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Lucjan SYCH and Barbara SYCH

An Evolutionary Interpretation of Several Ontogenetic Stages of the Tooth Development in Rabbit

[Pp. 33—44, Pls. VI—XIII, 2 text figs]

Ewolucyjna interpretacja niektórych stadiów ontogenetycznego rozwoju uzębienia królika

Эволюционная интерпретация некоторых стадий онтогенетического развития зубов кролика

Abstract. The existence of two morphological gradients in the dentition of both contemporary and fossil lagomorphs was pointed out, using comparisons of different stages in the ontogenetic development of dental structures, such as hypostria and crescent. This last structure, which disappeared in lagomorphs in the Miocene, was successfully identified in the early developmental stages of the permanent premolars and molars of the rabbit. Resemblances were found in the order in which several dental structures arise and disappear in ontogeny and phylogeny.

INTRODUCTION

Treatment of individual teeth in the tooth-row as structures serially homologous in their ontogeny (VAN VALEN, 1970; BUTLER, 1952; and a number of other authors) suggest the studying of their phylogenetic (historical) homology, provided that suitable comparative fossil material is available. Such a study is possible because there are some common links in two sorts of variation, the serial variation (successive teeth of the tooth-row show a gradation in their morphological pattern) and the evolutionary one (particular tooth structures, remote from each other in time, show a differentiation in the morphological pattern of individual teeth, which, presented in one tooth-row, cannot be explained in terms of serial variation without finding intermediate stages). The common links of these two sorts of variation are the parts of the morphological pattern that repeat in different stages of their ontogeny regardless of the geological age of the species they pertain to. It will be to the point to quote BUTLER'S (1967) opinion: "It is unlikely therefore that stages in ontogeny will recapitulate completed teeth of ancestral forms..." (p. 561) and "thus, whereas the tooth as a whole cannot be regarded as recapitulating ancestral stages, details of the pattern may follow parallel paths in ontogeny and phylogeny" (p. 562). Then, at least some of the dental structures compared in various stages of ontogeny and phylogeny show common elements that have the same genetic basis. It should be added that this fact is illustrated to a very various degree by different groups of mammals. In the *Lagomorpha* this parallelism is found repeatedly (SYCH, 1976, in press). Moreover, in course of the evolution of lagomorphs some morphological gradients show changes the reminiscences of which one can try to find in the ontogeny of contemporary species. *Oryctolagus cuniculus* (L.) makes convenient material in this respect. We examined several consecutive stages of the growth of teeth on it, thus having an opportunity to get to know at least two different morphological gradients in the development of dentition.

Another purpose of this study was an attempt to identify the structure termed the "crescent", missing in the permanent dentition of the contemporary species of the *Lagomorpha* but of a great morphological importance in the fossil forms up to the end of the Miocene. The question also put forward in this study is whether in the presence of great morphological differences between the upper and lower dentition it is possible to find a common section of the developmental path in the ontogeny of the *Lagomorpha*. In other words — using the terms of the theory of morphogenetic fields and gradients — whether there is a common gradient in the development of the pattern of the upper and lower tooth-row in their ontogeny.

Acknowledgment. We wish to thank to Mrs. Halina KOWALIK for preparing numerous laborious auxiliary drawings of the histological sections of basic importance at the tooth shape reconstruction.

MATERIAL AND METHOD

Two kinds of material were used, histological material and sets of teeth of contemporary and fossil lagomorphs.

The histological material consisted of 13 series of sections representing several postnatal stages of the rabbit *Oryctolagus cuniculus* (LINNAEUS, 1758). These series had been used by Prof. J. STACH for his studies on the ontogeny of the incisors and on tooth replacement in the dentition of mammals (1904 and 1910). Decalcified specimens were prepared by the celloidin technique, stained with eosin and haematoxylin, and sectioned in horizontal and sagittal planes. The following developmental stages were used for observation in the present study:

1. newborns — 1 series of sagittal sections through both mandible and maxilla at the same time,

2. 4-day-old specimens — 3 series: 2 sagittal through mandible and maxilla and 1 horizontal of mandible,
3. 9-day-old specimens — 3 series: 2 sagittal through mandible and maxilla and 1 horizontal series of mandible,
4. 12-day-old specimens — 1 horizontal series of mandible,
5. 21-day-old specimens — 2 sagittal series of mandible and maxilla,
6. adults — 2 series of sagittal sections of mandible and maxilla and 1 horizontal series of mandible.

In addition, observations were made on skulls of 2-day-old rabbits from two different litters, a specimen of *Oryctolagus cuniculus*, about 15 days of age, from the collection of the British Museum (HINTON'S collection, Herefordshire) and fossil material: a series of specimens from four age groups of *Desmatolagus gobiensis* MATHEW & GRANGER, 1923 Ser. No. MgM III 79 and 80, in the collection of the Institute of Palaeozoology, Polish Academy of Sciences, in Warsaw and a series of specimens of *Paleolagus haydeni* LEIDY 1856 No. ZZS MF/873/8, in the collection of the Institute of Systematic and Experimental Zoology, Polish Academy of Sciences, in Cracow.

OBSERVATIONS

General Remarks on Distinctive Characters of Successive Stages

Upper Tooth-row

Newborns (Pl. VI).

M^1 and M^2 in the form of buds, M^1 being several times as large as M^2. Out of the milk-teeth, DP^3 has the form of an undifferentiated bud; DP^3, DP^4 and M^1 have a very shallow hypostria and a crescent. The buds of the permanent premolars are lacking. The teeth are all hidden deep under a gum layer.

4-day-olds (Pl. VII)

Out of the molars, only M^2 is well developed, with a short hypostria and crescent. M^2 occurs merely as a large bud, showing no differentiation into characteristic structures. There are, as yet, no traces of M^3. DP^2, DP^3 and DP^4 are present, but their characteristic structures are poorly differentiated. Nevertheless, the hypostria occurs in the form of a shallow fold on DP^3 and DP^4. The crescent is best developed on DP^4, small on DP^3, whereas on DP^2 it is but a deep fold pressed in from in front. From among the premolars, only P^4 and P^3 are visible; P^4 is more advanced in development than P^3, still in primordial form, its shape being undifferentiated into typical structures. No traces of P^2. All teeth still hidden under gum.

9-day-olds (Pl. VIII)

The first and second upper molars are well developed, both with a hypostria (shorter on M^2 than on M^1) and crescent (smaller on M^2 than on M^1). M^3 is a bud, globular in shape.

On DP^3 and DP^4 the hypostria and crescent are still more advanced and the anterior fold on DP^2 is still deeper than in the 4-day specimens.

P^3 and P^4, with hypostria and crescent, larger (longer) than DP^3 and DP^4. DP^2 already bears a trace of hypostria. Only the tops of the DP^3 and DP^4 crowns have erupted.

21-day-olds (Pl. IX)

M^1 and M^2 erupted; M^3 hidden deep, undifferentiated. DP^2, DP^3 and DP^4 completely erupted, with first traces of the wear of their crowns. Premolars with hypostria and crescent.

Lower Tooth-row

Newborns (Pl. VI)

DP_3, DP_4 and M_1 well developed, with their trigonids and talonids, i. e., respectively, the anterior and posterior parts, differentiated and separated from each other. M_2 still in the form of a globular bud.

4-day-olds (Pl. X)

In addition to the differentiation of DP_3 into the trigonid and talonid, there appears another external fold which cuts into the trigonid also on the buccal side. Thus DP_3 becomes three-lobed. The buds of the permanent P_3 and P_4 lose their globular shape and attain, respectively, a three- and a two-lobed structure. M_2 is divided into an anterior and a posterior lobe.

