A C T A T H E R I O L O G I C A

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Tooth Anomalies in Some Canidae

[With 1 Table & 7 Figs.]

A number of series of tooth anomalies of the same type in three carnivore species is described. The most interesting are the following: supernumerary teeth near Pm^4, which appearance may be accounted by atavismus; reduction of M^2, that demonstrates the possible way of demolarisation of this tooth under the shortening of maxillary tooth-row; the splitting of the Pm^1—Pm^3, that shows an influence of morpho-genetic field upon development of the tooth under abnormal condition. Generalized scheme of possible ways, by which the appearance of supernumerary teeth in mammalian tooth row may be accounted, is discussed.

I. INTRODUCTION AND METHOD

Some interesting dental anomalies were found during an examination of the skulls of the fox *Vulpes vulpes* (Linnaeus, 1758), the arctic fox *Alopex lagopus* (Linnaeus, 1758) and the grey fox *Urocyon cinereoargenteus* Erxleben, 1777 in the collections of the Zoological Museum, Lomonosov University in Moscow, the Institute of Zoology, U.S.S.R. Academy of Sciences, and the Biological Institute, Siberian Centre of the U.S.S.R. Academy of Sciences.

The present paper contains a detailed description of these anomalies and an analysis of quantitative relations, which permit a better grounded discussion of the origin of dental anomalies.

In order to characterize the teeth quantitatively, the following measurements have been taken: (1) the overall tooth height, from the tip of the root to the highest point of te crown, (2) the length and (3) width of the crown, measured by the cingulum, and (4) the length and (5) height of the crown top, measured using a micrometer eye-piece, the straight line connecting the points where the meso-distal ridge merges with the cingulum being assumed as the crown basis. On the other hand, to characterize the position of a tooth in the tooth-row a projection was produced using a camera lucida and the angle between the meso-distal axis of two neighbouring teeth was measured. The meso-distal axis of a tooth is the straight line that connects the remotest mesial and distal points of the alveoli of

respectively the anterior and the posterior root. The nomenclature adopted for the elements of the tooth crown is that used by Vandebroek (1961). The description of each anomalous specimen is preceded with data concerning the specimen number, collection, sex and locality. The following designations are used for the collections: ZM — Zoological Museum, ZI — Zoological Institute, Ac. of Scs. and BI — Biological Institute, Ac. of Scs.

II. DESCRIPTION OF ANOMALIES

1. Fox, *Vulpes vulpes* (Linnaeus, 1758)

Coll. No. 9144, ZI, ♀, Białowieża Forest. Partial transverse split of both P^1 crown into two cusps. Tops of split crown disposed in meso-distal tooth axis, there being no ridge between them. The right tooth has two roots and the left one one. Each root of the right premolar has a separate alveolus and the root of the left tooth is somewhat elongated.

Coll. No. 25385, ZI, ♀, Vologda Oblast. Anomaly of P^1 analogous to the previous one. Its root is single and does not differ from the roots of normal P^1 teeth.

Table 1

The measurements of the first abnormal premolars in the fox.

Coll. no.	Anterior cusp		Posterior cusp		Split depth	Crown length
	Length	Weight	Length	Weight		
9144 right	3.4	3.1	4.2	2.4	3.2	7.6
9144 left	2.0	3.1	2.5	2.4	2.4	5.0
25385 right	2.2	3.0	2.9	3.0	1.6	5.1

In all the three teeth the anterior cusp is shorter and higher than the posterior one (Table 1, Fig. 1 a, b, c). The middle vertical axis of anomalous P teeth has not probably been shifted down the tooth-row.

