**Anomalies and pathological changes of skulls and dentition of wild small mammal species from Germany**

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**Abstract.** Skulls, jaws and teeth of wild terrestrial small mammals (Sciuridae, Soricidae, Erinaceidae, Talpidae, Gliridae, Arvicolidae, Muridae) are occasionally affected by anomalies and pathologies. The present study documents a total of 362 anomalies and 122 pathological changes across 20 different species. These are all based on data published in Germany, supplemented by our own records. Cases were classified into 14 different categories, according to bone and dental anomalies, fractures and inclusions, bone proliferation, dental disease and extreme wear of teeth. An additional category to specifically account for bone proliferation of the skull was not needed, but such findings are to be expected. The most frequent finding was abnormal tooth growth, particularly the elongation of the upper incisors. In individual cases, there was evidence that small mammals are able to recover even from serious injuries to the skull.

**Key words:** anomaly, pathology, skull, teeth

**Introduction**

Intra-specific morphological diversity comprises a normal range of phenotypic variability, but also includes marked deviations from this norm. These deviations can be attributed to pathological changes, anomalies, and the effects of disease and are a feature of all species. Despite their ubiquity, there are no uniform scientific rules for the concepts of abnormality and malformation of phenotypic traits; on the one hand, these constitute flexible transitions, and on the other, represent characteristics that are part of normal variation in one population but potentially constituting an anomaly in another (Miles & Grigson 1990). From this perspective, it is important to give recognition to such pathological anomalies and disease, and also to understand them as part of natural phenotypic variation.

Pathologies and abnormal structures are common in the animal kingdom and, in wild and domestic animals, may also affect different parts of the body, including the skulls, jaws and teeth (Hamar 1970,
Gräfner 1986, Miles & Grigson 1990, Baumgärtner & Gruber 2015, Böhmer 2015, Stephens et al. 2018). A comprehensive work on the variation and disease of mammalian teeth does exist (Miles & Grigson 1990), though small mammals are comparatively underrepresented. Altogether, there has been relatively little research on this subject, and publications generally discuss only single cases or small samples and do not always specify observations (e.g. Johnson 1952, Mohr 1954, Buchalczyk 1961, Miyao & Mori 1969, Steinborn & Vierhaus 1984, Gräfner 1986, special section of this paper).

Here, we compiled all data published on this subject in Germany, supplemented with our own findings. The results were categorized to provide an overview of the variation in anomalies and pathologies in small mammals. Variability, such as those observed in the molar roots of Muridae (e.g. Robel 1971) and in molar patterns of Arvicolidae (e.g. Wolf et al. 2003, Kapischke et al. 2009), were not included.

**Material and Methods**

We limited our research to corresponding structures on the skulls, jaws and teeth of wild terrestrial small mammals, obtained mostly from owl pellets. The material was analysed for the presence of anomalies and pathological changes, and the phenomena identified were photographically documented. The material primarily came from the collections of Jentzsch, Kapischke, Kraft and Wolf, supplemented by additional records from publications and unpublished data from other authors. Classification, based on the location of the changes (skull, jaws, teeth) and the type of variation (Fig. 1) was based on Miles & Grigson (1990). For the classification of extreme tooth wear, we referred to Renaud (2005) and Steiner (1967). Extreme tooth wear was recognised when all molars have been worn down to the roots or showed a minimum residual of tooth crowns.

In many cases, if multiple anomalies and/or pathological changes were found in a single animal, items could be assigned to more than one classification. All of these features were individually documented, regardless of any mutual dependency, and the associated categories were additionally marked with “+ #”, where # represents the corresponding ordinal number from Fig. 1. Faunistic clues appear only once, each under the first mention of a specimen, and similar findings were summarized to the greatest extent possible. The order and nomenclature of the species is based on Angermann & Hackethal (1995). A detailed specification of the genera *Mus* and *Arvicola* has not been conducted.

The following abbreviations have been used: LJ – lower jaw, UJ – upper jaw, Proc. – processes, spc. – specimen/s, BB – Brandenburg, BW – Baden-Wuerttemberg, BY – Bavaria, MV – Mecklenburg-Western Pomerania, NRW – North Rhine-Westphalia, SH – Schleswig-Holstein, SN – Saxony, ST – Saxony-Anhalt. Unless otherwise stated, the phenomena described are single specimens, and the skulls are stored in the collections of Jentzsch, Kapischke, Kraft or Wolf. Photographs were taken by R. Kraft (photo print from diapositive, Figs. 2-6) and M. Kunath (Figs. 7-15).

**Results**

Based on data from the literature and own observations of individual specimens from 20 small mammal species in Germany, a total of 362 anomalies and 122 pathological changes were documented. These phenomena can be assigned to 15 different categories; of these, 14 have been recorded (Fig. 1).
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Table 1 provides an overview of the assignment of occurrences in individual small mammal species. No. 115, the common shrew, exhibited five different phenomena, the maximum number found in a single specimen. The most frequently observed phenomena were excessive tooth growth and deviations from the normal number of teeth.

Special section
Order Eulipotyphla
Family Erinaceidae

European hedgehog Erinaceus europaeus Linnaeus, 1758
# 2.1.1 Fractures/inclusions (skull excluding jaws)
Wolf (2017): Healed fracture in the central area of the cranium in the contact area of crista sagittalis and crista orbitalis (1♂, 13.7.2013, Leipzig-Plagwitz, SN).

Family Talpidae

European mole Talpa europaea Linnaeus, 1758
# 1.2.3 Dental anomaly (absent or supplementary teeth)

Stein (1963): 32 ♂♂, 9 ♀♀ with one or two supplementary premolars, 3 ♂♂, 1 ♀ with missing premolar in the LJ, 3 ♂♂ with supplementary premolars, 13 ♂♂, 3 ♀♀ with missing premolars in the LJ (1949-1962, Fürstenwalde, BB).

Family Soricidae

Common shrew Sorex araneus Linnaeus 1758 (Figs. 2, 3)
# 1.1 Bone anomaly, morphology
Maternowski (2015): Proc. coronoideus (right LJ) proximally turned (11.03.2013, Rheinau-Hohbühn, BW).