9-day-olds (Pls. XI, XII)

DP_3 and DP_4 are at the stage of eruption and so is the anterior portion of the trigonid of M_1. Permanent P_4 and M_2 elongated and equal in height, M_1 being about one and a half times as high as M_2.

21-day-olds (Pl. XIII)

Crenulation becomes visible on the large external fold of P_4, M_1 and M_2.

Hypostria

In the newborn and 2-day-old specimens the hypostria occurs merely on DP^3 and DP^4 and has the form of a scarcely marked grooved depression, which extends along the lingual wall of the tooth (Pl. VI, a). On the 4th postnatal day this groove lengthens and deepens to reach one-sixth of the linguo-buccal width of the crown of DP^3 and DP^4 (Pl. VII, a). At this time the buds of the permanent premolars do not show any differentiations yet except for P^4, which, being still in the form of a bud, has a small fold homologous to the hypostria (Pl. VII, a). In the 4-day specimen the hypostria of M_1 is deep and cuts into the tooth for over a half of its width. If this fold does not extend up to the root end in the lingual part of DP^3 and DP^4, it divides this part all over its height in M^1. At this stage M^3 has already a typical broad depression, which in its situation corresponds closely to the hypostria. On the 9th day the hypostia is present in nearly all teeth except M^3, which has an extremal position, and DP^2.

Then the permanent P^2 has a broad indent on the lingual side, which must be considered to be homologous to the hypostria on other teeth.

The profusely vascularized formative tissue containing numerous ectomesenchymal cells and vessels grows in as far as the bottom of the hypostria. This process increases so that in the 21-day specimens this tissue occurs in numerous internal foldings (the so-called crenulation — the term introduced by systematicians) of the hypostria. Sure enough, the activity of the ectomesenchymal cells is qualitatively differentiated here, since in the crown region the inside of the hypostria in older specimens is abundantly filled with cement, whereas in the root region the activity of the tissue tends to produce enamel. On account of the continuous growth of the teeth throughout the lifetime this process should, in addition, be studied in detail histochemically.

A slight undulation of both walls of the hypostria, which can be seen well in sagittal sections, is characteristic (Pl. IX, a, b, c). The undulation of tissue in this region is caused by a quicker increase in the number of cells of the tissue maternal to enamel. This is undoubtedly connected with the origin of the above-mentioned crenulation of the hypostria. Crenulation appears shortly before the 21st postnatal day.

Crescent

The crescent fold, made up of dentine and enamel and appearing in both deciduous and permanent teeth, deserves special attention. In the newborns it is visible merely on DP^2, DP^3, DP^4 and M^1, being already not only an accumulation of formative tissue in the coronal portions of these teeth but a structure which differentiates in the bucco-lingual direction (Pl. VI, a, b, c). The vascular network, abundant in the tissue that forms the crescent, communicates also with the network inside the pulp cavity. During its formation the crescent of M^1 is connected with the posterior region of the tooth, its part being pushed backwards (Pl. VI, b). On the 2nd postnatal day the shape of the crescent is better defined, i.e. one can distinguish its horns pointing sidewards. In the course of another two days the crescent expands inward and at the same time it appears on DP^2 as a deep fold, which on neighbouring DP^3 becomes closed in the front by the anterior wall of the tooth (Pl. VII, b). On DP^4 the fold is already closed and bent so that it is of semilunar shape (Pl. VII, a). The crescent of M^1 has the shape of a fold that opens posteriorly and, as a result, for a short time the pattern of the crown of M^1 constitutes the reversal of that on DP^3 and the fold of the crescent becomes partly removed. This is an evident intensification of the gradient of change of the anterior fold on DP^2 into the crescent (Pl. VII, c). The structures described are serially homologous. The intermediate shape of the crescent in DP^3 and M^1 on the 4th postnatal day, when it is still partly open on the anterior side, is here of great importance. The crescent, as a rule, develops from the well-vascularized formative tissue surrounding the crown portion of the teeth in the central region of each of them. It is supplied by the vessels from the pulp cavity. On the 9th day the crescent already occurs also in M^2, though it is less advanced in development than the crescent of M^1 (Pl. VIII, a, b). In the bud of the permanent P^2 an infolding develops on the anterior side. It corresponds to the fold of DP^2, which gives rise to the crescent of the next milk-teeth.

It is characteristic that the maximum of the crescent development in the permanent M^1 and M^2 falls in the period from the 9th to 21st postnatal day. The crescent of the 21-day-old specimens is relatively less well-developed and on the lingual side it fuses with the expanding hypostria. This phenomenon seems easy to explain, if we take into consideration the fact that its developmental process is controlled by the activity of two portions of the formative tissue, the crown-surrounding portion and that inside the cavity. At the time of the rapid growth of both these teeth their crown parts soon go beyond the zone of the formative tissue that surrounded them and the activity of the internal formative tissue supports the intensely developing hypostria. In consequence of these two phenomena the crescent remains at the stage of morphological development at which it has left the zone of activity of the formative tissue in a certain place of the morphogenetic field. This is also illustrated by the permanent P^3 and P^4, whose growth in height is prevented by the presence of DP^3 and DP^4. As a result, the possibility of formation of the crescent in the zone of activity of the crown portion of formative tissue is greater than in the case of M^1 and M^2. The crescents of P^3 and P^4 are actually very greatly differentiated as early as the 9th postnatal day and, what is more, they attain a greater differentiation at that time than do the crescents of DP^3 and DP^4 at any stage of growth. DP^3 and DP^4 erupt before the 9th postnatal day and therefore their crowns lose contact with the formative tissue relatively early and their crescents become raised above the gum and detained at the developmental stage at which they were about the 4th day. What, however, happens to the crescents of P^3 and P^4 in the course of their further growth? The formative tissue that surrounds their crowns and, at the same time, roots stops acting in favour of the enamel and dentine of the crescent and becomes the seat of the reduction process of the root portions of the milk-teeth. Simultaneously, owing to the growth of P^3 and P^4 in heigth, their crown portions leave the zone of activity of the gradients that have moulded them. There remains only a close connection of the internal part of the crescent with the vessels and formative tissue that grows deep into the then expanding hypostria. On the 21 postnatal day we find that the centrally arising folds of the hypostria crenulation interfere with the crescent and come to predominate over it. When finally the permanent premolars emerge after the shedding of their deciduous predecessors, their temporarily unworn occlusal surfaces show hardly any traces of the crescents, which now are united with the occlusal portions of the hypostriae.

Big External Fold

Ontogenetically, this is one of the oldest structures, well seen even in newborns (Pl. VI, a, b, c). It separates the trigonid and talonid, is very wide on the buccal side (Pls. X, XI, a, b, c) and narrows gradually towards the lingual side. At further stages it only undergoes a deepening in the lingual direction (Pl. VII, a, b, c). Crenulation, in the form of small undulations, appears about the 21st postnatal day (Pl. XIII, a). It is not as conspicuous as the crenulation of the hypostria, in which it besides resembles the adult specimens.

DISCUSSION

In the course of the evolution of the *Lagomorpha* from the Upper Eocene up to the present time their dentition has undergone considerable changes. The general directions of these changes are dealt with in a separate paper (Sych, in press). Here we take into account only the moments they share with the ontogenetic development. The order in which various structures appear, starting from the moment when the original subglobular shape of the tooth buds begins to chang in an apparent manner, is as follows:

1. the big fold (R) between the trigonid and talonid sets in the lower dentition several days before the birth,
2. the beginnigs of the crescent can be seen in newborns,
3. the hypostria appears distinct only between the 2nd and 4th postnatal day, and
4. the crenulation of the hypostria is not visible until about the 20th day.