Coll. No. S-94276, ZM, ♀, Bet-Pak-Dala. Complete transverse split of right P^1 into two distinct teeth situated in the longitudinal axis of the tooth-row. Either of them has one top and one root. The posterior tooth is somewhat longer than the anterior one, its root is partly divided by a vertical groove, which is missing on the root of the anterior tooth. The crown of the posterior part of the split premolar is also more complex than the crown of the anterior part. In addition to the meso-distal ridge, pronounced on both parts as well as on normal P^1 teeth, the crown of the posterior part has a ridge, which on the internal slope descends from the apex of the eocon to the internal portion of the cingulum which is somewhat thickened (Fig. 1c and d).

Coll. No. 7132, BI, Novosibirsk Oblast. Partial split of crown of right

P^3 by transverse fissure into two cusps. There is no meso-distal ridge between the anomalous cusps. Sub-parallel ridges descend one from either cusp in a meso-central direction. The ridge on the anterior cusp is more conspicuous. An indistinct distocon occurs in the distal part of the crown. This premolar has three roots in its longitudinal axis (Fig.

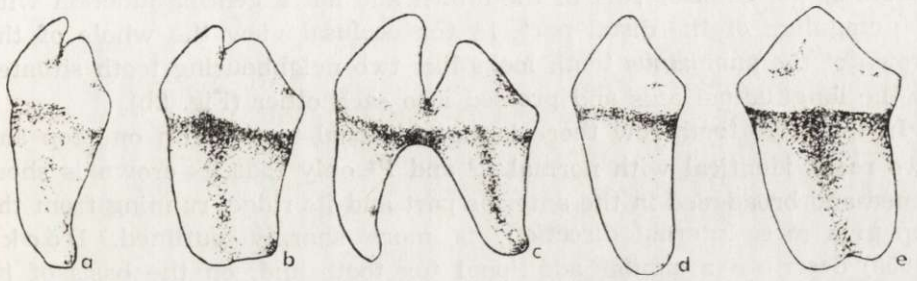

Fig. 1. Asymmetrical split of P^1 in the fox (*Vulpes vulpes*), a side view.
a — left P^1 (9144), b — right P^1 (25385), c — right P^1 (9144) d—e — anterior and posterior parts of right P^1 (S-94276).

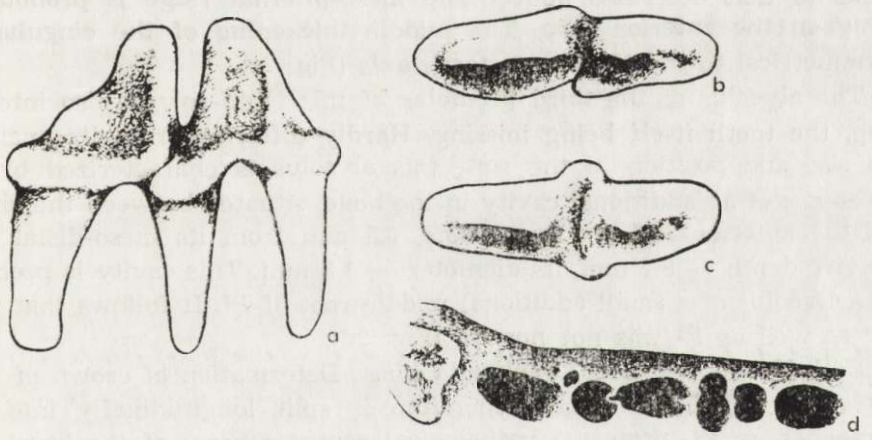

Fig. 2. The split of P^2 and P^3 in the fox (*Vulpes vulpes*).
a — right P^3 (7132), lingual view, b — occlussal view of the same tooth, c — right P^2 (S-3016), occlussal view, d — arrangement of some alveoli of the right maxilla S-3016).