Own observations:
No. 55: Right Proc. condylaris significantly abbreviated + # 2.4 (03.08.2008, Ossig, ST) (Fig. 3A).
No. 59: Proc. coronoideus of left LJ proximally turned, right LJ and skull not available (25.03.2003, Saalkreis, ST, leg. Jentzsch) (Fig. 3B).
No. 115: Alveoli partially fused + # 1.2.3 + # 2.1.2 + # 2.1.3. + # 2.2.2 (Wallerfing, BY, col. Bavarian State Collection of Zoology Munic).
# 1.2.3 Dental anomaly (absent or supplementary teeth)
Own observation:
No. 115: M₁ and M₂ missing + # 1.1 + # 2.1.2 + # 2.1.3 + # 2.2.2 (Fig. 2).

# 2.1.2 Fractures/inclusions jaw
Own observations:
No. 115: Completely healed fracture of corpus of right LJ (Fig. 2).

# 2.1.3 Fractures/inclusions (teeth)
Own observation:
No. 115: I₁ broken at base # 1.1 + # 1.2.3 + # 2.1.2 + # 2.2.2.

# 2.2.2 Bone proliferation (jaws)
Own observation:
No. 115: Right LJ, ventral bulge and porous surface, several openings along a recessed vertical cavity + # 1.1 + # 1.2.3 + # 2.1.2 + 2.1.3.

# 2.4 Extreme abrasion of the teeth (Abrasio dentium)
Own observation:
No. 55: I₁ of the right and left LJ worn-out near alveolus + # 1.1 (Fig. 3A).

Eurasian water shrew *Neomys fodiens* (Pennant 1771) (Fig. 4)

# 1.1 Bone anomaly, morphology
Own observations:
No. 60: Right Proc. postglenoidalis not helically curled, but clearly widened (16.02.2007, Wilster/ Rumphleth, SH).
No. 61: Both indentations of the spirally rolled Proc. postglenoidalis formed as continuous holes (19.01.2008, Langenklint, SH).
No. 62: Crooked rostrum, turned to the left (23.02.2008, Gaarz, BB).

# 2.1.2 Bone proliferation (jaws)
Own observation:
No. 118: Proc. coronoideus with exostosis + # 2.3.1 + # 2.4 (Notzing, BY, col Bavarian State Collection of Zoology Munic) (Fig. 4).

# 2.3.1 Enamel abrasion
Own observation:
No. 118: I₁ with enamel limited to the tip, dentin medially reduced + # 2.4 + # 2.1.2.

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**Fig. 2.** Common shrew No. 115. Completely healed fracture of corpus of right LJ and absence of M₁ and M₂.

**Fig. 3.** Common shrew No. 55. Right LJ with shortened Proc. condylaris and worn-out I₁ (A). Common shrew No. 59. Left LJ with a Proc. coronoideus proximally deflected (B).

**Fig. 4.** Eurasian water shrew No. 118. Proc. coronoideus of left LJ with exostosis (below), right LJ with normal expression (above).
# 2.4 Extreme abrasion of the teeth (Abrasio dentium)
Own observation:
No. 118: I₂ und P₄ heavily worn+ # 2.1.2.

Greater white-toothed shrew Crocidura russula (Hermann, 1780) (Figs. 5, 6)
# 1.1 Bone anomaly, morphology
Own observations:
No. 120: Left LJ, exostosis at the upper edge of the Proc. coronoideus + # 2.3.1 (Roßstadt, BY, col. Bavarian State Collection of Zoology Munic).
No. 121: Left LJ, exostosis in anterior third of the corpus, including the alveolus of I₁ + # 1.2.3 (Sonnefeld, BY, col. Bavarian State Collection of Zoology Munic) (Fig. 5).

# 1.2.1 Tooth anomaly (tooth position)
Kraft (2002): As a result of the fracture both I¹ each ventrally inclined 45° + # 2.1.3 (Löffelsterz, BY).

# 1.2.3 Dental anomaly (absent or supplementary teeth)
Borkenhagen (2011): Missing teeth (P², P³, M¹ for 51 out of 151 animals) (SH).
Kapischke & Lange (2010): Supplementary antemolar in the left UJ (19.03.2008, Mechau, ST).
Own observations:
No. 63: Left UJ, supplementary antemolar (2001-2004, Stollberg, SN, leg. K. Wetzel).
No. 64: Left UJ, missing P₄, instead there is one pin tooth or two pin teeth (2 spc., 1992, Trainau/Lichtenfels, BY, col. Bavarian State Collection of Zoology Munic).
No. 121: Missing I₂ and P₄ + # 1.1 (Fig. 5).

# 2.1.2 Fractures, inclusions (jaw)
Own observations:
No. 119: Left LJ with transversal fracture, presumably caused by osteomyelitis; healed resp. body of mandible bridged by ventral callus formation, roots of M₁ and M₂ partially exposed in the area of the fracture gap, mandible body with larger visible cavities (X-ray image), from M₂ a strip-like compression extends diagonally backwards/downwards (possibly dead sequestra) (Schottenstein, BY, col. Bavarian State Collection of Zoology Munic) (Fig. 6).

# 2.1.3 Fractures/inclusions (teeth)
Kraft (2002): Loss of mandible tips of both LJ, presumably through injury, right in front of the premolars, root stumps of the I₁ are still in the mandible body, scarped ridges of the break lines show callus formation + # 1.2.1.

# 2.3.1 Enamel abrasion
Own observation:
No. 120: I₁ with a conspicuous notch at the upper edge + # 1.1.

Bicoloured shrew Crocidura leucodon (Hermann, 1780)
# 1.2.3 Dental anomaly (absent or supplementary teeth)
Own observation:
No. 66: Left P² greatly enlarged, P³ missing, abnormal pigmentation of the coat (Taucha, SN, Kapischke 2007).

Order Rodentia
Family Sciuridae
Eurasian red squirrel Sciurus vulgaris Linnaeus, 1758
# 1.2.2 Tooth anomaly (tooth growth)
Butzeck (1988): Left I₁ arching several centimetres to the left, tip touching on the left side, strongly inflamed eyeball. Pupil screwed into orbita and apparently without function, eyelid also inflamed + # 2.2.2 (1 ♂, wild living, 23.02.1987, zoo Cottbus, BB).
# 2.2.2 Bone proliferation (jaws)
Butzeck (1988): severe exostoses and callus formation in the lower jaw area after chronic periodontium suppuration. The animal also showed an indentation of the facial skull in the nasal region medially and an asymmetrical pelvic structure, for which the authors assume traumatic causes + # 1.2.2.