Historically, these structures appear, in outline, in the following order:

1. The oldest, Upper Eocene, species have an almost fully developed fold between the trigonid and talonid (R), at least in the crown portions of most of the cheek teeth, and very distinct folds of the crescent, the maximum development of which is already attained in most Oligocene genera (e. g. *Desmatolagus* Matthew & Granger, 1923, *Palaeolagus* Leidy, 1856 or *Sinolagomys* Bohlin, 1937).

2. The hypostria undergoes a gradual deepening starting from the Oligocene to attain its full advancement as late as the Pliocene.

3. Crenulation first appears, in a slight form, in the lower dentition in the American Oligocene species of the genera *Megalagus* Walker, 1931 and *Palaeolagus* Leidy, 1856, but in the upper dentition it does not develop fully before the Pliocene or longer. Thus, the parallelism of the ontogenetic development of the rabbit teeth and the general phylogenetic tendencies is quite conspicuous here.

In phylogeny the two-lobed structure of the upper teeth, i.e. their division by the hypostria into the anterolophid and posterolophid was attained later than was the two-lobedness of the lower teeth and the same phenomenon can be observed in the development of the rabbit. As regards the gradient activity of the evocators (inductors) responsible for the morphogenesis of these structures, it seems possible not only that the gradient of development of the big lateral fold was historically the oldest, but also that it widened the range of activity in the morphogenetic field of the whole of dentition by extending with time on the upper tooth-row, where the activity of the formative tissue resulted in the rise of the hypostria. The hypostria is an internal fold and the big fold of the lower teeth an external one. The occlusion of the two teeth-rows is such

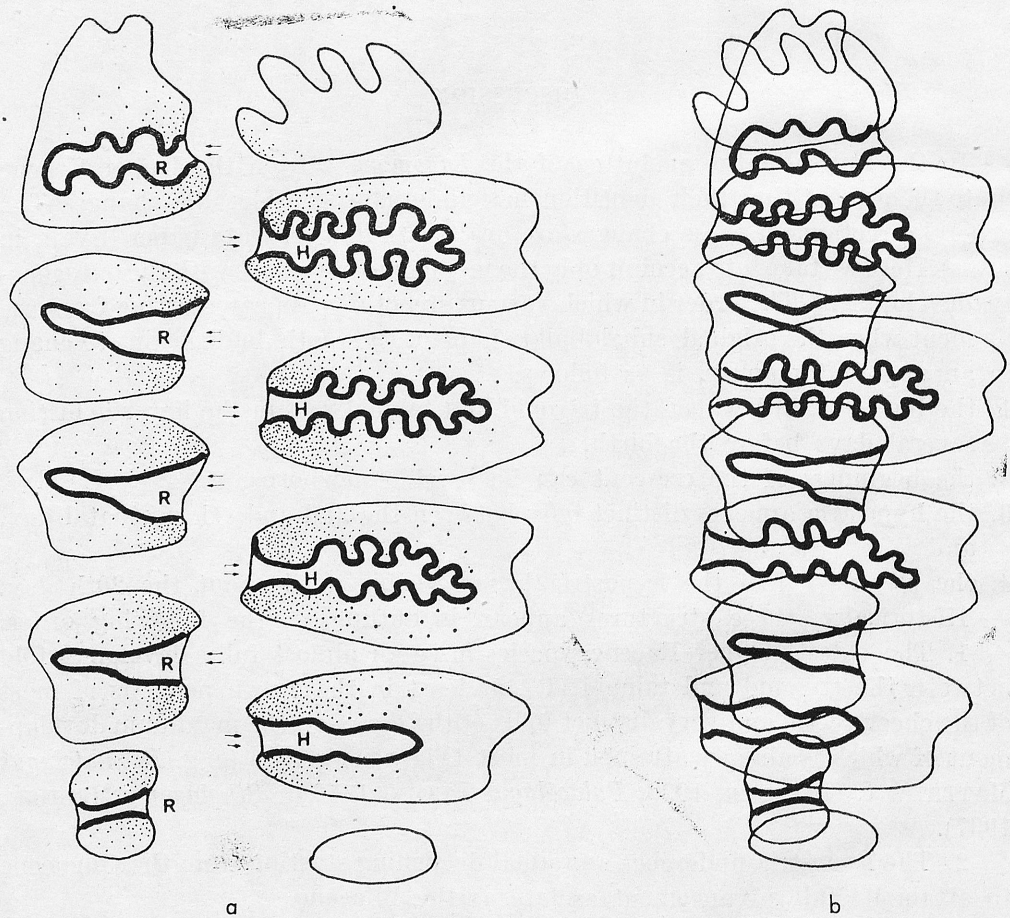

Fig. 1.a. Lower and upper tooth rows of rabbit with the big external fold (R) and hypostria (H) marked respectively with thick line. The gradient activity and its directions marked with arrows. The dots represent intensity of gradient. b. The same tooth rows in occlusion

that only the lingualmost portions of the upper teeth are in close contact with the buccalmost portions of the lower teeth. Thus, the admission of the existence of an antero-porterior axis of the gradient, placed centrally along these two tooth-rows and weakening both lingually and buccally, seems as a rule reasonable. A model of the action of such a gradient is presented in Fig. 1, which also shows the occlusion of the tooth-rows. The hypostria and the big external fold would therefore have common evocators, graduated by the same gradient, "activated" with delay in the upper dentition.

Fossil and contemporary lagomorphs provide examples of morphological differences between the milk-teeth and the corresponding permanent teeth in the same species (Wood, 1940; Dawson, 1958). Moreover, some milk-teeth, even those of contemporary species, e. g., of the genus *Ochotona* Gray, repeat in their shape the morphology of the permanent dentition of the species living tens of millions of years earlier. The milk-teeth of the old Oligocene forms of the genus *Palaeolagus* Leidy evidently bear some characters of the permanent teeth of their ancestors from the Upper Eocene. Therefore, the finding of the crescent in the milk dentition of the rabbit is nothing peculiar. The crescent is one of the oldest parts of the tooth in the evolution of the *Lagomorpha*. The