2a). The anterior and posterior roots correspond to the roots of normal P^3 as regards their position in relation to the cusp of the crown and the third root is situated under the fissure of the crown. The cross-section of this root is an ellipse, a long axis of which forms an angle of 35° with the meso-distal axis of the tooth. The grooves running on the internal side of the extreme roots extend on the middle root, without how-

ever reaching to its cusp. The internal and external parts of the cingulum form a bulge over the additional root. The internal bulge is separated by a steep bend from the cingulum of the distal part of the crown but passes gently into the cingulum of the anterior part. On the other hand, the external thickening passes more abruptly into the cingulum of the anterior part of the crown and has a gentler junction with the cingulum of the distal part. In the occlusal view the whole of the crown of the anomalous tooth looks like two neighbouring teeth situated in the longitudinal axis and pressed into each other (Fig. 2b).

In the same tooth-row there is an additional tooth, with one top and two roots, identical with normal P^2 and P^3 only that its crown is shortened and broadened in the anterior part and its ridge, running from the top in a meso-internal direction, is more sharply outlined. Döcke (1959) described a similar additional fox tooth and, on the basis of its likeness to P^3, considered it to be a part of the split bud of P^3. In our case the additional tooth differs from both P^2 and P^3 to the same degree.

Coll. No. S-3016, ZM, Kanin Peninsula. Partial splitting of P^2, analogous to that described above. The meso-internal ridge is pronouneed only on the anterior cusp. The middle thickening of the cingulum is symmetrical to the transverse tooth axis (Fig. 2c).

The alveolus of the third premolar of this tooth-row is also interesting, the tooth itself being missing. Hardly differing from its analogue in size and position in the row, this alveolus is characterized by the presence of an additional cavity in the bone, situated between the alveoli of the anterior and posterior roots, 1.5 mm from its meso-distal axis. Cavity depth — 6.7 mm, its diameter — 1.8 mm. This cavity is probably the alveolus of a small additional middle root of P^3. It follows that right P^3 as well as P^2 was not normal (Fig. 2d).

Coll. No. S-1984, ZM, Orenburg Oblast. Deformation of crown of right M^2 (Fig. 6a). The external cingulum is split longitudinally into two branches, which protect a pathological robust process of the basal portion of the external margin of the crown from above and from below. The process unites the lower branch of the cingulum with the roots and the upper branch with the external cusps. The external part of the trigon has three round cusps, the eocrista being lacking. Each cusp is closely surrounded by the appropriate portion of the upper branch of the split external cingulum. The external middle cusp has an apical process directed buccally. The internal part of the trigon is reduced to low small cylinders at the base of the crown, corresponding to the epicrista and plagiocrista in respect of their position. The endocon is hardly changed. The distal margin of the crown has a process resembling a root. The roots of the tooth are almost unchanged.

Coll. No. S-87397, ZM, Yakutsk Region. Deformation of crown and roots of left M^2 (Fig. 6b). The while of the crown is bent so much that the talon and external cusps are brought close to each other. The cingulum is missing. The distocon is well developed and it bears the corresponding meso-distal portion of the ridge. Instead of the eocon there is a cup-shaped depression, the margins of which rise above the base of the crown. The epicon is thickened and displaced towards the eocon. The endocon is raised above the crown base and shifted towards the distocon. There is no plagiocrista, and therefore the base of the talon is not separated from the base of the trigon. The meso-external root is strongly reduced, the disto-external root is elongate and thickened and the internal one is overgrown and extended transversely.

Coll. No. S-87936, ZM, Yakutsk Region. Anomal of left M^2 expressed by a decrease in size and a simplified structure (Fig. 5a and b). Crown length — 6.4 mm, width — 4.5 mm, overall tooth height — 8.4 mm. In its occlusal view the crown is triangular, the cingulum is well developed. There are three cusps: the external ones (eocon and distocon) have a pronounced meso-distal ridge; the internal cusp is joined to the distocon by a poorly developed ridge; it is much smaller than the external cusps and nearly fused with the cingulum. The single root of this tooth is of the shape of a pyramid, the vertices of the base of which lie under the cusps of the crown. The root has two grooves, an external and an antero-internal, which separate the part of the root under the eocon.