Family Gliridae
Hazel dormouse *Muscardinus avellanarius* (Linnaeus, 1758)
# 1.2.1 Tooth position
Schulze (1987): Growth of I\(^1\) of UJ sideways to the right passing LJ, both I\(^1\) seem to have forced away the antagonists in UJ + # 1.2.2 (1 ♀, Hand capture, 21.10.1972, Südharz, ST).

# 1.2.2 Tooth anomaly (tooth growth)
Schulze (1987): All I show elongated growth, which led to injuries due to the malpositioning: lower I scraped the palate down to the bone and led to ulcerated wounds, right I\(^1\) injured the tip of the tongue and the gingiva in the area of both I\(^1\), animal was apathetic and emaciated + # 1.2.1.

Family Muridae
Black rat *Rattus rattus* (Linnaeus 1758)
# 1.1 Bone anomaly, morphology
Becker (1966): Both spc. each with nose bent to the left and the right, respectively (offspring of wild catch, March 1948, Liepe, BB).

Brown rat *Rattus norvegicus* (Berkenhout, 1769)
# 1.1 Bone anomaly, morphology
Becker (1966): Nose bent to the right or the left ("bent nose") (2 spc., offspring of wild caught specimen, Berlin-Dahlem).

Wood mouse *Apodemus sylvaticus* (Linnaeus, 1758)
# 1.1 Bone anomaly, morphology
Goethe (1955): At the position of one M\(^2\), only three alveoli (tooth not developed? Heiden, NRW, leg. Zippelius).

# 1.2.2 Tooth anomaly (tooth growth)
Schmidt (1991): Elongated, strongly backward curved I\(^1\) due to heavy wear of the I\(^1\) in the LJ (02.11.1987, Sauen near Beeskow, BB).

# 2.4 Extreme wear of the teeth (Abrasio dentium)
Renaud (2005): Molars worn down to the roots or showing minimal crowns (14 spc., 1957-1974, northern Germany).

Yellow-necked mouse *Apodemus flavicollis* (Melchior, 1834) (Fig. 7)
# 1.1 Bone anomaly, morphology
Own observation:
No. 56: Right LJ, Proc. condylaris not developed, Ramus mandibulae strongly reduced and laterally dented rostrum due to elongated I\(^1\) + # 1.2.2 (29.09.2007, Annaburg, ST, leg. K. Nehring) (Fig. 7A).

# 1.2.1 Tooth position
Own observation:
No. 108: Right M\(^3\) outside the normal tooth row and shifted in direction of I\(^1\), + # 1.2.2 (26.12.2011, Magdeburg, ST).

# 1.2.2 Tooth anomaly (tooth growth)
Own observations:
No. 56: Elongated I\(^1\) and I\(^2\) in all jaws, with right I\(^1\) protruding above the mandible body in the area of the diastema, I\(^1\) laterally pressed against the

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**Fig. 7.** Yellow-necked mouse No. 56. Skull and right LJ with dented rostrum, reduced bone leaf between Proc. coronoides and Proc. angularis and elongated I in LJ and UJ (A). Yellow-necked mouse No. 31. Left LJ with heavily worn molars (B).
rostrum, creating a recess + # 1.1 (Fig. 7A).
No. 108: Both I\(_1\) slightly elongated + # 1.2.1.

# 1.2.4 Fusion of teeth
Herold (1955): Both UJ, fusion of two roots and symmetric fusion of the crowns of M\(_1\) and M\(_2\) (01.07.1954, Erßdorf, NRW).

# 2.4 Extreme wear of the teeth (Abrasio dentium)
Own observation:
No. 31: Crowns of all teeth in UJ and LJ worn to near the root area, in case of right M\(_1\) mesial and distal root already separated + (16.01.2008, Purzien, ST, leg. K. Nehring) (Fig. 7B).

**Striped field mouse Apodemus agrarius** (Pallas, 1771)
# 1.2.2 Tooth anomaly (tooth growth)
Own observation:
No. 104: Left I\(_1\) circularly elongated + # 2.2.2 (20.12.2012, Kloschwitz in Vogtland, SN).

# 2.2.2 Bone proliferation (jaws)
Own observation:
No. 104: Left LJ with proliferation in the area of the I\(_1\) + # 1.2.2.

**Apodemus spec. Kaup, 1829** (**Apodemus flavicollis sylvaticus**)
# 1.1 Bone anomaly, morphology
Wilhelm et al. (2014): both LJ with “mushroom-shaped” articular process (Dresden, Leubnitz-Neuostra, SN).

**House mouse Mus spec.**
# 1.2.2 Tooth anomaly (tooth growth)
Krauss (1991): Elongated I\(_1\) in the UJ almost achieving ring closure with normal growth of the I\(_1\) in the LJ, wear in the contact area with the two I\(_1\) (Harthau, SN).

# 1.2.3 Dental anomaly (absent or supplementary teeth)
Goethe (1955): M\(_2\) associated alveoli missing, tooth not formed (Holter casle, NRW).

**Family Cricetidae**
**European hamster Cricetus cricetus** (Linnaeus, 1758)
# 1.2.2 Tooth anomaly (tooth growth)
Mohr (1954): Elongated I\(_1\) (photo page 83).

**Voles (Arvicolidae)**
**Musk rat Ondatra zibethicus** (Linnaeus, 1766)
# 1.1 Bone anomaly, morphology
Akkermann (1974): Shortened diastema in LJ + # 1.2.2 + # 2.3.2 (Dümmer, NS).

**Bank vole Myodes glareolus** (Schreber, 1780) (Fig. 8A)
# 1.1 Bone anomaly, morphology
Own observation:
No. 54: Proc. condylaris shortened and rostrally turned, opening of the alveolus shifted towards the base of the missing Proc. coronoides, Proc. angularis clearly reduced and caudally extended
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(Brüken, ST, leg. Jentzsch) (Fig. 8A, normal expression Fig. 8B).

# 2.1.1 Fractures/inclusions (skull excluding jaws)
Wolf (2003): Healed, almost circular fracture in the area of the skull, bone medially lowered towards the brain, bone plate consisting of remains of the original skull roof (24.03.2001, Brandis, SN).

Water voles *Arvicola* spec. Lacépède, 1799 (Fig. 8B)
# 1.2.2 Tooth anomaly (tooth growth)
Altner (1961): Elongated I₁, tooth tips drift apart. Kapischke & Lange (2015): Elongated I₁ with blunt tips (Collection Kulicke). Due to the malfunction of the antagonists, the cranially descending chewing surface of the right toothrow in the UJ, I₁ is elongated and irregularly worn + # 1.2.5 + # 2.2.2 (19.05.2007, Dammwolde, MV).

