## **ORIGINAL PAPER**



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# First fossil record of *Varanus* (Reptilia, Squamata) from Switzerland and the earliest occurrences of the genus in Europe

Georgios L. Georgalis<sup>1\*</sup>, Bastien Mennecart<sup>2</sup> and Krister T. Smith<sup>3,4</sup>

## Abstract

We here describe two isolated fossil teeth from the Early Miocene (MN 4) of Hüenerbach, Switzerland. The material is tentatively referred to *Varanus*, marking the first occurrence of this iconic lizard genus in the Swiss fossil record, while it also represents one of its earliest occurrences from Europe, being coeval with other records from Spain, France, and the Czech Republic. Important diagnostic features in the teeth of extant *Varanus* are discussed, coupled with comparisons with related taxa. The prominent serration in one of the two Swiss teeth is an unusual feature for European varanids. In addition, the sole other lizard specimen from Hüenerbach is also described, being referred to an indeterminate lacertid, with potential affinities to the genus *Janosikia*.

Keywords Varanidae, Squamata, Lizards, Taxonomy, Neogene, Swiss Molasse

## **1** Introduction

The emblematic lizard genus *Varanus* (commonly known as Monitor Lizards) is diverse and widespread, currently inhabiting a large range of habitats across Africa, Asia, and Australia (Pianka et al., 2004). In addition to a high species (at least 85) and ecological diversity, there is also a considerable disparity of size in *Varanus* (Brennan et al., 2021; Collar et al., 2011), which encompasses pygmy monitors as well as the largest extant lizard, the iconic Komodo Dragon (*Varanus komodoensis* Ouwens,

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\*Correspondence:

Georgios L. Georgalis

dimetrodon82@gmail.com

<sup>1</sup> Institute of Systematics and Evolution of Animals, Polish Academy of Sciences, Sławkowska 17, 31-016 Kraków, Poland

<sup>2</sup> Naturhistorisches Museum Basel, Augustinergasse 2, 4056 Basel, Switzerland

<sup>3</sup> Department of Messel Research and Mammalogy, Senckenberg Research Institute and Natural History Museum, Senckenberganlage 25, 60325 Frankfurt Am Main, Germany

<sup>4</sup> Faculty of Biosciences, Goethe University, Max-von-Laue-Straße 13, 60438 Frankfurt Am Main, Germany

1912), and the largest ever terrestrial lizard, i.e., the famous Megalania (*Varanus priscus* [Owen, 1859]) from the Quaternary of Australia (Fejérváry, 1935; Hecht, 1975; Hocknull et al., 2009; Pianka et al., 2004).

The fossil record of Varanidae, although still very incomplete, demonstrates a great diversity across most of the Cenozoic and a wide geographic distribution, encompassing broad areas that are currently well outside the range of extant forms, such as North America and Europe (Georgalis et al., 2021; Molnar, 2004), including a form with anatomical and physiological adaptations unique among tetrapods: the re-evolution of a fourth eye from the pineal organ (Smith et al., 2018). In fact, the varanid fossil record is far richer in Europe than on any other continent, spanning from the earliest Eocene up to the Middle Pleistocene (Augé, 2005; Augé et al., 2022; Fejérváry, 1918, 1935; Georgalis et al., 2017, 2021; Hoffstetter, 1969; Villa et al., 2018). The richness of the European fossil record is likely due to intensive sampling effort, reflecting a long history of palaeontological discoveries, with the first European varanid fossils recovered and described already during the 1860s (Gaudry, 1862-1867; see details in Georgalis, 2019). Two valid



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genera are currently recognized in the European fossil record: the extinct North American-typified genus Saniwa Leidy, 1870, known from a few Eocene localities in Western Europe (Augé, 2005; Augé et al., 2022; Georgalis et al., 2021), and the extant genus Varanus documented in many localities across Central, Western, and Southern Europe spanning from the Early Miocene up to the Middle Pleistocene (Delfino et al., 2013; Georgalis et al., 2017, 2018; Ivanov et al., 2018; Villa et al., 2018). It is not believed that the Neogene varanids from Europe are related to the Eocene forms; instead the Neogene Vara*nus* represents the product of subsequent dispersal(s) to the continent. The approximate timing of the arrival of Varanus in Europe is not known with certainty, but it probably took place around during the Early Miocene (Delfino et al., 2013; Ivanov et al., 2018). This is supported by the fact that the earliest fossil occurrences of *Varanus* in Europe appear all penecontemporaneously in a few localities in the Czech Republic, France, and Spain, all of Early Miocene age (MN 4) (see Discussion below).