2. Arctic Fox, *Alopex lagopus* (Linnaeus, 1758)

Coll. No. S-30373, ZM, Bering Island. Additional root on right P^3, smaller than the normal ones and situated between them under the internal margin of the cingulum. It is directed perpendicularly downwards. The middle portion of the cingulum over this tooth is thickened. The size and shape of the tooth crown are normal.

Coll. No. S-5090, ZM, Medniy Island. Bilateral anomaly of P^3, analogous to that described above. The additional roots on both teeth are similar to the previous one in respect of size and position. On both teeth the ridge extending meso-internally from the apex of the eocon and the thickening of the cingulum over the addditional root are more pronounced than they are in the previous case (Fig. 3a). The anomaly is accompanied by slight changes in the position of the teeth in the normal tooth-row. Döcke (1959) described an analogous case of an increase in the number of roots in P^3 of the fox, in which the presence of a third tooth was accompanied by the splitting of the tooth crown into two cusps.

Coll. No. 9490, ZI, Medniy Island. Additional tooth in the left mandible, situated between P_2 and P_3 on the internal side of the tooth-row. In this connection the position of these last teeth in the tooth-row is somewhat changed. The crown of the additional one-cusp tooth is fairly high and conic; the cingulum is lacking. Three roots, the bases of which lie close to each other, can be distinguished as an anterior, a posterior and a middle one. All the three roots are underdeveloped and thin, which is especially true of the middle one. This tooth differs sharply from any permanent or milky tooth of the arctic fox (Fig. 3b). It may have developed from a part of the entirely split bud of P^2 or P^3. It may as well belong to the anomalous milky generation.

Coll. No. 2171, ZI, Medniy Island. Additional tooth in left maxillary tooth-row. It is situated on the internal side of P^4 and its anterior part

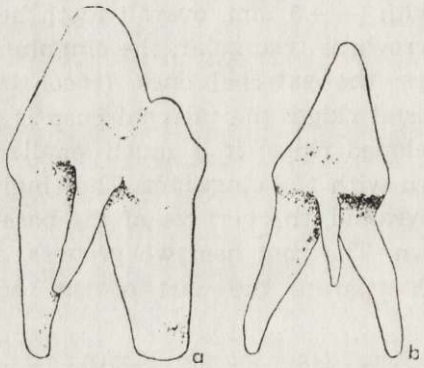

Fig. 3. Abnormal three-root teeth of *Alopex lagopus*, a lingual view. a — P^3 (S-5090), b — additional tooth in the mandible (9490).

squeezes into the space between the eocon of this last tooth and the internal margin of its crown. The angle between the meso-distal axes of the additional tooth and P^4 is 18°. The crown of the additional tooth is typical, with two cusps, the distocon being lower than the eocon. A poorly developed ridge, which forms small thickenings where it fuses with the cingulum, descends meso-internally from the apex of the cusp, homologously to the eocon. The cingulum is well developed, especially in the distal portion of the crown, where it forms a bulge, the distostyle. The anterior portion of the crown is wider than the posterior. The tooth has three roots, two normally developed (mesial and distal) and the third one very thin, which is a splinter of the antero-internal portion of the posterior root and has a separate alveolus.

Coll. No. 2321, ZI, Medniy Island. Bilateral anomaly of maxilla, analogous to the previous one (Fig. 4a). The angles between the mesodistal

axes of the additional teeth and the respective carnassials are 28° on the left side and 45° on the right. The structural elements of the crown of the right additional tooth are less pronounced than those in the previous case. The tooth has two roots, normally positioned in relation to the crown base. The crown of the left additional tooth is broken and

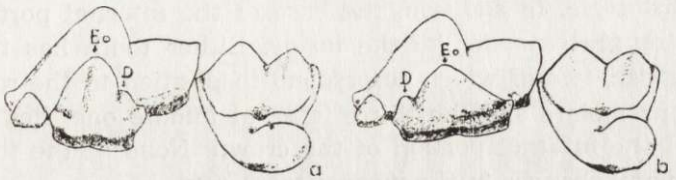

Fig. 4. Additional teeth by P^4 in *Alopex lagopus* (a lingual view of the left tooth-row).
a — position of additional tooth (2171), b — revers position of additional tooth (S-35694).