# 1.2.3 Dental anomaly (absent or supplementary teeth)
Lerp & Sametschek (2009): Loss of M₁ in the right LJ, tooth socket was originally existing and in the further course of life completely ossified, thereby lengthening the antagonist in the UJ (2008, Leipzig county, SN).

# 2.2.2 Bone proliferation (jaws)
Nitsche (1996): Right LJ at the level of M₁ to M₃ with porous bone growth, probably osteosarcoma (Ziebigk near Köthen, ST).
Kapischke & Lange (2015): Exostosis of the left LJ branch in the form of a blister-like bony thickening + # 1.2.2 + # 1.2.5 (Dammwolde) and in the early stage (1959-1961, Collection Kulicke).

# 1.2.5 Dental abnormalities (other maldevelopments)
Altner (1961): Obliquely worn-out M in both UJ and both LJ, surfaces in same direction. Kapischke & Lange (2015): All molars deep-seated, M₁ completely sunken + # 1.2.2 + # 2.2.2.

Own observation:
No. 57: Alveolus of the left I₁, labially exposed (03.08.2008, Ossig, ST) (Fig. 8C).

Field vole *Microtus agrestis* (Linnaeus, 1761)
# 1.2.1 Tooth position
Nitsche (1996): LJ molars labially displaced + # 2.2.2 (Pösigk, ST).

# 1.2.2 Tooth anomaly (tooth growth)
Kapischke & Dankhoff (2007): Right LJ with abnormal growth of M₁, corresponding hole in antagonistic M₁ (Grünewalde, BB).
Kulicke & Kapischke (1997): Almost circular I₁, irregular molar wear on one of the LJ (2 spc., Kulicke Collection at the Forest Research Institute).

Own observation:
No. 47: Anterior lobe of the left M₁ strongly extended + # 2.1.3 + # 2.4 (03.03.2008, Fiener Bruch, ST, leg. Birth) (Fig. 9).

# 1.2.3 Dental anomaly (absent or supplementary teeth)
Kraft (2000): Roundish, pin-shaped front lobe of right M₃, separated as an autonomous tooth (1998, Vierkirchen, BY).

# 2.1.3 Fractures/inclusions (teeth)
Jentzsch (2006): M³ with diagonal fracture in the crown area reaching from the lingual side behind the front lobe to the back lobe, stone stuck in the crater, inner side of the tooth lingually displaced (04.03.2005, Drömling Nature Park, ST).
Lange & Kapischke (2009): Diagonal fracture of the right M₁ (12.07.2008, Minzow, MV).

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Fig. 8. Bank vole No. 54. LJ with shortened and distally oriented Proc. condylaris, shifted opening of tooth canal (A). Reference with normal expression (B). Water vole No. 57, left LJ with exposed tooth socket of I₁ (C).
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Own observation:
No. 47: Fracture behind anterior lobe of the left M₁ + # 1.2.2 + # 2.4 (Fig. 9).

# 2.2.2 Bone proliferation (jaws)
Kulicke & Kapischke (1997): LJ branches mostly on one side, sometimes also on both sides with blister-like, bony thickenings, probably actinomycoses (9 spc., 1954-1956, Eberswalde, BB).
Nitsche (1996): Both LJ with large exostoses on the outside below the molars and opening on the left in the rostral masseter fossa and on the right at the level of the diastema + # 1.2.1.

# 2.4 Extreme wear of the teeth (Abrasio dentium)
Own observation:
No. 47: Anterior lobe of the left M₁ as antagonist of the extended left M₁ mesially sloping + # 1.2.2 + # 2.1.3.

Common vole Microtus arvalis (Pallas, 1778) (Figs. 10-15)
# 1.1 Bone anomaly, morphology
Kapischke et al. (2012): Ossification of the symphysis of the LJs (Winter 2010/2011, Dresden, SN).
Kapischke (2014): Deformed Proc. articularis (Goltzsch, SN).
Manegold (2000): Left LJ with strongly deformed Ramus mandibulae (1997/1998, Kamern, ST).
Maternowski (2017): Right LJ with hole in the Ramus mandibulae (Sandweiser, Baden-Baden, Baden-Württemberg).

Own observations:
No. 7: Proc. condylaris distally, Proc. angularis proximally deflected, thus tip of LJ with I₁, and anterior half of M₁ linguually curved, anterior lobe with abnormal tooth pattern (2015, Schullwitz, SN, leg. Kapischke).

No. 15: Proc. angularis of the left LJ club-like shape (07.09.2011, Dresden-Leubnitz, SN).
No. 37: Proc. coronoides extension extended, basal with hole + # 2.1.3 + # 2.3.1 + 2.3.3 (1995, Berga, ST, leg. Jentzsch) (Fig. 10A).
No. 50: Proc. angularis extended and club-shaped (25.08.2004, Mösthinsdorf, ST, leg. G. Klümpen).
No. 51: Left Proc. angularis basally dented (08.03.2008, Drobitz, ST, leg. Jentzsch).
No. 80: Deformation of Proc. articularis (06.06.2014, Rohrbach, SN, leg. Wolff) + # 1.2.2 + # 2.3.1 + # 2.3.2.
No. 116: Left LJ, Proc. condylaria with mushroom-shaped exostosis (January 2020, Dresden, Leubnitz-Neuostra, SN, leg. Wilhelm).

# 1.2.1 Tooth position
Kapischke et al. (2015): Upper I crossing each other (2014, Dresden, SN).
Kapischke (2014): Diagonally ground M₁ and extended M₁ with surface buccally sloping down, respectively (2 spc., Chemnitz-Rabenstein); M₁ surface lingually sloping down (Dresden-Kleinzechachwitz).
Lange & Kapischke (2007): All molars worn in the same sloping direction (see Manegold 2000) (21.02.2007, Wetterndorf, SH).
Manegold (2000): Tooth surfaces of the molars worn into likely or opposite direction and molars worn diagonally to lingual, respectively + # 1.2.2 + # 2.1.3 (5 spc., 1997/1998, Kamern, ST).
Maternowski (2001): I₁ drift apart apically + # 1.2.2 (18.10.1994, Wendefeld, BB).