We here describe two incomplete, isolated teeth from the Early Miocene (MN 4) locality of Hüenerbach, Switzerland, that we tentatively refer to *Varanus*. If our identification is correct, these two specimens mark the first record of Varanidae from Switzerland and also rank as one of the oldest occurrences of the genus *Varanus* from Europe, coinciding in age with the other Czech, French, and Spanish remains. The prominent serration of one of the Swiss teeth is discussed, together with important diagnostic features in the dentition of extant *Varanus* and comparisons with other related taxa. The sole other lizard specimen from Hüenerbach, an indeterminate lacertid with probable affinities to *Janosikia*, is documented, adding to the extremely poor fossil record of Cenozoic squamates from Switzerland (Fig. 1).

### 2 Institutional abbreviations

*AMNH*, American Museum of Natural History, New York, USA; *ISEZ*, Institute of Systematics and Evolution of Animals, Polish Academy of Sciences, Krakow, Poland; *MNHN*, Muséum national d'Histoire naturelle, Paris, France; *NMB*, Naturhistorisches Museum Basel, Basel, Switzerland; *NMP*, Národní Muzeum Praha, Prague, Czechia; *PIMUZ*, Palaeontological Institute and Museum, University of Zurich, Zurich, Switzerland; *SMF*, Senckenberg Forschungsinstitut und Naturmuseum, Frankfurt am Main, Germany.



**Fig. 1** Location map of Hüenerbach by the city of Langnau im Emmental (Canton of Bern, Switzerland). The Swiss molasse Basin Tertiary Formations are marked highlighting the fact that the Hüenerbach locality is at the transition between the OMM and OSM. Ba. Basel, Be. Bern, Ge. Geneva, Zu. Zurich (modified after Mennecart, 2012)

### **3** Geological settings and biostratigraphy

The locality of Hüenerbach (Swiss Coordinates 627.225/197.160) is situated south of the city of Langnau im Emmental (Canton of Bern, Switzerland). Burdigalian sediments, dated by magnetostatigraphy to 18.0–16.2 Ma, cover all the area (Schlüchter et al., 2019). Two different Formations can be observed there (Kälin & Kempf, 2009; Schlüchter et al., 2019). Marine sediments belong to the St. Gallen Formation (Obere Meeresmolasse or OMM, i.e., the upper marine molasse). In the middle of the marine deposits, a little more than 2 m of continental sediment belong the Eimätteli Member of the Napf Formation (Obere Süsswassermolasse or OSM, i.e., the upper freshwater molasse) (Schlüchter et al., 2019). The OMM of the St. Gallen Formation seems to be here mostly brackish with local marine incursions (Schlüchter et al., 2019). The Eimätteli Member can be composed of dark marls and coals that host numerous mammal localities in this area of Switzerland: Schriberschwändili, Eiboden, Hegengraben, Choleren, and Hüenerbach (Kälin & Kempf, 2009; Schlüchter et al., 2019). All these localities yielded a fauna similar in age (MN4b), and are located in Chron 5Cr, providing an age of ca. 17 Ma (Kälin, 1997; Kälin & Kempf, 2009; Schlüchter et al., 2019). These remarkable layers possess an extensive lateral continuity and form a marker horizon at a regional scale (Kälin & Kempf, 2009).

A diverse fauna including more than 250 micromammal teeth preserved at the NMB confirmed a MN4b age in Hüenerbach (Kälin & Kempf, 2009). This diverse assemblage comprises mammals pertaining to Eulipotyphla (Galerix sp., Soricidae indet.), Rodentia (Microdyromys sp., Glirudinus minutus, Glirudinus sp. II, Peridyromys sp./Prodyromys sp., Miodyromys sp., Megacricetodon collongensis, Democricetodon franconicus, Eumyarion sp., Anomalomys minor, Ligeromys cf. florancei, Spemophilinus sp., Sciuridae sp. II), Lagomorpha (*Prolagus* sp.), and Ruminantia (*?Heteropox larteti*). Additional fossil remains from Hüenerbach are currently stored at the NMB (BM pers. obs.) including a badly preserved shark tooth and foraminifera (?Elphidium). They are most likely reworked from the nearby marine layers. In addition, there is an upper left molar of the small ruminant Lagomeryx sp. plus a few reptile remains, i.e., some crocodilian teeth, a lizard tooth-bearing element (presented below), and the two varanid teeth described herein.