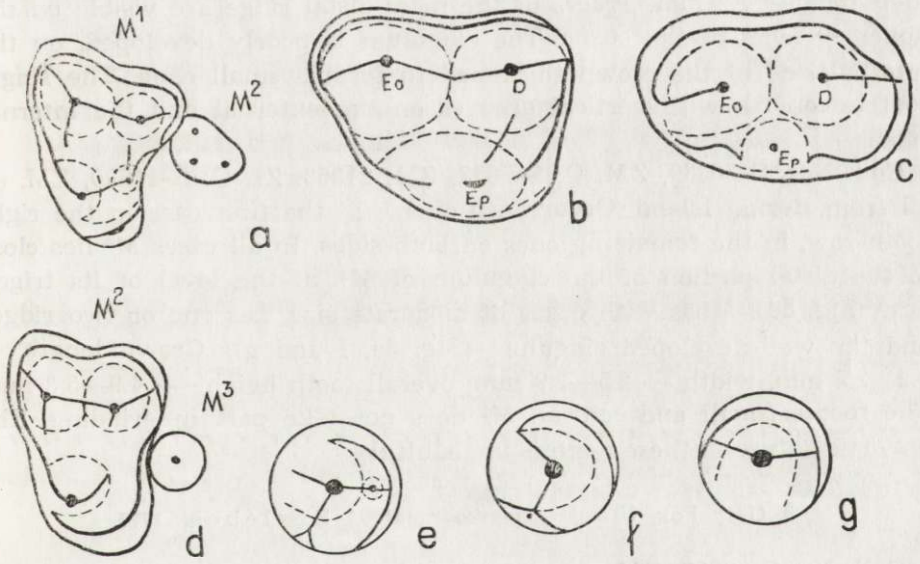

Fig. 5. Reduced M^2 and atavistic M^3 in the fox and arctic fox.
a — position of reduced M^2 in relation to M^1 in the fox (S-87936) and arctic fox (S-35929), b — crown structure of reduced M^2 in the fox, c — same in the arctic fox, d — position of atavistic M^3 in relation to M^2 in the arctic fox (S-30339, S-5033, 21358 and 11990), e—g — variation in structure of atavistic M^3 in the arctic fox.

missing from the collection. This tooth has two roots smaller than those in the right additional tooth.

Coll. No. S-35694, ZM, ♂, Dikson Island. Additional teeth in both maxillary tooth-rows, situated on the internal side of the carnassials.

They differ from the previous cases in being turned by 180° (Fig. 4b). The meso-distal axes of the additional teeth and carnassials are subparallel. The crown of these teeth resembles the crown of No. 2171 in general characters. The meso-distal ridge is distinct on the anterior slope of the eocon. Although poorly developed, the cingulum forms the mezostyle and distostyle. In addition, the base of the internal portion of the crown in strongly extended to the inside. Either tooth has three roots of the same size, two of which correspond in position to the roots of the two-rooted premolars and the third, internal middle one, lies under the extension of the internal portion of the crown. None of the three specimens shows any changes in the normal tooth-row.

Coll. No. S-35929, ZM, Dikson Island. Anomalous left M^2, showing a change in size and a simplified structure (Fig. 5a and b). Crown length — 4.4 mm, width — 3.4 mm, overall tooth height — 6.3 mm. Crown oval in shape, with two cusps. Cusps low and conical; distance between their tops — 1.2 mm. Traces of the meso-distal ridge are visible on the upper surfaces of the cusps. The cingulum is poorly developed, on the internal side of the crown thickened to form a small cone. The single root is conical, with vertical grooves on the external and the internal side.