Own observations:
No. 22: Right I₁ with labially deflected thin tip, left I₁ very thin + # 1.2.2 (02.07.1995, Nellschütz, ST, leg. M. Schlüter).
No. 24: Molars of left LJ and left UJ worn-out into opposite direction + # 1.2.2 + # 2.1.2 + # 2.2.2 (25.12.2015, Trafo Nellschütz, ST) (Fig. 10C, D).
No. 30: Both M₂ labially displaced + # 2.2.2 (September 2007, Wittgendorf, ST, leg. F. Köhler).
No. 53: Right I₁ buccally deflected (15.02.2011, Dresden-Gohlis, SN).
No. 76: Left I₁ buccally deflected (18.02.2016, Altmügeln, SN).

# 1.2.2 Tooth anomaly (tooth growth)
Altnner (1961): Extension of all cheek teeth of right LJ and of right M₁ from mesial to apical (“Pan flute”), respectively (2 spc.).
Bischoff (2005): Strongly elongated I₁, grown into the oral cavity + # 1.2.3 (22.08.2005, Gülpe, ST).
Dolch (2016): Strongly elongated I₁ (8 spc., 20.09.2014, Mankr, BB).
Goethe (1955): Left LJ arched outwards, anterior tip of M, protrudes 6.5 mm from the inner alveolar rim (1945, Heiden, NRW; 2 spc., 1945, Reelkirchen, NRW).
Jaschke (2017): Strongly elongated I₁ (26 spc., 10./11.10.2005, NSG Havelländisches Luch; 5 spc., 08.02.2008, 3 spc., 14.12.2008, Garlitz; 4 spc., 09.12.2008, Barnewitz; 5 spc., 18.12.2008, Damme, BB).
Kapischke (2014): Circular I₁ (Goltzsche, SN; Torgau-Köllitzsch, SN).
Lange (2020): Both I₁ circularly grown + # 1.2.3 + # 2.3.1 (26.22.208, Volkendorf, NS); left LJ “Pan flute” (2019, Steinburg, SH).
Lange & Kapischke (2007): Lengthened right M₁, molars of LJ obliquely worn-out from frontal to caudal (21.02.2007, Wetterndorf, SH).
Manegold (2000): Circular I₁ + # 1.2.1 + # 2.1.3; elongated right I₁ (1997/1998, Kamern, ST); elongated M₁ of left LJ in the area of the anterior lobe and separated from the remaining tooth by a gap (1997/1998, Kamern, ST); right M₁ 30 % extended compared to left M₁, with strong cement inclusions (1997/1998, Kamern, ST) + # 2.1.3.
Maternowski (2001): Strongly elongated I₁, in one case circular right I₁ and half circular left I₁ (18.10.1994, Wendefeld, BB); strongly elongated I₁ + # 1.2.1.
Nitsche (1996): Extended left M₁ atrophied with antagonist in UJ (Fraßdorf, ST); elongated paired I₁ (3 spc., Fraßdorf, Libbesdorf, ST, 6 spc., Hinsdorf, ST); elongated, circular I₁, in one case left I₁ broken off + # 2.3.2 (2 spc., Hinsdorf, 4 spc., Pösigk, ST).
Schmidt (1991): M₁ growth malformation (3 spc., Harthau, SN).
Uttendörfer (1939): Strongly elongated I₁ (1898) + # 1.2.3; extension of M₁ from mesial to apical (“Pan flute”) (1936).

Own observations:
Elongation of both I₁:
No. 2: Due to atrophy of both I₁, right I₁ tip broken off + # 2.1.3. + # 2.3.1 (2015, Schullwitz, SN, leg. Kapischke) (Fig. 14A).
No. 5, 48: + # 2.1.3 (2015, Schullwitz, SN, leg. Kapischke; 12.05.2015, Dresden-Tolkewitz, SN, leg. K. Fabian).
No. 22: + # 1.2.1.

Fig. 10. Common vole No. 37. Left LJ with extended process, hole in the Proc. coronoides, enamel hypoplasia in the molar region, broken I₁, and progressive caries at M₃ (A). Common vole No. 24. Left LJ lingually with embedded stone, widened dental bed and exostosis in the area of I₁ (B), labially with exostosis and obliquely ground molars (C), obliquely ground molars in the left UJ (D).
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No. 26, 35, 42, 44, 45: Almost circular, tooth tips partly growing apart (1995, Berga, ST, leg. Jentzsch; 08.03.2008, Drobitz, ST, leg. Jentzsch; 16.01.2008, Purzien, ST, leg. K. Nehring; 3 spc., 28.01.2003, Niemberg, ST, leg. G. Klammer).

No. 83: + # 1.2.3 (01.07.2015, Nemt, SN; 20.02.2011, Magdeburg, ST).

No. 65, 66, 109, 110:+ # 2.3.2 (15.10.2011, Göbschelwitz, SN, leg. I. Kittel; 01.06.2016, Bernau, BB; 2 spc., 27.10.2010, Dresden, SN, leg. H. Kapischke).

Fig. 11. Common vole No. 49. Left right LJ, M, buccally penetrating into the corpus mandibulae (A). Common vole No. 33. Right UJ with extension of M, from mesial to apical (“Pan flute”), in the opposite LJ tooth row normally developed (B).

Fig. 12. Common vole No. 40. Left skull with elongated I’ (A). Common vole No. 39. Left LJ with elongated I, (B).

Fig. 13. Common vole No. 34. Right LJ with cross-braked M, (A). Common vole No. 23. Both LJ each with bone proliferation in the area of the diastema, in the right LJ shaping a hole (B).
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No. 84: Circular, lower jaw normal (01.07.2015, Nemt, SN).
No. 97, 112: + # 2.3.2 (31.01.2015, Altmügeln, SN; 20.12.2012, Kloschwitz/Vogtland, SN; 2008, Brandis, SN).
No. 100: + # 2.3.2 (31.01.2015, Altmügeln, SN).
No. 74, 79, 86, 102, 111: Circular (19.02.2016, Lüttnitz, SN; 18.02.2016, Altmügeln, SN; 2 spc., 08.01.2015, Blankenhain, SN; 20.12.2012, Kloschwitz/Vogtland, SN; 2008, Körlitz, SN).
No. 105: + # 2.3.2 (01.07.2015, Nemt, SN; 20.02.2011, Magdeburg, ST).
No. 123: Strongly elongated I 1 (3 spc., 23.10.2019, Hackeboe (1 spc., 27.12.2019, Christinenthal, SH).
No. 124: right I 1 circularly elongated + # 1.2.3 (SH, leg. L. Lange).
No. 125: right I 1 circularly elongated + # 1.2.3 + # 2.3.1 (23.10.2019, Wilster, SH, leg. L. Lange).
No. 126: left I 1 needle like elongated + 2.4 (22.12.2019, Itzehoe, SH, leg. L. Lange).