## 4 Material and methods

The fossil specimens are permanently curated at the collections of NMB. The fossils were found during field campaigns between April 1994 and October 1995 by D. Kälin. Comparative skeletal material of extant

varanids, including 26 species of Varanus examined for tooth serrations, was studied at the collections of ISEZ, MNHN, NMP, PIMUZ, and SMF. The evolution of serrations in Varanus was examined in Mesquite v3.40 (build 877) (Maddison & Maddison, 2021) based on the phylogeny of Pyron et al. (2013). The stacked photographs of the specimens were taken using a VHX-6000 | KYENCE. In order to study the pulp cavity in extant varanoids, we µ-CT scanned one specimen (SMF 336) of Lanthanotus borneensis Steindachner, 1878. This specimen was scanned on a Rayscan 200 at SMF (parameters: 90 kV, 89  $\mu$ A, 1600 projections, final voxel resolution 20.7  $\mu$ m). For the same reason, we studied a µ-CT scan of a specimen (PIMUZ A/III 1493) of Varanus salvator (Laurenti, 1768) that was provided to us by PIMUZ. Also, the  $\mu$ -CT scan of one specimen (AMNH 58389) of Varanus indicus (Daudin, 1802) was studied from Morphosource (https://www.morphosource.org/) (Media 000404967, ark:/87602/m4/404967).

## **5** Systematic Palaeontology

Squamata Oppel, 1811

Anguimorpha Fürbringer, 1900 Varanidae Gray, 1827 (sensu Estes et al., 1988). *Varanus* Merrem, 1820 ?*Varanus* sp. Figure 2. *Material.* Two isolated teeth (NMB Hüe.1 and NMB

Hüe.2).

Description. Both teeth are incomplete, with NMB Hüe.1 missing the tip and tooth base, and NMB Hüe.2 being slightly abraded and also lacking the tooth base (Fig. 2). They are rather small, unicuspid, labiolingually compressed, and posteriorly curved; the curvature is more pronounced in NMB Hüe.1. A sharp carina runs throughout both the mesial and distal margins of both teeth, being especially prominent in NMB Hüe.1. In that specimen, both mesial and distal carinae are distinctly serrated, comprising prominent denticles; these denticles are fairly regular in size (about 0.09 mm/denticle) and gently rounded in profile, separated by interdenticle grooves. The serration of the distal carina of NMB Hüe.1 is prominent throughout its preserved length, while that of the mesial carina is more prominent at mid-height on the tooth and diminishes apically and especially basally. In NMB Hüe.2, the portions where the two carinae are preserved are eroded. Plicidentine (the infolding of dentine in the pulp cavity; Kearney & Rieppel, 2006) is not documented in either tooth, although it could have been present on the non-preserved tooth bases. The pulp cavity of both teeth is distinctive in being labiolingually compressed. Surrounding this slot-like pulp cavity, the basal surface of the tooth is covered by scallop-shaped



Fig. 2 ?Varanus sp. from Hüenerbach. a-f tooth NMB Hüe.1 in lingual (a), labial (b), mesial (c), distal (d), occlusal (e), and ventral (f) views; g-l) tooth NMB Hüe.2 in lingual (g), labial (h), proximal (i), distal (j), occlusal (k), and ventral (l) views

erosional features reminiscent of Howship's lacunae, which mark the action of osteoclasts that have destroyed dental tissue in preparation for tooth shedding (LeB-lanc et al., 2023). In NMB Hüe.1, where the pulp cavity is more well exposed and visible, measurements on these scallop-shaped erosional features reveal typical diameters of around 30–40  $\mu$ m (mean range around 20–50  $\mu$ m), values that are consistent with our interpretation of them as Howship's lacunae.

## 6 Discussion

The two teeth can be assigned to the total clade of *Varanus* based on the presence of strongly developed carinae combined with strong labiolingual compression that encompasses the pulp cavity, serration, and their overall shape (Bhullar & Smith, 2008; Bullet, 1942; Georgalis et al., 2019; Ivanov et al., 2018; Kearney & Rieppel, 2006; Peyer, 1929). The first two features are apomorphic.