Coll. Nos. S-30339, ZM, ♀; S-5083, ZM; 21358, ZI, ♀; S-11990, ZM, ♂, all from Bering Island. Occurrence of M^3, in the first case in the right tooth-row, in the remaining ones on both sides. In all cases M^3 lies close to the distal portion of the cingulum of M^2, at the level of its trigon base (Fig. 5d). M^3 is with cusps of moderate size, has one or two ridges and the well-developed cingulum (Fig. 5e, f and g). Crown length — 2.2—2.5 mm, width — 2.5—2.9 mm, overall tooth height — 4.9—5.3 mm. The root is small and conical. M^3 does not take part in grinding. The atavistic nature of these teeth is undoubtful.

3. Grey Fox, *Urocyon cinereoargenteus* Erxleben, 1777

Coll. No. S-93387, ZM, provenance unknown. Anomaly in structure of left M^1 and M^2. The crown of M^1 (Fig. 6c) is somewhat reduced in size and concave in the region of the trigon base, which causes a change in the curvature of the distal portion of the cingulum and the bringing of the endocon, rising above the base of the talon, and the internal cusps near together. The epicon has no longer its normal pyramidal shape but is transformed into a cylindrical structure inclined towards the trigon base. The epicrista and plagiocrista are lacking. The roots are reduced and the angle between the external pair of roots and the internal root is increased as a result of the distortion of the crown.

The crown of M^2 (Fig. 6d) is somewhat smaller and the trigon base lies deeper than it does on right M^2. The curvature and shape of the distal portion of the cingulum are the same in both M^2. The talon of the abnormal M^2 is narrower and raised more distally to the trigonal portion of the crown than it is in the right tooth. The epicon is displaced inward the crown, lying close to the distal portion of the cingulum. The epicrista is expanded so much that the epicon is the highest cusp of the crown. The epicon bears an apical process directed towards the meso-distal ridge and forming a specific bridge over the trigon base. The external part of the cingulum closely embraces the eocon and distocon and fuses with the meso-distal ridge between these cusps. The roots of this tooth

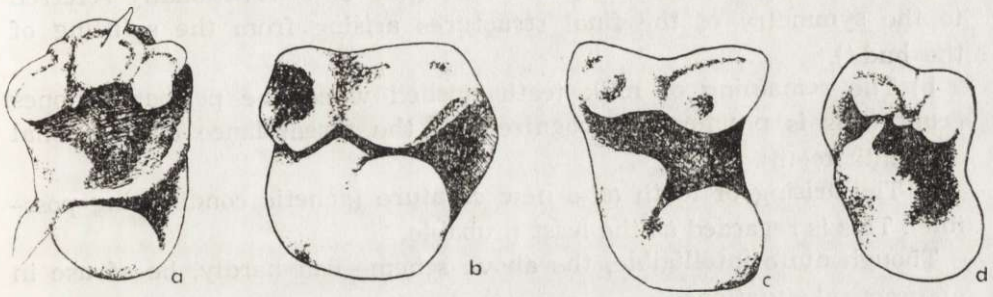

Fig. 6. Anomalies of the upper molars in the fox (*Vulpes vulpes*) and grey fox (*Urocyon cinereoargenteus*) (occlusal view).
a — right M^2 of *V. vulpes* (S-1984), b — left M^2 of *V. vulpes* (S-87397), c — left M^1 of *U. cinereoargenteus* (S-93387), d — left M^2 of same specimen.

are also abnormal; the internal root is uncovered and sticks out above the base of the crown. The external roots have their bases close to each other.