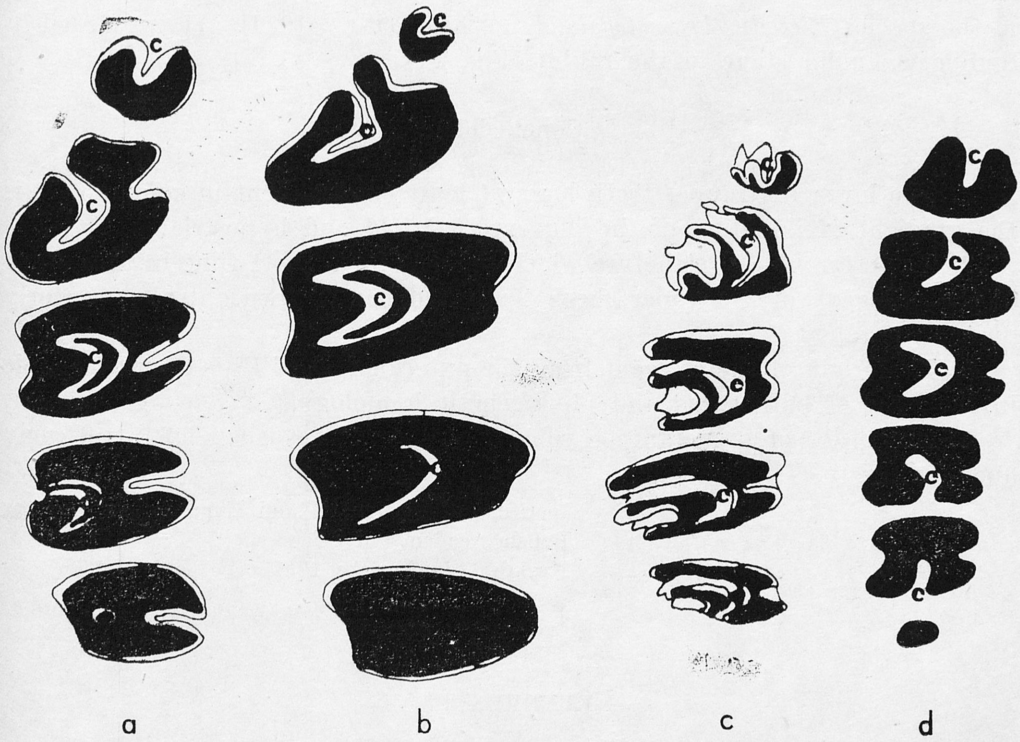

Fig. 2. Upper tooth rows of: *Palaeolagus haydeni* Leidy No ZZS MF /973/8 (a), *Desmatolagus gobiensis* Matthew & Granger No MgM III 79 (b) and *Piezodus Branssatensis* Viret from the paper by Lopez Martinez (1974) plate IV (c) and young *Oryctolagus cuniculus* (L.) (d) reconstructed on the basis of histological sections (see also Plate II, c). The development of the crescent (c)

Asiatic Upper Eocene species of the genera *Lushilagus*, and *Shamolagus*, and American *Mytonolagus*, have it in the central portion of the crown of P^3—M^1. In all the later species it is pronounced; it suffices to mention by way of example fold such genera as *Desmatolagus* MATTHEW & GRANGER, 1923, *Palaeolagus* LEIDY 1856, and *Piezodus* VIRET, 1929. The characteristic gradation of this pattern on the successive teeth of the upper row is observed in various species of these genera (Fig. 2). Thus we may speak of the gradient that accompanied the morphogenesis of the crescent. This gradient can be presented as a result of the action of a certain morphogenetic force which mouds the crescent from a simple fold on the anterior side of P^2, through the stage at which it is pressed into the middle of P^3, with its being simultaneously bent so as to attain a semilunar shape. The force that moulds the crescent on the successive premolars and molars would act on towards the rear, causing the pushing of this structure into the posterior portion of M^2. This position of the crescent can be seen, among others, in some species of the genus *Desmatolagus*. In the fossil material the "pushing-out" of the crescent to the rear, beyond the crown, and its transformation into an enamel fold which opens to the outside on the posterior wall of M^2 is known in the species *Piezodus brassatensis* (LOPEZ MARTINEZ, 1974). We succeeded in finding a similar stage in the rabbit (Fig. 2d).

Conclusions

1. The lower and upper teeth have at least one gradient in common. It is the gradient of infolding of the big external fold and hypostria.

2. The crescent is a structure which subsists for a short time in the course of the ontogeny of the upper cheek teeth and has its own antero-posteriorly directed gradient.

3. The origin of the crescent from the anterior fold of P^2 is unquestionable in the light of both serial and phylogenetic homology.

4. The order of appearance of some dental structures is similar in ontogeny and phylogeny.

Institute of Systematic and Experimental Zoology
Polish Academy of Sciences
Kraków, Sławkowska 17

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STRESZCZENIE

Opisano istnienie dwóch gradientów morfologicznych w uzębieniu współczesnych i kopalnych *Lagomorpha*. Uzębienie górne i dolne ma jeden gradient wspólny. Jest nim gradient towarzyszący wpuklaniu wielkiego fałdu zewnętrznego w zębach dolnych oraz powstawaniu hypostrii, tj. drugiego dużego fałdu w zębach górnych. Hypostria jest ontogenetycznie i filogenetycznie młodszą strukturą niż crescent, który zanikł u form mioceńskich. Crescent udało się jednak zidentyfikować w rozwoju osobniczym królika, gdzie występuje on przez krótki okres po urodzeniu i zostaje zdominowany przez rozwijającą się hypostrię. Rozwojowi crescentu towarzyszy gradient o kierunku przód-tył. Równocześnie wyjaśniono pochodzenie crescentu z przedniego fałdu P^2, co wydaje się nie budzić wątpliwości zarówno w świetle homologii serialnej, jak i filogenetycznej. Kolejność pojawiania się pewnych struktur zębowych królika jest podobna w ontogenezie i filogenezie.

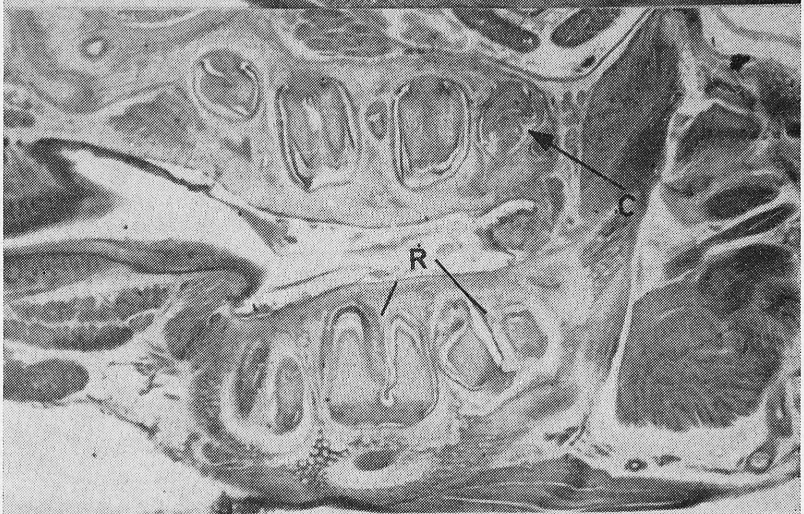
РЕЗЮМЕ

Описано существование двух морфологических градиентов зубной системы современных и ископаемых *Lagomorpha*. Нижние и верхние зубы имеют один общий градиент. Это — сопутствующий градиент выпуклению большой внешней складки в нижних зубах и гипострии т. е. второй большой складки в верхних зубах. Гипострия онтогенетически и филогенетически является младшей структурой, чем кресцент, который исчез у миоценских форм. Кресцент, однако, удалось идентифицировать в онтогенетическом развитии кролика, где он обнаружен лишь после рождения, а затем подавляется развивающейся гипострией. Развитию кресцента сопутствует градиент с направлением перёд-зад. Одновременно выяснено происхождение кресцента из передней складки P^2, что кажется вероятным с точки зрения сериальной и филогенетической гомологии. Последовательность появления некоторых структур зубной системы кролика похожа в онтогенезе и филогенезе.

