doi.org/10.1371/journal.pone.0174711.

[19] K. Wernike, M. Beer, C.M. Freuling, B. Klupp, T.C. Mettenleiter, T. Muller, B. Hoffmann, Molecular double-check strategy for the identification and characterization of Suid herpesvirus 1, J. Virol. Methods 209 (2014) 110–115, https://doi.org/10.1016/j.jviromet.2014.08.022.

[20] J.F. Zachary, Nervous system, in: M.D. McGavin, J.F. Zachary (Eds.), Pathologc Basis of Veterinary Disease, 4th edition, Mosby Elsevier, 2007, pp. 833–971.