III. DISCUSSION

An analysis of the anomalies described and their comparison with the data from literature permit some generalizations. The most interesting cases are those of the occurrence of additional teeth simultaneously with P^4 (specimens Nos. 2171, 2321 and S-35694). Cases of an anomalous increase in the number of teeth in mammals are well known, such cases are however evidently rare (of. Lüps *et al.*, 1972). Particular authors (Wood & Wood, 1933; Cohrs, 1952, cited after Dolgov & Rossolimo, 1964; Döcke, 1959; Kurtén, 1963) explain the appearance of additional teeth in different ways. Their interpretations may be classified as follows:

1. Original typical polyodontia. The occurrence of additional teeth is

atavistic in its nature and conditioned by the genetical rearrangement or by activation of the morphogenetic field (which is also genetically conditioned). Additional teeth appear at the beginning or at the end of the row of cheek teeth.

2. Secondary atypical polyodontia. The occurrence of additional teeth is not associated with atavisms and is hardly possible as a result of genetic rearrangements. There is a view (Sheppe, 1964) that all the cases of polyodontia are secondary in this sense. The additional teeth are not precisely located. Secondary polyodontia may arise from:

a) The complete splitting of a permanent or or milk tooth bud. It is supposed that the teeth developing from parts of a split bud which are supposed to be identical. This similarity may be conventionally referred to the symmetry of the final structures arising from the splitting of the bud *).

b) The remaining of milk teeth unshed when the permanent ones erupt (this is practically recognized by the resemblance of additional and milk teeth).

c) The arising of tooth as a new creature (genetic conditioning possible). This is regarded as the least probable.

Though quite intelligible, the above scheme can hardly, be of use in all practical situations.

The additional tooth in the mandible of No. 9490 indicates that the anomaly of the milk dentition or the »secondary« one of a single part of the split bud makes the identification of additional teeth and, in consequence, an analysis of their origin impossible in a great many cases. An analysis of the structure of the additional teeth in Nos. 2171, 2321 and S-35694 shows that all the above-listed causes of origin may be applied to some degree for these teeth.

Firstly, these anomalies may result from the sufficiently early split of the bud of P^4. In this case, in consequence of a slight differentiation of cells, the external part of the split bud may have led to the formation of the normal carnassial (which agrees with somatic embryogenesis). Then the position of the additional teeth in No. S-35694 may be explained as a result of the reversed movement of the internal part of the split bud. That this is possible is evidenced by the following fact. Zarudnoi (1890) described a cheetah skull with two normally developed parmanent fangs, situated in the longitudinal axis of the left maxillary tooth-row, the posterior one being turned round its vertical axis by 180°.

*) Gudin (in litt.) believes that the partial or complete split of a tooth bud is atavistic and that it supports the concrescence theory of origin of multicuspidate teeth.

It is also possible that these teeth belong to the abnormal milk dentition, as they have some resemblance to the second milk premolar.

Lastly, these teeth may have arisen as new structures, for if the additional and normal teeth of the arctic fox are arranged in the sequence shown in Fig. 7a—e, *i.e.*, permanent P^2, additional tooth of Nos. 2321 and S-35694, milk P^2 and permanent P^4, it will be seen that in this sequence the molarization of teeth increases, which is expressed by an increase in the complexity of the structure of their crowns and roots. If this sequence is not an artefact and is compared with the cheek tooth-row, where the molarization of homologous structures increases from the front backwards, it may be supposed that the appearance of these additional teeth is related to atavism to some degree.

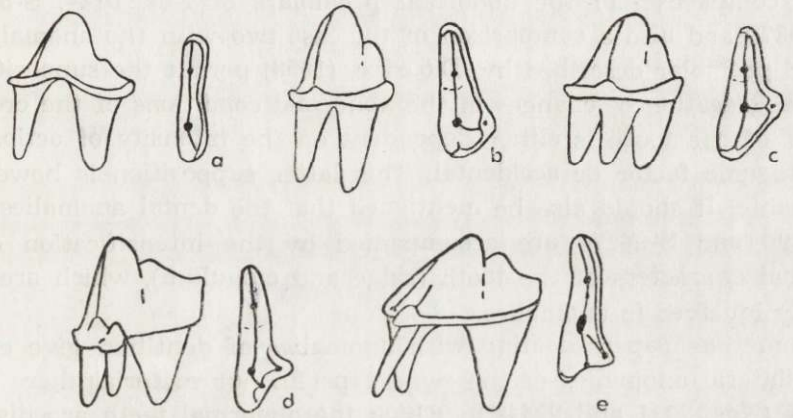

Fig. 7. A diagram suggesting the atavistic nature of the additional teeth of the arctic foxes 2171, 2321 and S-35694.