Plate VI

Sagittal sections of maxilla and mandible of the newborn rabbit. Numbers of the teeth are given from left to right. Abbreviations: C — crescent, H — hypostria, R — big external fold (reëntrant). a. Lingual region. Maxilla: DP^4—M^1, mandible: DP_3—DP_4 b. Intermediate region. Maxilla: DP^2—M^1, mandible: DP_3—M_1 c. Buccal region. Maxilla: DP^2—M^1, mandible: DP^4—M_1

a



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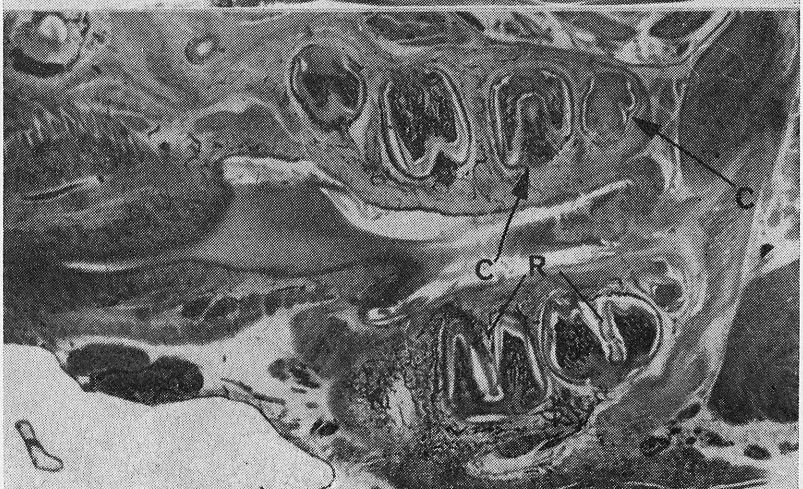
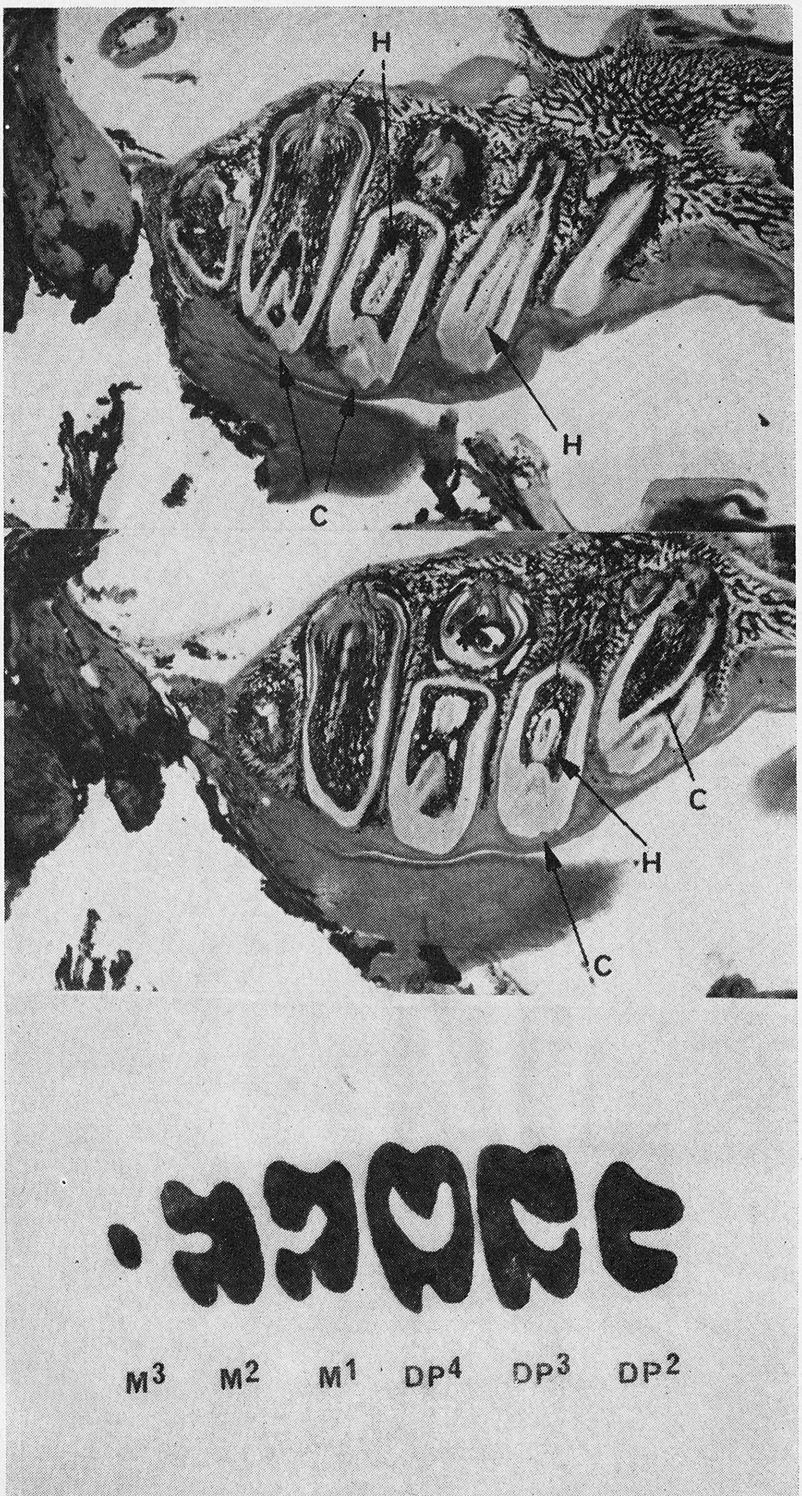


c

L. Sych, B. Sych

Plate VII

a and b. Sagittal sections of maxilla of the 4-day-old rabbit. Numbers of the teeth are given from left to right. Abbreviations: C — crescent, H — hypostria. a. Lingual region. M^2—DP^2 b. Intermediate region. M^1—DP^2 c. Schematic reconstruction of the crescent in the upper tooth row in horizontal plane, based on the 4- and 9-day-old specimens. The direction of the crescent gradient is from DP^2 to M^2. See also fig. 2 in the text



a

b

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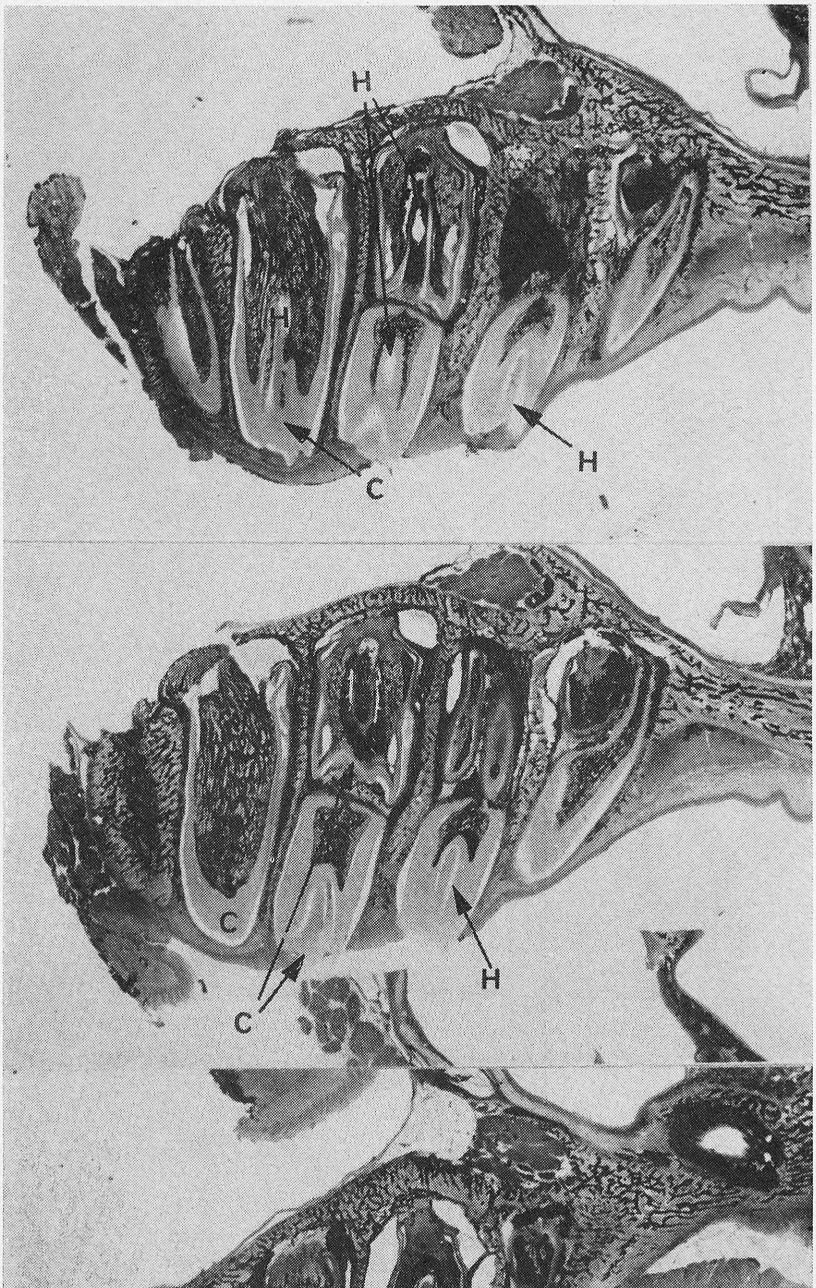
Plate VIII