Elongation of re I 1:
No. 1: + # 2.3.2 (2015, Schullwitz, SN, leg. Kapischke).
No. 13: Due to atrophy/break of the right I 1, + # 2.3.1 (Gombsen/Kreischa, SN, leg. Kapischke).
No. 39, 41: (2 spc., 16.01.2008, Purzien, ST, leg. K. Nehring) (Fig. 12B).
No. 73: Circular (20.12.2015, Magdeburg, ST).
No. 106: + # 2.3.2 (20.02.2011, Magdeburg, ST).
Nr. 121: + # 2.3.2 (12.01.2020, Borsfleth, SH, leg. L. Lange).

Elongation of teeth le I 1:
No. 3: Almost circular + # 2.1.3 (2015, Schullwitz, SN, leg. Kapischke).
No. 14: (Dresden-Gohlis, SN, 15.02.2011, leg. Kapischke).
No. 40: Almost circular, growing slightly outwards + # 2.1.3 (16.02.2008, Purzien, ST, leg. K. Nehring) (Fig. 12A).

“Pan flute”: No. 12: Left M 1 “Pan flute” and front lobe buccally deflected, left M 1 sunk in and less worn-out than other molars + # 1.2.5 + # 2.2.2 (29.12.2015, Klenzschachwitz, Sachsen).
No. 33: Extension of right M 1 from mesial to apical (“Pan flute”) + # 1.2.5 + # 2.3.3 (03.08.2008, Ossig, ST) (Fig. 11B).

Elongation, growth of other teeth:
No. 24: Right and left M 3 + # 2.1.1++ # 2.1.2 + # 2.2.2.
No. 38: Right and left M 1, anterior lobe approximately 0.9 mm higher than distal tooth edge (16.01.2008, Purzien, ST, leg. K. Nehring).
No. 80: I 1 continual growth inside the tooth socket + # 1.1 + # 2.3.1 + # 2.3.2.
No. 96: Right M 1 obliquely (08.01.2015, Blankenhain, SN).
No. 101: Both M 1 (20.12.2012, Kloschwitz/Vogtland, SN).
No. 49: Right M 1, abnormal tooth pattern, buccally penetrating into the corpus mandibulae (07.07.1995, Förstgen, SN) (Fig. 11A).
No. 28: Teeth of the left upper toothrow + # 1.2.5 + # 2.3.3 (Mai 2008, Reußen, ST).
No. 122: Laterally extended right upper molars, chewing surface laterally sloping down (31.01.2020, Dresden, Leubnitz-Neuostra, SN).

# 1.2.3 Dental anomaly (absent or supplementary teeth)
Bischoff (2005): Missing I 1 + # 1.2.2.
Kapischke (1995): Additional molar, UJ, left side (1994, Piskowitz, SN, leg. Würfel).
Kapischke (2011): Left M₂ consists of two separate teeth (2010, Dresden, SN).

Kapischke (2014): Supplementary tooth in LJ (Frauendorf, SN).

Kraft (2000): Supplementary pin-like tooth adjacent to the front edge of the right M₃ (Woringen, BY); divided right M₁ (1998, Oberndorf).

Lange (2000): On both sides four molars in the UJ (26.12.1998, Bekdorf, SH).

Kapischke (2014): deformed M₁ (SN).

Own observations:
No. 36: Left M₁ between first labial and first lingual dental triangle transversely divided, tooth margins developed + # 2.2.2 (05.10.2006, Sachau, ST, leg. Jentzsch).

No. 81: Right I₁ missing, tooth socket closed (06.02.2015, Meltewitz, SN).

No. 83: Both I₁ missing + # 1.2.2.

No. 103: Right I₁ missing, tooth socket almost overgrown

No. 124: Right I₁ swaged (23.10.2019, Hackeboe, SH); right I₁ of normal length, but strongly tapered + # 1.2.2.

No. 125: Left I₁ of normal length, but strongly tapered + # 1.2.2 + 2.3.1.

# 1.2.5 Dental abnormalities (other maldevelopments)
Kapischke (2014): Necrotic M₁ (Röttenbach, SN)

Own observations:
No. 4: Tooth roots barely developed, only the front lobe pronounced + # 2.2.2.

No. 12: M₁ lost or not formed + # 1.2.2 + # 2.2.2.

No. 16: Right M₁, voluminously widened, associated alveolus widened (15.02.2011, Dresden-Gohlis, SN) (Fig. 14B).

No. 28: Left M₁, voluminously widened, associated alveolus widened + # 1.2.2 + # 2.3.3.

No. 33: Deviating tooth pattern of the right M₁ + # 1.2.2 + # 1.2.5.

No. 78: Left M₁ not erupted, tooth socket closed (18.02.2016, Altmügeln, SN).

# 2.1.2 Fractures/inclusions (jaw)
Own observation:
No. 24: Left LJ at the level of the M₃ with embedded stone and exposed periodontium + # 1.2.1 + # 1.2.2 + # 2.2.2 (Fig. 10B).

# 2.1.3 Fractures/inclusions (teeth)
Kapischke (2014): Broken M₄, inclined and divergently worn (Dresden-Kleinschachtzach, SN); Broken hind lobe of M₁ (Goltzsche, SN).

Kapischke & Kraft (2012): Crater in M₁ possibly due to the inclusion of a foreign body (e.g. grain of sand or small stones) (Dreschen, BY); enclosure of a foreign body in M₁ (Etting, BY); Fracture in M₄, separate anterior lobe (2 spc., Dresden, SN und Vierkirchen, BY).

Kapischke et al. (2006): Left M₁ lingual with enclosed sand grain in the second dentine triangle, this slightly rounded off.

Manegold (2000): Li LJ broken off at the top + # 1.2.1 + # 1.2.2; Right M₁ split antagonistic M₁ up to the third outer anticline + # 1.2.2.

Own observations:
No. 2: Left I₁ broken off, indicated breaking edge of left I₁ already clearly visible due to enamel hypoplasia + # 1.2.2 + # 2.1.3 + # 2.3.1 (Fig. 14A).

No. 3, 40: Right I₁ broken off + # 1.2.2.

No. 5: Both I₁ broken off + # 1.2.2.

No. 17: Crown area of the posterior lobe of right M₃ broken off (14.09.2011, Dresden-Leubnitz, SN).