In their analysis of tooth form in Anguimorpha, Bhullar and Smith (2008) concluded that a "Hershey's kiss" morphology—"roughly conical shafts and tooth bases lingually produced and mesiodistally expanded" (p. 297)—were synapomorphic of *Heloderma* Wiegmann, 1829, *Lanthanotus* Steindachner, 1878, *Varanus*, and their fossil relatives. Labiolingual tooth crown compression, with mesial and distal carinae, is a synapomorphy of *Lanthanotus* and *Varanus*, and in *Varanus* this compression further extends to the tooth base, giving the teeth a



Fig. 3 Pulp cavity of extant varanoids. **a**-**b** Middle right dentary tooth (reversed) of *Lanthanotus borneensis* SMF 336 in lingual (**a**) and mesial (**b**) views. **c**-**d** Middle left dentary tooth (reversed) of *Varanus indicus* AMNH 58389 in lingual (**c**) and mesial (**d**) views. **e**-**f** Middle right maxilla tooth (inverted) of *Varanus salvator* PIMUZ A/III 1493 in lingual (**e**) and mesial (**f**) views

lenticular cross-section (Bhullar & Smith, 2008). While the tooth bases are not fully preserved in the Swiss material, and an unknown part of them may have been eroded in preparation for tooth shedding, yet, the remaining pulp cavity is highly compressed, a feature seen in *Varanus* but not *Lanthanotus* that therefore correlates with the overall derived tooth of *Varanus* (Fig. 3).

The presence of distinct serration on both margins of NMB Hüe.1 is worth discussing further here. Such prominent, distinct serrations on both tooth margins is more common in other reptiles, such as some theropod dinosaurs (see Wick et al., 2015; Wills et al., 2023). However, denticles on the serrated carinae of theropods are usually higher and even more prominent (Wick et al., 2015; Wills et al., 2023) and in any case, theropod affinities of this Miocene Swiss material can be readily discarded by a stratigraphic rationale. Prominent denticles on serrated carinae can be also observed in several crocodylomorphs, including certain "ziphodont" forms from the Eocene of Europe, such as planocraniids and sebecosuchians (e.g., Brochu, 2013; Legasa et al., 1994; Martin, 2016; Martin et al., 2023)-these forms, however, are totally absent from the European Neogene. Besides, Eocene sediments in the vicinity of Hüenerbach are only present many kilometers away from the locality, and they are marine and not terrestrial ones (Flysch of the peri-Alpine sea). Furthermore, serrated teeth have been documented in extinct and extant varanids (Farlow et al., 1991; Fejérváry, 1918, 1935; Georgalis et al., 2019; Hocknull et al., 2009; Janeczek et al., 2023; Smith, 2006; Wick et al., 2015). As a matter of fact, serration densities over the carinae can be high in certain small to medium-sized extant varanids, such as Varanus bengalensis (Daudin, 1802) and *Varanus varius* (White, 1790) (Farlow et al., 1991; Wick et al., 2015), while distinct serrations can occur also in the largest taxa of the group, such as *Varanus salvator*, *V. komodoensis*, and *V. priscus* (Bullet, 1942; Fejérváry, 1918, 1935; Hocknul et al., 2009; Janeczek et al., 2023).

In our survey of extant Varanus spp. (Table 1), we found some evidence that the occurrence of serration can be associated with size. For instance, in larger but not smaller Varanus prasinus (Schlegel, 1839), serration was present. In Varanus gouldii (Gray, 1838) prominence increased from juvenile through intermediate to large individuals. In small juvenile Varanus salvator, serration was absent, but it was well developed in larger specimens. Nevertheless, parsimony-based character optimization on the phylogeny of Pyron et al. (2013) finds unambiguous support for multiple origins of serration within Varanus (Fig. 4), in which case the occurrence of serration would be evidence for attribution of a taxon possessing serrated teeth to the Varanus crown. That being said, the African clade that is the sister-group to Varanus griseus (Daudin, 1803) is well known for its blunt, rounded teeth (D'Amore, 2015), which lack serration (even in juveniles, where blunt teeth are less well developed), as is fruiteating Varanus olivaceus Hallowell, 1857. Blunt teeth are certainly derived in Varanidae, and both Varanus taxa (the African clade and *V. olivaceus*) occupy critical positions on the tree that strongly influence ancestral state reconstruction. Thus, we do not regard this interpretation-that serration evolved multiple times within Varanus, rather than being synapomorphic of crown Varanus and lost multiple times—as secure.