Sagittal sections of maxilla of the 9-day-old rabbit. Numbers of the teeth are given from left to right. Abbreviations: C — crescent, H — hypostria. a. Lingual region: M^2—DP^2, P^4 and P^2. b. Intermediate region: M^1—DP^2 (M^2 very slightly marked), and P^4—P^2. c. Buccal region: DP^4—DP^2 and P^4—P^2



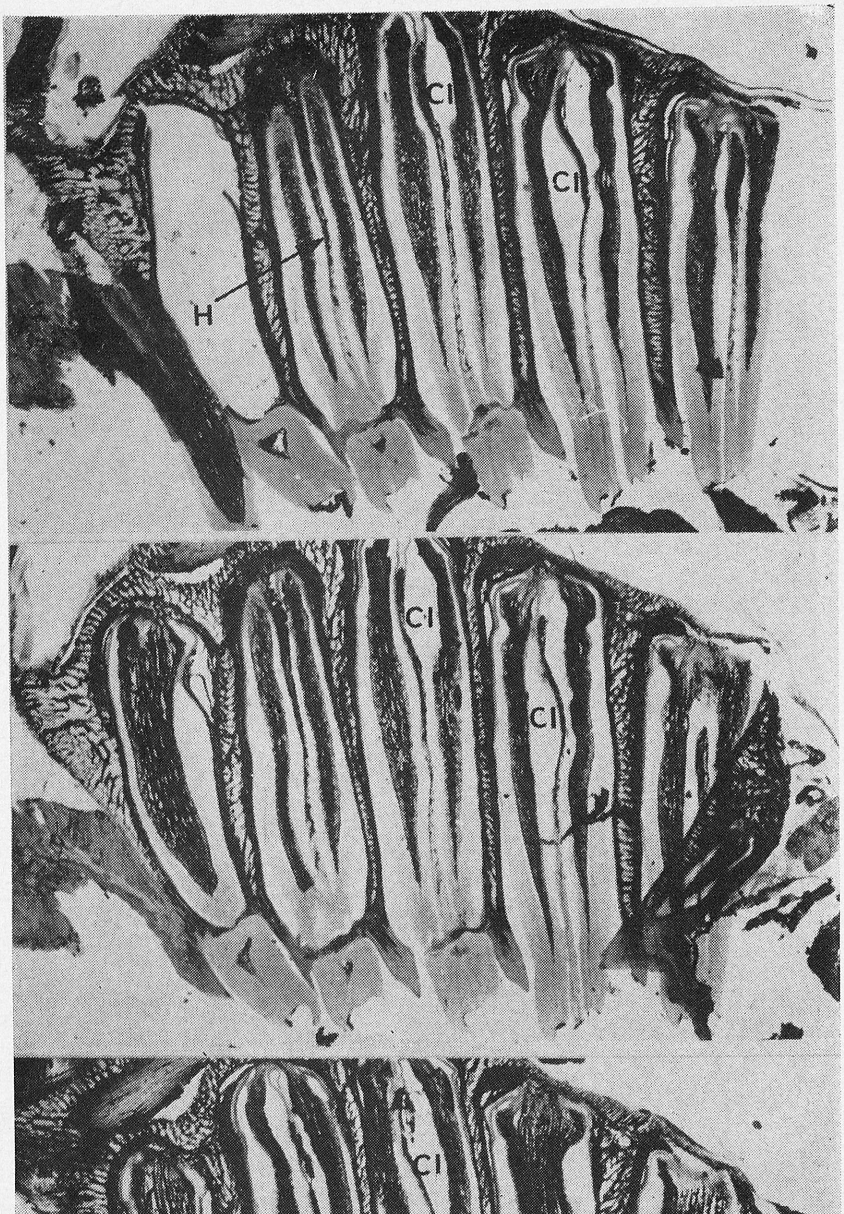
a

b

c

Plate IX

Sagittal sections of maxilla of the 21-day-old rabbit. Numbers of the teeth are given from left to right. Abbreviations: C — crescent, Cl — crenulation, H — hypostria. a. Lingual region: DP^2—M^2 and P^2—P^4. b. Intermediate region: DP^2—M^2 and P^2—P^4. c. Buccal region: DP^3—M^2, and P^2—P^4



a

b

c

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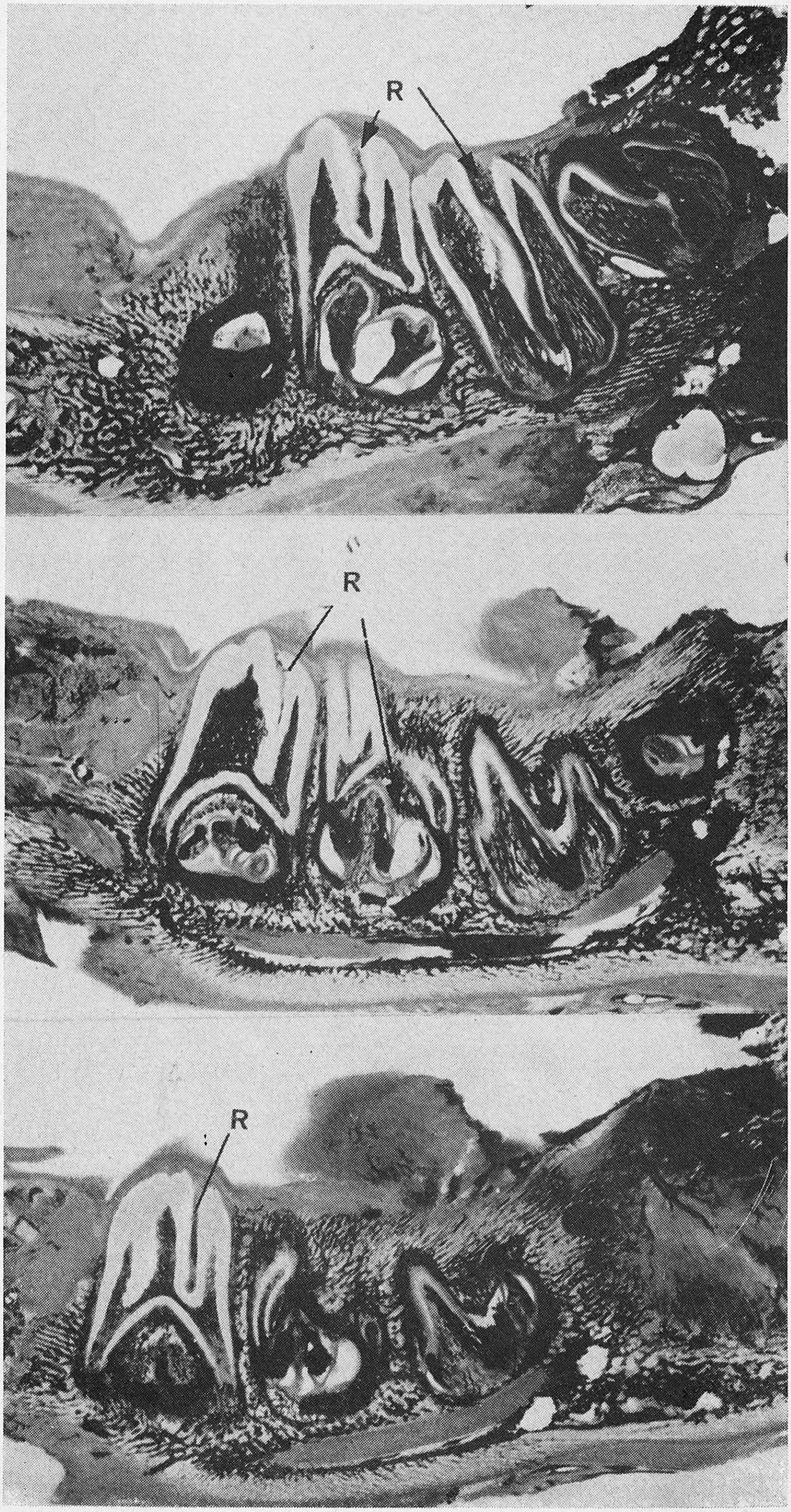
Plate X