The left column — lingual view of teeth, the right column — occlusial view of the same teeth, relative sizes of teeth are not followed. a — permanent P^3 of arctic fox, b — additional tooth (2321), c — additional tooth (S-35694), d — milk P^2 of arctic fox and e — permanent P^4 of arctic fox.

Special attention should be given to the reduction of M^2 in the fox and the arctic fox. This anomaly very probably shows a possible way of the progressive demolarization of M^2 in the process of the evolutionary shortening of the tooth-row from the rear. In addition, a number of such characters as the presence of a ridge connecting the distocon with the internal cusp and the incomplete fusion of this last with the internal part of the cingulum, allow us to homologize the internal cusp with the epicon and the whole crown of the reduced tooth with the trigonal part of the crown of normal M^2.

A close analysis of the above-described splits of crowns and whole teeth of P^1, P^2 and P^3 shows that the parts of a split tooth are not

identical. It is noteworthy that the meso-internal ridge, which occurs in the anterior portion of the crown of normal P^2 and P^3, is better developed on the anterior cusp of split P^2 and P^3. On the posterior cusp this ridge is very poorly developed (P^3) or lacking (P^2). On the contrary, the posterior part of split P^1 (No. S-94276) possesses this ridge. It may well be that the nonconformity found between the parts of a split tooth depends on the stage of the histomorphological differentiation of the bud during which it undergoes an influence of the teratogenic factor (in splits of P^2 and P^3), or on different fates of the parts of a split bud, *e.g.* the posterior part of split P^1 of No. S-94276 may have developed under the influence of a different gradient of the morphogenetic field of premolars.

A comparison of the abnormal premolars of Nos. 9144, S-5090 and S-30373 and also a comparison of the last two with the anomaly of the third premolar described by Döcke (1959) permit the supposition that the aggregation of changes in the abnormal conditions of the crown and roots of one tooth is either dependent on the intensity of action of the teratogenic factor or accidental. This latter supposition is however less probable. It should also be mentioned that the dental anomalies of Nos. S-5090 and S-94276 are accompanied by the intensification of some normal characters of the tooth (ridge and cingulum), which are not directly involved in anomalies.

Numerous papers dealing with anomalies of dentition give examples of bilateral anomalies of the same type. In our material there are two cases (Nos. 2321 and 9144) in which the abnormal teeth are distributed in parallel rows and characterized by a different degree of development of one and the same abnormal character. Moreover, there are two cases of anomalies of the same type concerning two neighbouring teeth of the same row (S-3016 and S-93387) to a various degree.

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ANOMALIE UZĘBIENIA NIEKTÓRYCH *CANIDAE*

Streszczenie

Opisano różnorodne anomalie uzębienia u lisa *Vulpes vulpes* (Linnaeus, 1758), pieśca *Alopex lagopus* (Linnaeus, 1758) i *Urocyon cinereoargenteus* Erxleben, 1777 (Rys. 1—7, Tabela 1). Do najciekawszych anomalii zaliczyć należy dodatkowy ząb obok Pm^4, co określa się jako cechę atawistyczną. Redukcję M^2 można uważać za typowy objaw zmniejszania się liczby zębów, przy skracaniu się szeregu zębowego szczęki. Inne zmiany wyrażają się w zlewaniu się Pm^1 do Pm^3, co sugeruje zmiany morfogenetyczne w czasie rozwoju. Dyskutuje się też jakie są możliwości powstawania dodatkowych zębów.