Among European fossil *Varanus* though, tooth serrations are, in general, rare. In the sole named Early

Species	Incidence of serrations	Specimen number (SMF)
Varanus acanthurus	Absent	11639, 11642
Varanus albigularis	Absent	26580 (juvenile), 54578
Varanus beccarii	Present	11636
Varanus bengalensis	Absent	60428, 71569, 71570 (juvenile)
Varanus caudolineatus	Absent	40086
Varanus doreanus	Present	33290
Varanus dumerilii	Absent	11556, 11557 (juvenile)
Varanus eremius	Absent	11648
Varanus exanthematicus	Absent	11543, 21573 (juvenile)
Varanus flavescens	Present	11546, 54157
Varanus giganteus	Present	53263
Varanus gilleni	Absent	11627
Varanus gouldii	Present	11620 (juvenile), 59018, 99153
Varanus griseus	Present	32911, 33254, 74486
Varanus indicus	Present	32808, 79184
Varanus jobiensis	Present	75817
Varanus komodoensis	Present	37209, 57555, 68133
Varanus mertensi	Absent	53275
Varanus olivaceus	Absent	72156
Varanus prasinus	Present	11626 (small), 69454
Varanus rudicollis	Absent/present	40207, 59242
Varanus salvadorii	Present	58064, 67670
Varanus salvator	Present	11563 (juvenile), 32807, 40175, 81057
Varanus spenceri	Absent	53277
Varanus tristis	Absent	11630
Varanus varius	Present	11617

Table 1 Incidence of serrations (absent/not visible or present/visible) in extant species of Varanus



**Fig. 4** Parsimony-based character optimization on the tooth serrations based on the phylogeny of Pyron et al. (2013)

Miocene European varanid, Varanus mokrensis Ivanov et al., 2018, tooth serration is totally absent, this absence constituting one of the diagnostic characters of this species (Ivanov et al., 2018). In fact, as discussed by Georgalis et al. (2019), tooth serration in European fossil varanids has been reported only from a few Middle Miocene to Pliocene localities from Romania, Austria, Greece, Italy, France, and Hungary; accordingly, the Swiss tooth NMB Hüe.1 represents the oldest occurrence of a serrated-toothed varanid from Europe. One of most prominent examples is attested by the varanid teeth that were recently described by Georgalis et al. (2019) from the latest Miocene / earliest Pliocene locality of Maramena in Greece, where four different kinds of tooth serration were documented: teeth either completely serrated (both mesially and distally), completely non-serrated, serrated mesially but not distally, and serrated distally but not mesially; it was nevertheless unclear whether these differences constituted some kind of intraspecific variation or diagnostic features or even taphonomic alteration (Georgalis et al., 2019). More abundant and complete specimens are required in order to assess the diagnostic utility / degree of variability of serration of fossil varanid teeth and this applies as well to the new Swiss material described herein.

In summary, two derived features that characterize crown Varanus-labiolingual compression extending to the tooth base and visible in the pulp cavity, and serration of the tooth carinae-suggest that the Swiss material pertains to the total clade of *Varanus*. Basal striations (indicating plicidentine) are expected to be present in an animal of such a taxonomic position (e.g., Estes et al., 1988), so their absence in the Swiss material must be attributed to breakage and basal erosion. At present no strong evidence ties the Swiss material to any subclade of Varanus (which would justify its position in the crown), yet Varanus is the only varanid genus yet reported from the Neogene of Europe. Consequently, we tentatively assign the two fossil teeth from Hüenerbach to Varanus. Only additional and more complete specimens from the locality will confirm this identification.

This new material marks the first described specimens of varanids from Switzerland-the more distantly related Palaeovaranus sp. from the Eocene locality of Dielsdorf (Georgalis & Scheyer, 2019) pertains to a different clade, Palaeovaranidae Georgalis, 2017, which may be related to Shinisaurus Ahl, 1930, or to Varanus+Lanthanotus (Dong et al., 2022; Smith & Habersetzer, 2021). The new Hüenerbach teeth are of further biogeographic importance. In Europe the oldest occurrences of Varanus are all of Early Miocene (MN 4) age. These are documented from the localities of Mokrá (MN4a/b boundary), Czech Republic (Varanus mokrensis; Ivanov et al., 2018), Artenay (MN 4a), France (Varanus cf. hofmanni of Hoffstetter, 1969; Varanus sp. of Augé & Guével, 2018), Béon 1 (=Montréal-du-Gers) (MN 4a), France (Varanus sp. of Rage & Bailon, 2005), and Can Mas (MN 4b), Spain (type of Iberovaranus catalaunicus Hoffstetter, 1969; revised as Varanus sp. by Delfino et al., 2013); a further mention of coeval (MN 4) varanids is also known from Córcoles (MN 4a), Spain (Varanus ?hofmanni of Alférez & Brea, 1981), although this record was not accompanied by any kind of figure, description, or collection number and therefore its validity cannot be confirmed. All these occurrences pertain to indeterminate species of Varanus, with the notable exception of Mokrá, which yielded the sole currently recognized valid species from the Early Miocene of Europe (Varanus mokrensis; Ivanov et al., 2018). To the aforementioned scarce Early Miocene occurrences, we now add here the varanid from Hüenerbach, which with an age of MN 4b, ranks also as one of the earliest occurrences of Varanus. The genus became subsequently rather successful during the Middle and Late Miocene of Europe, with multiple occurrences across the continent (e.g., Conrad et al., 2012; Fejérváry, 1918; Georgalis,