No. 27: Posterior lobe of right M₃, continuously broken + # 2.3.3 (01.07.1995, Berga, ST, leg. G. Schröter) (Fig. 15).

No. 34: Right M₁, broken in the middle, tooth edges partially healed + # 2.3.3 (01.10.2007, Axien, ST, leg. K. Nehring) (Fig. 13A).

No. 37: Left I₁ aborted at the level of the alveolus, probably also fracture in the crown area of the left M₃ + # 1.1 + # 2.3.1 + # 2.3.3 (Fig. 10A).

No. 48: Both I₁ broken + # 1.2.2.

No. 75: Right M₁ partly broken (18.02.2016, Altmügeln near Oschatz, SN).

No. 120: Left M₁ dental crown broken crosswise and widened by bonelike foreign object, root still connected, hind root canal in the crater visible from above (31.01.2020, Wilster, SH, leg. L. Lange).

# 2.2.2 Bone proliferation (jaws)
Manegold (2000): Both LJ in the area of I₁ with bone proliferation (1997/1998, Kamern, ST).

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**Fig. 15.** Common vole No 27. Right LJ with caries and fracture of the posterior lobe of M₁.
Own observations (exostoses of diastema on or near the tooth socket of I₁, tooth necks of I often exposed):
No. 18: Right LJ (14.09.2011, Dresden-Leubnitz, SN, leg. Kapischke).
No. 6, 23, 32: both LJ, No. 23 in the right LJ shaping a hole (15.02.2011, Dresden-Gohlis, SN, leg. Kapischke; 27.02.2009, Trafo Nellschütz, ST, leg. M Schlüter; 31.12.1995, Berga, ST, leg. Schröter) (Fig. 13B).
No. 24: Instead of I₁, strong exostoses and exostosis labial in the area of the LJ corpus + # 1.2.1 + # 1.2.2 + # 2.1.2 (Fig. 10B, C).
No. 25: Left LJ (08.10.2008, Königsmark, ST).
No. 30: Right LJ + # 1.2.1.

Own observations (bone proliferations in other areas of the jaw):
No. 4: Tooth socket of the M₁, lingual + # 1.2.5.
No. 12: Loss of bone mass in the area of corpus mandibulae at the level of M₁, root area of left I₁ exposed like a window + # 1.2.2 + # 1.2.5.
No. 20: left LJ Ramus mandibulae atrophied, proliferation spreads to the tooth socket of the lower molars, Proc. angularis fin-like (30.06.2012, Dresden-Tolkewitz, SN, leg. Kapischke).
No. 36: Front lower area of both mandible bodies + # 1.2.3.
No. 82: Bubble-like Proc. angularis, especially in the area of the root of I₁ (06.02.2015, Meltewitz, SN).

# 2.3.1 Enamel abrasion
Lange (2020): Enamel in both I₁ limited to the tip of the tooth + # 1.2.2 + # 1.2.3.
Own observations:
No. 1, 13: Enamel restricted to the tip of the tooth in right I₁, completely missing in left I₁ + # 1.2.2 + # 1.2.5.
No. 2: Enamel in both I₁ limited to the tip of the tooth and left alveolar region, dentine severely damaged, left I₁ almost broken off + # 1.2.2 + # 2.1.3 + # 2.3.1 (Fig. 14A).
No. 37: Left lower toothrow lingual and labial in the upper crown area + # 1.1 + # 2.1.3 + # 2.3.3 (Fig. 10A).
No. 80: Left M₃ without enamel + # 1.1 + # 1.2.2 + # 2.3.2.
No. 107: Both I₁ (20.02.2011, Magdeburg, ST).
No. 125: Right I₁ with two gaps of lost enamel + # 1.2.2 + 2.3.1.

# 2.3.2 Dental disease (atrophied teeth)
Nitsche (1996): Both I₁ each atrophied + # 1.2.2 (2 spc., Hinsdorf, 4 spc., Pösigk, ST).

Own observations:
No. 1: Right I₁ atrophied, only visible as a stump in the alveolus + # 1.2.2.
No. 52: Tooth root of left I₁, atrophied (15.02.2001, Dresden-Gohlis, SN).
No. 65, 66, 85, 98, 100, 109, 110: Both I₁ atrophied + # 1.2.2.
No. 113, 114: Both I₁ atrophied (2008, Brandis, SN).
No. 67, 68, 69, 70, 71, 72: Both I₁ atrophied, tooth socket almost overgrown (20.12.2015, Magdeburg, ST).
No. 77, 103: Right I₁ atrophied, tooth socket almost overgrown (1 spc., 20.12.2012, Kloschwitz/Vogtland, SN; 1 spc., 18.02.2016, Altmügeln, SN).
No. 80: Left M₃ atrophied (“shapeless clump”) without enamel pattern, right I₁ not protruding + # 1.1 + # 1.2.2 + # 2.3.1.
No. 87, 99: Both I₁ and I₂ atrophied (08.01.2015, Blankenhain, SN; 31.01.2015, Altmügeln, SN).
No. 88, 89, 90, 91, 92, 93, 94: Both I₁ atrophied (08.01.2015, Blankenhain, SN).
No. 97, 105, 106, 112: Right I₁, atrophied + # 1.2.2.
No. 121: Both I₁ brittle, visible in the tooth socket, left I₁, with normal length, but very thin and brittle + # 1.2.3 (12.01.2020, Borsfleth, SH, leg. L. Lange).

# 2.3.3 Caries
Own observations:
No. 27: Area of the tooth fracture of M₁ + # 2.1.3 (Fig. 15).
No. 28: Hole on the surface of left M₁ + # 1.2.2 + # 1.2.5.
No. 33: At the posterior lobe of the malformed right M₁ + # 1.2.2 + # 1.2.5.
No. 34: Right LJ with caries at mesial edge of the posterior tooth section of M₁ + # 2.1.3.
No. 37: Mesially advanced at left M₃ + # 1.1 + # 2.1.3 + # 2.3.1 (Fig. 10A).

# 2.4 Extreme wear of the teeth (Abrasio dentium)
Kapischke (2014): Blunt, worn I in the UJ and LJ (Dresden-Kleinzschachwitz).
Own observation:
No. 126: Left I₁, with beginning of cavity at the base formed mesially by the antagonist + # 1.2.2.