Sagittal sections of mandible of the 4-day-old rabbit. Numbers of the teeth are given from left to right. R — big external fold (reëntrant). a. Lingual region: DP_4—M_2 and P_3—P_4. b. Intermediate region: DP_3—M_2, and DP_3—M_1 and P_3—P_4. c. Buccal region: DP_3—M_1 and P_3—P_4



a

b

c

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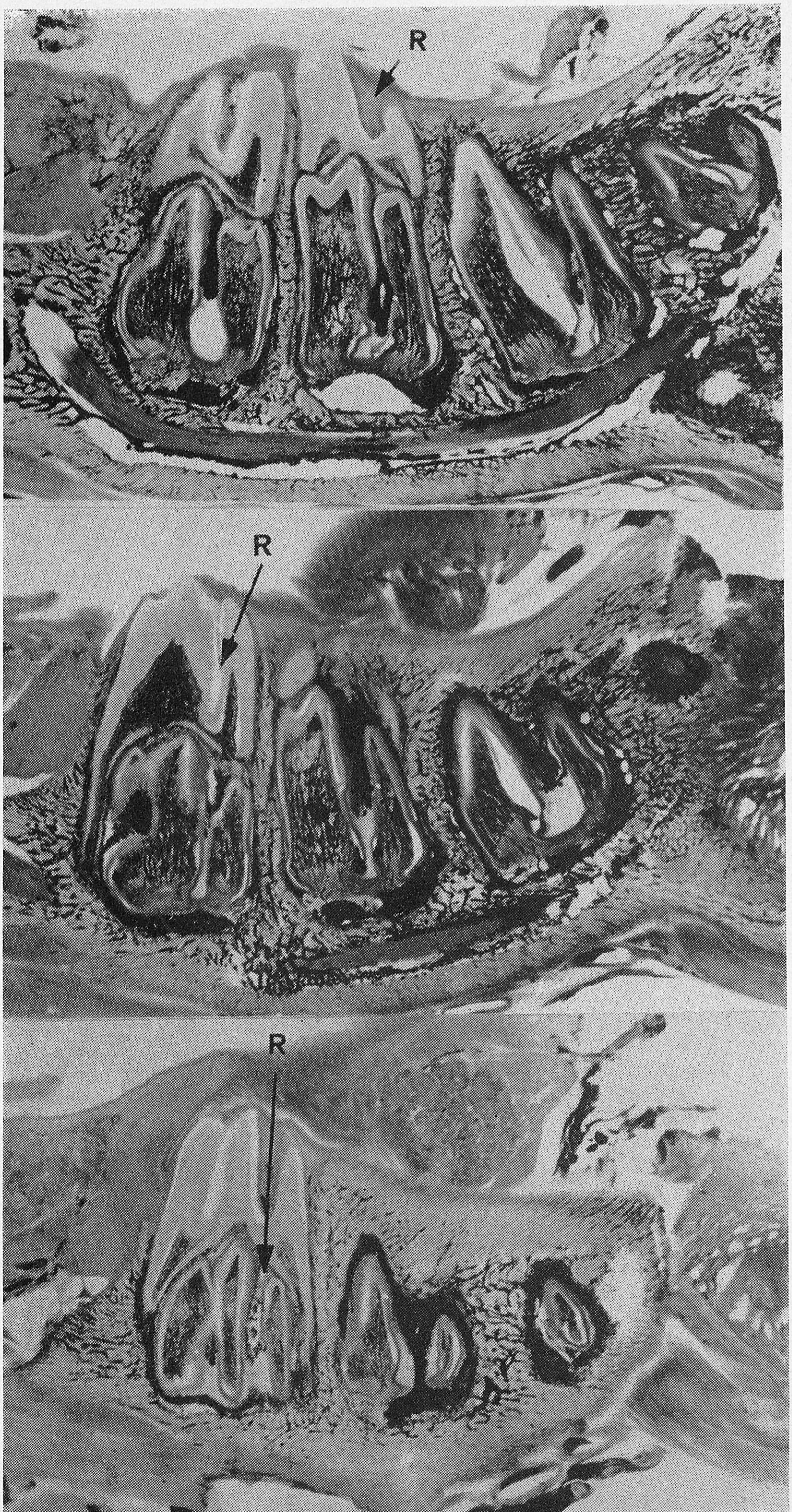
Plate XI

Sagittal sections of mandible of the 9-day-old rabbit. Numbers of the teeth are given from left to right. R — big external fold (reëntrant) between trigonid and talonid. a. Lingual region: DP_3—M_2 and P_3—P_4. b. Intermediate region: DP_3—M_2, and P_3—P_4. c. Buccal region: DP_3—M_1 and P_3—P_4



a

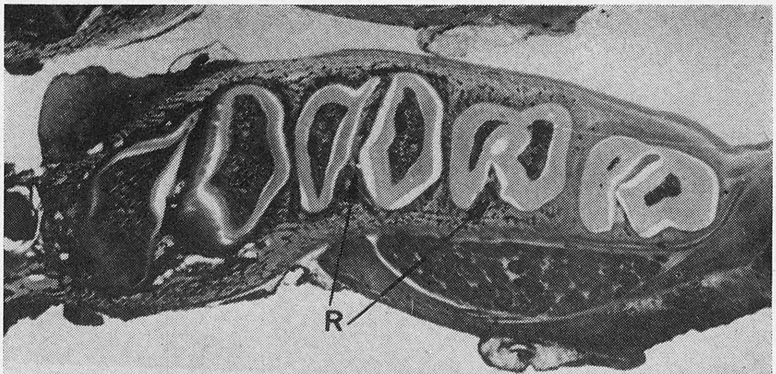
b

c

L. Sych, B. Sych

Plate XII

Horizontal sections of mandible of the 9-day-old rabbit. Numbers of teeth are given from left to right. Abbreviations: Cl — crenulation, R — big external fold (reëntrant) between trigonid and talonid, t — lingual top of P_2, v — roots of DP_4. a. Occlusal region of the milk teeth — M_2, M_1, DP_4, DP_3. b. Occlusal region of the permanent premolars — M_3, M_1, P_4 with the rest of the roots of DP_4 (v), DP_3 with the lingual top of P_3 (t). c. Intermediate region of the permanent premolars — M_2, M_1, P_4 with the rest of the DP_4 roots (v), P_3. d. Root (ventral region of the permanent premolars — M_1, P_4 with the rests of DP_4 roots (v), P_3



