

## Lungs and mesopneumonia of scincomorph lizards (Reptilia: Squamata)

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### Abstract

Mesopneumonia of 28 and lungs of 44 species of scincomorph lizards are described, representing mesopneumonia in six of the seven scincomorph families and lungs of all seven families of this taxon. Except for gymnophthalmids and scincids, a family typical organization of mesopneumonia occurs. In cordylids, gerrhosaurids, xantusiids and lacertids the complete right ventral mesopneumonium (VMp) inserts cranially on the posterior vena cava and caudally on the dorsal surface of the right liver lobe. The left VMp is attached to the ventrolateral body wall in cordylids and lacertids; in gerrhosaurids the left VMp is short and inserts on the pericardium and the posterior vena cava; in xantusiids the left VMp is reduced and the lungs are fused cranially with the pericardium. In scincids the VMp of both sides vary in length and insert on the ventral mesentery, or may be lacking completely. The visceral topology of the gymnophthalmids *Calyptommatus* and *Notobachia* differs from the general scincomorph pattern, with the liver and stomach elongated and situated on the right and left side of the body cavity, respectively. The left and the right VMp extend over the entire length of the lungs and insert on the ventral mesentery. All lungs examined in the study are single-chambered and show no major structural variability of the inner surfaces, except in lacertids, some gerrhosaurids, *Cordylus*, and two genera of gymnophthalmids (*Echinosaura* and *Neusticurus*). In these groups, rows of dorsomedial niches are present.

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### Introduction

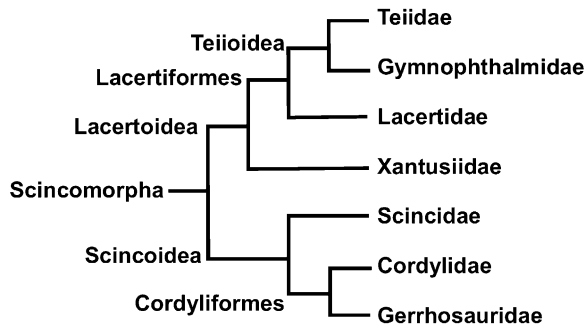
Scincomorpha comprises seven families forming two clades. One group (Scincoidea) comprises Scincidae, Cordylidae and Gerrhosauridae, whereas the other (Lacertoidea) contains Xantusiidae, Lacertidae, Teiidae

and Gymnophthalmidae (Fig. 1; Estes et al. 1988). The number of species exceeds 1900 for all scincomorph lizards, with approximately 1227 scincids (Greer 2001), 54 cordylids (Uetz 2004), 32 gerrhosaurids (Uetz 2004), 26 xantusiids (Uetz 2004), 264 lacertids (Uetz 2000), 117 teiids (Uetz 2000), and 182 gymnophthalmids (Uetz 2000).

The lungs of 13 and the mesopneumonia of 24 scincomorph species are described in detail, representing all or six of the seven scincomorph families, respectively (see Part 1 of the accompanying Organisms Diversity and Evolution Electronic Supplement at

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**Fig. 1.** Phylogenetic relationships of scincomorph lizards following Estes et al. (1988).

<http://www.senckenberg.de/odes/05-06.htm>). In most cases qualitative data for only one or two species per family is available (e.g. Milani 1894; Broman 1904; Becker 1993). However, within the Teiioidea the mesopneumonia (Klein et al. 2000), and within the Varanoidea the lung structure (Becker et al. 1989), comprise a useful character only at the family level. Therefore, description of a small number of species per family represents a meaningful contribution. The aim of the present paper is to describe the mesopneumonia and provide quantitative morphological data for the lungs of representatives of all families of scincomorph lizards, and thereby to develop some hypotheses about the functional and systematic value of the mesopneumonia–lung complex.

## Materials and methods

Specimens from the Alexander Koenig Zoological Research Institute and Museum (ZFMK) in Bonn, Germany, and from the collection of P.L.B. Rocha (Universidade Federal da Bahia, Brazil) were used. Snout-vent length (SVL), total length (TL), and body mass ( $M_B$ ) were recorded as reference data (see Electr. Suppl. 05-06, Pt. 2).

The visceral topology and location of mesos in each group are presented, followed by a description of the lungs. Definitions of the mesos and representation of the results follow Klein et al. (2000). Briefly, a standard schematic diagram, representing the parietal and visceral surfaces within a body cavity, is used to document the origin and insertion of the investigated mesos (DM = dorsal mesentery, VM = ventral mesentery; DMp = dorsal mesopneumonium, VMp = ventral mesopneumonium). The part of a meso attached to the organ is defined as its origin; the distal part as insertion.

To visualize the lungs, a combined toluidine blue-PAS (Periodic-Acid-Schiff reaction) en-bloc staining method was used. This method, which selectively stains tracheal cartilage and lung parenchyma, is as follows: (1) tap

water, 6–8 h; (2) periodic acid (0.5%), 60 min; (3) Schiff's reagent, 10 min; (4) tap water, 5 min; (5) acid ethanol (70%, 1% HCl conc.), 16 h; (6) toluidine blue (0.25%, pH < 2), at least 4 h; (7) ethanol (70%), several repetitions to wash out superfluous toluidine blue; (8) ethanol (50%), 5 min; (9) clearing and storage of lungs in glycerol.

The following data for the respiratory system (glottis, trachea and lungs) were collected [units of measurement in square brackets]: length of respiratory system measured from cranial tip of glottis to most caudal end of lungs ( $L_{RS}$  [mm]), length of lungs ( $L_{Lu}$  [mm]), length of left lung ( $L_{le}$  [mm]), length of right lung ( $L_{ri}$  [mm]), length of trachea ( $L_{Tr}$  [mm]), length of extra-pulmonary bronchus ( $L_{Br}$  [mm]), length of prehilary region ( $L_{Ph}$  [mm]), number of niches ( $N_{Ni}$ ), number of tracheal cartilages ( $N_{TC}$ ), parenchymal type (ed = ediculae, fav = faveoli) and parenchymal distribution (het = heterogeneous, hom = homogeneous).  $L_{RS}$ ,  $L_{Lu}$  and  $L_{Tr}$  were standardized to SVL,  $L_{Tr}$  and  $L_{Br}$  were standardized to  $L_{RS}$ ,  $L_{Ph}$  was standardized to  $L_{Lu}$ , and the quotients of lung length over trachea length ( $L_{Lu}/L_{Tr}$ ), and length of left lung over length of right lung ( $L_{le}/L_{ri}$ ) were calculated.

## Results

### Scincomorpha

#### General visceral topology

The heart lies in its pericardial cavity at the level of the shoulder girdle, connected caudally via the vena cava to the liver. The latter is composed of two lobes, divided in the mediosagittal plane. The right lobe is larger than the left one and extends dorso-caudally, contacting the meso of the right gonad with its caudal end. The gall bladder is embedded in the ventro-caudal part of the right liver lobe and the stomach lies on the left side of the abdominal cavity. The lungs lie dorso-caudally to the heart and dorsally to the cranial parts of liver and stomach. No intrapulmonary bronchi are present and the extra-pulmonary bronchi, when present, are short. Intestine, gonads and fat bodies, whose presence and size vary according to the nutritional status of a specimen, fill the caudal part of the body cavity.

### Scincidae

#### Visceral topology and mesos

The viscera of skinks show no deviation from the general scincomorph pattern. DMp originate on the dorsal mid-line of the lungs and insert on the border alimentary canal-DM. The VMp vary in their development

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