Discussion
Biodiversity is a measure of the qualitative, quantitative or functional diversity of biotic objects at all organizational levels within a concrete or abstract, spatial or temporal reference space (Beierkuhnlein 2003). This definition includes biodiversity at the level of organs.
and, by extension, must also include abnormal and pathological phenomena found therein. While unusual deviations from the norm in the functional performance of an organism may be irrelevant, disadvantageous, or advantageous, diseases are usually associated with impairment and, directly or indirectly, may undermine fitness or compromise survival. Small mammals show a capacity to survive such anomalies and even severe pathological phenomena for surprisingly long periods of time, which is why these features should be considered a component of population biodiversity.

Our results demonstrate that even small species, such as mice and other small mammals, appear able to not only survive the course of disease and, presumably, tolerate substantial pain and discomfort over long periods of time, but even to undergo recovery. Examples include cases of healed wounds and survival of viral and bacterial infections, which may be associated with development of an immune response. Other examples include injuries or maldevelopment of various bones of the torso skeleton (Forsman & Otto 2006) as well as anomalies and pathological changes to the skull. Lerp & Sametschek (2009) documented a period of approximately six weeks between the loss of teeth in a water vole and eventual death by predation, showing that up until the time of its death, the animal was able to feed. A bank vole with a healed fracture of the skull, found by Wolf (2003), also showed evidence of recovery. Mohr (1954) observed field hamsters in which the upper incisor grew in a circular shape after breaking off the lower incisor, but as the lower incisor regrew, it ground on the upper incisor, so that the excess part eventually broke off. In most cases, the development of the observed phenomena required a period of several weeks to have developed in this way.

Anomalies and pathologies are regularly observed in the skulls of wild small mammals and have also received wider recognition in older zoological papers (e.g. Johnson 1952, Mohr 1954, Buchalczyk 1961, Miyao & Mori 1969, Steinborn & Vierhaus 1984, Gräfner 1986, Miles & Grigson 1990). The reasons for this interest are quite diverse. In the case of anomalies, they are probably often genetically determined. Included among them are undeveloped or supplementary teeth and deviant bone forms. Bone anomalies associated with the teeth and jaw are often caused by osteomyelitis resulting from abscesses. Lawson (2010) was able to detect the coagulase-positive *Staphylococcus aureus* pathogen in cultured samples of the mandibulofacial and maxillofacial abscesses of mice he examined. He found the cause of inflammation to be crushed hair in the sulci gingivalis of the upper or lower jaw molars, which was presumably ingested and then chewed during coat care. The process of abscess formation as assumed by Lawson (2010) is shown in Fig. 16. Bone or tissue tumours can lead to impaired chewing behaviour, resulting in crooked tooth surfaces. Stones are sometimes able to cause tooth fractures, resulting in caries and tooth loss, but it is also possible for fractured pieces to establish themselves as independent teeth.

The most conspicuous, and second most frequently observed phenomenon in our study, occurs predominantly in mice and rodents and relates to the excessive lengthening of the incisors and the often simultaneously present atrophy or absence of the antagonist (see Gräfner 1986, Miles & Grigson 1990). The illustrations presented by Hoffmann (1958) and Ulbrich (1930) each show a muskrat skull in which the right upper incisor has grown completely circular and has already started another revolution. The skull shown in Miles & Grigson (1990) is that of a black rat (*Rattus rattus*) in which the growth of an incisor has reached almost two complete revolutions. Brandner (1951) states that such characteristics in muskrats can also be the result of nutritional disorders, lack of tooth wear, congenital jaw anomalies, other damage to the teeth and jaws or infections, and that they particularly affect old animals. The latter certainly

![Barbering](image-url)

**Barbering**

**Mastication/Fragmentation of hair**

**Fragments penetrate and expand the gingival sulcus**

**Staphylococcal organisms carried into the submucosa**

**Abscess develops**

**Bone dissolution**

Fig. 16. Etiopathogenesis of mandibulofacial and maxillofacial abscesses in mice proposed by Lawson (2010).
also applies to extreme wear of the teeth (abrasio
dentium). Absent or supplementary teeth account
for 30% of all specimens described here. However,
111 of the 144 findings of that phenomenon can be
traced back to the investigations of Stein (1963) on
moles and of Borkenhagen (2011) on greater white-
toothed shrews.

Pathologies and anomalies occur with varying
frequency in different populations. Dolch (2016)
found that of 80 field mice from pellet samples,
one in eight was observed to have elongated upper
incisors, and Jaschke (2017) reported rates between
1.6% and 11.5% in populations of the same
species. From pellet analyses from the Dresden
area, Kapischke (2017) reports rates of 5.1%
(Leubnitz-Neuostra) and 2.7% (Kleinzschachwitz)
of pathological changes in field mice. Among 114
wood mice from northern Germany, the proportion
of animals with extremely worn teeth was 9.6%
(Renaud 2005).

The overview presented here includes 15 different
anomalies and pathological phenomena, 14 of
which have been documented in a total of 20 species
of terrestrial small mammals (Fig. 1). At 75%, the
proportion of anomalies outnumbered strictly
pathological findings. Due to their low abundance,
some communal species, such as brown rats or
squirrels, are underrepresented in owl pellets.
To date, there are no sources from Germany for
information on the field hamster (Cricetus cricetus).
In the latter half of the 19th century, the species
was still common in this country (Nechay 2000),
but apparently no corresponding studies have
been published, while there have been findings
of malformed mandibles for the species from the
Netherlands (Van Bree & Jansen 1962).

Other phenomena, such as the rotation of a P₄ in a
squirrel of the genus Petaurista, found in the USA,
whose buccal surfaces were mesially oriented
(Miles & Grigson 1990), or bone proliferations
on the skull, can also be expected for the local
faunal area presented in this paper. The latter
is regularly reported in domestic animals (e.g.
Negrin et al. 2006, Gold et al. 2019). The absence
of bony proliferations on the skull goes against 25
findings of these phenomena in the jaws of small
mammals. The reasons for this absence can only
be speculated upon. Perhaps there is a higher
risk of contracting an infection through an injury
to the mobile lower jaw area, which then leads
to a bone ulcer. However, although there have
been no corresponding publications from other
faunal regions, in general such a phenomenon
can be expected in the cranial region of wild small
mammals. We broadly assume that all the findings
recorded in our study can occur in all small
mammal species and that these will be revealed in
further studies.

A combination of several abnormal and/or
pathological phenomena has been illustrated,
both in the literature studied here and our own
research. In many cases, the sequence of events
that has led to these phenomena is not clear. Further
research in this field is necessary to be able to fully
characterise their origin.

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