2019; Georgalis et al., 2018; Villa et al., 2018; Weithofer, 1888). A second valid species is currently recognized among these younger occurrences, *Varanus marathonensis* Weithofer, 1888, distributed over the Middle and Late Miocene of Greece and Spain (Fejérváry, 1918; Villa et al., 2018; Weithofer, 1888). The distribution of *Varanus* in Europe became progressively confined during the Pliocene and the genus ultimately became extinct on the continent during the Quaternary, with their youngest record documented in the Middle Pleistocene of Athens, Greece (Georgalis et al., 2017).

Different scenarios have been suggested regarding the arrival of the Neogene *Varanus* in Europe, with either an African or Asian origin indicated, based upon molecular data and fossil evidence (Conrad et al., 2012; Dong et al., 2022; Georgalis et al., 2020; Ivanov et al., 2018; Smith et al., 2008; Vidal et al., 2012; Villa et al., 2018). This uncertainty is exacerbated by the fact that the Early Miocene coincidentally marks the earliest fossil record of *Varanus* in both Europe, Africa, Asia, and Australia (see Georgalis et al., 2020). Nevertheless, the nearest living relative of *Varanus, Lanthanotus*, as well as taxa inferred to be on the stem of *Varanus* (except for *Saniwa*) and *Lanthanotus*, are all Asian.

Besides these varanid teeth, the locality of Hüenerbach also yielded a single other squamate, the lizard tooth bearing element NMB Hüe.3 (Fig. 5). This probably represents a fragment of the posterior portion of a right maxilla. The overall morphology of the specimen and particularly of the teeth is reminiscent of the gallotiine lacertid Janosikia Čerňanský et al., 2016. This lizard has been previously recorded in a few Early Miocene localities in Germany and France (Čerňanský et al., 2016; Georgalis & Scheyer, 2021), while it has been recently also identified in Switzerland from the Middle Miocene (MN 5) of Schmiedrued-Pfyffrüti level 642 (originally described as Bavaricordylus sp. by Jost et al., 2015; subsequently reidentified as Janosikia sp. by Villa & Reichenbacher, 2022). A small accessory cusp seems to be present on the third (counting from anterior) preserved tooth, similar to that described from the other Swiss occurrence of Janosikia by Villa and Reichenbacher (2022). However, due to the incompleteness of the specimen, we only refer it to Lacertidae indet.

These new fossil specimens described herein add to the poorly known fossil record of Cenozoic squamates from Switzerland, a group which had so far been formally described from the country only from two Eocene (Pictet et al., 1855–1857; Hoffstetter, 1962; Hünermann, 1978; Rosselet, 1991; Georgalis & Scheyer, 2019) and five Miocene localities (Bolliger, 1992; Georgalis & Scheyer, 2022; Hünermann, 1981; Jost et al., 2015; Mennecart et al., 2016; Villa & Reichenbacher, 2022).



Fig. 5 Lacertidae indet. from Hüenerbach. Posterior portion of right maxilla NMB Hüe.3 in labial (a) and ventrolingual (b) views

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#### Author contributions

GLG, KTS, and BM wrote the manuscript; BM photographed the fossil specimens; KTS organized the  $\mu$ -CT scanning of *Lanthanotus* and the segmentation of the  $\mu$ -CT data of the extant material; GLG, KTS, and BM prepared the figures. All authors read and approved the final manuscript.

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#### Availability of data and materials

All fossil specimens described herein are permanently curated at the collections of NMB. Extant varanid specimens presented in Table 1 are permanently curated at the collections of SMF.

## Declarations

**Ethics approval and consent to participate** Not applicable.

#### **Consent for publication** Not applicable.

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## Competing interests

The authors declare that they have no competing interests.

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