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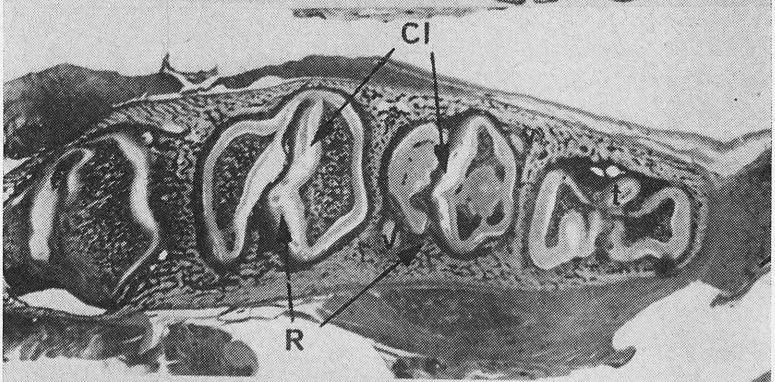

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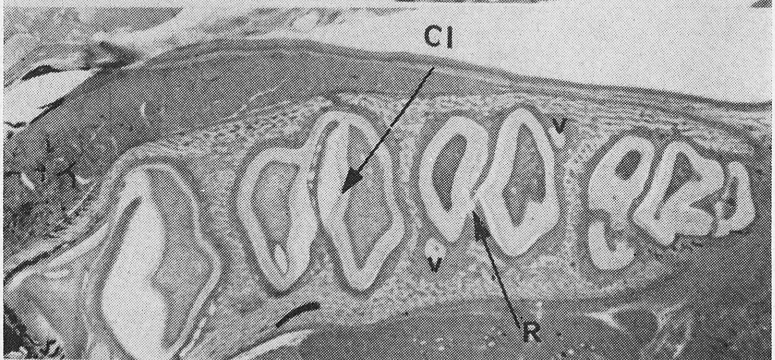

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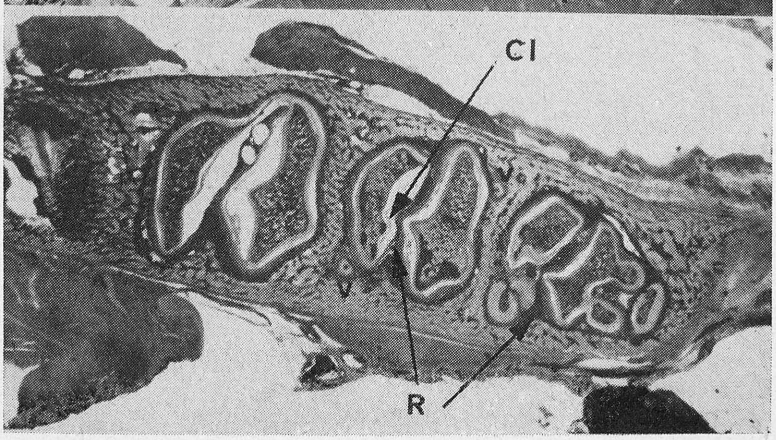

d

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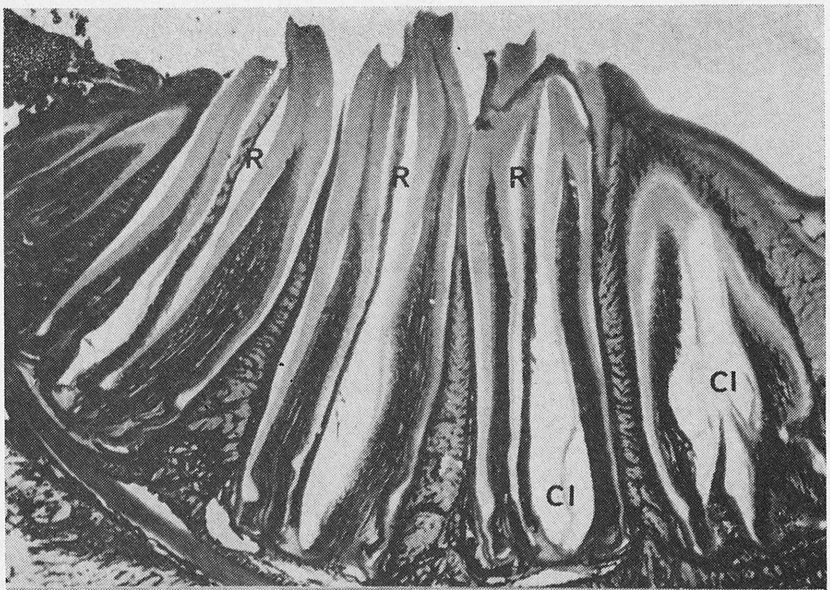
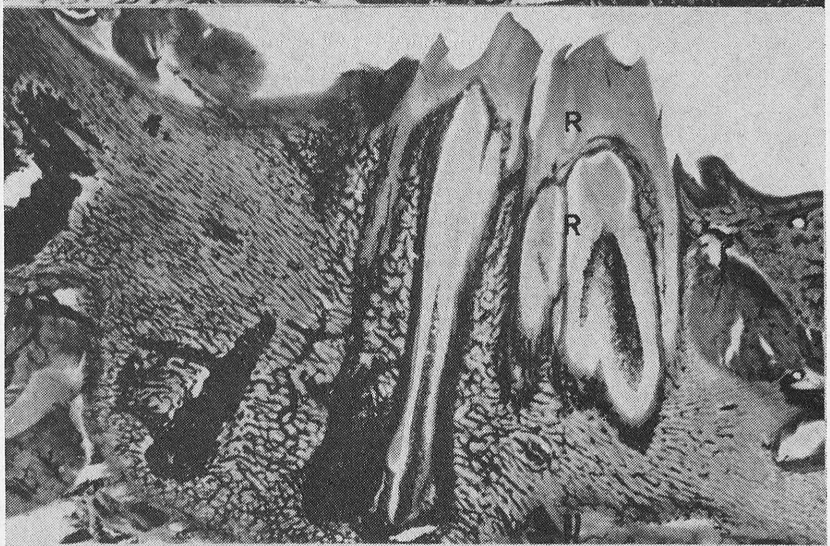
Plate XIII

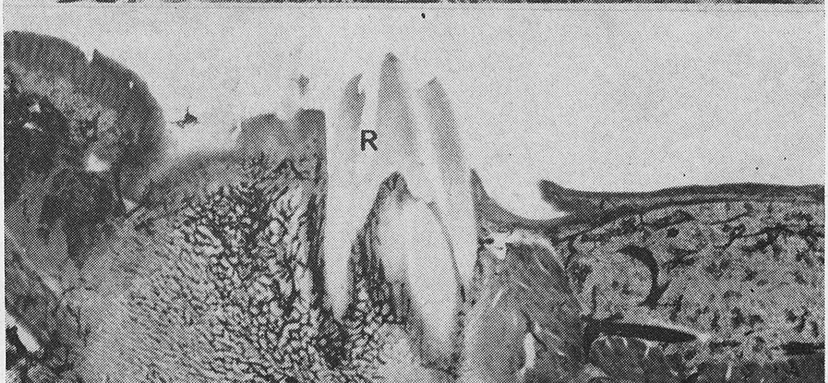
Sagittal sections of mandible of 21-day-old rabbit. Numbers of teeth are given from left to right. Abbreviations: Cl — crenulation, R — big external fold (reëntrant) between trigonid and talonid. a. Lingual region: M_3—P_3 and DP_4. b. Intermediate region: DP_4—DP and P_4—P_3. c. Buccal region: DP_3 and P_3



a



b



c

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