J. Zool., Lond. (1968) **154**, 487–493

The pineal vascular system in *Lacerta muralis*, with notes on the venous system of other lizards

ROY SWAIN

*Department of Zoology and Comparative Physiology, University of Birmingham**

(*Accepted 10 October 1967*)

(With 4 figures in the text)

Information on the pineal blood system of lizards is very limited. In view of a number of recent suggestions that the pineal complex may function in the secretion and/or storage of hormonal material it was considered necessary to obtain further information on the vascular pathways associated with it. A description is provided here of the pineal circulation in *Lacerta muralis*. This circulation is extensive and provides both an efficient supply to, and drainage from, all parts of the pineal complex. In particular there is an extensive capillary system draining the habenular, posterior, and subcommissural regions. The differences observed between the pineal venous systems of *Lacerta muralis*, *Lacerta viridis*, *Chalcides tridactylus*, *Agama cyanogaster*, and *Varanus niloticus* are also recorded. Such differences are restricted to the drainage systems associated with the dorsal sac and anterior wall of the epiphysis. It is concluded that the abundant pineal vascular system would provide a suitable pathway for removing secretory material from the pineal complex.

Contents

Introduction

The intracranial vascular system of lizards was described by Beddard (1905), and shortly afterwards Bruner (1907) discussed the cephalic veins and sinuses of reptiles, but, other than a brief mention by the latter author of the presence of epiphyseal veins in *Lacerta agilis*, no mention was made of a pineal circulation. Dendy (1909) observed such a circulation in the rhynchocephalian, *Sphenodon punctatus*, and more recently Steyn (1958) described one in the lizards *Cordylus polyzonus* (Family Cordylidae) and *Mabuya sulcata* (Family Scincidae). No other information is available on the vascular connections of the pineal region in lizards, and in view of the current interest in the pineal complex as a possible endocrine system it seems desirable to obtain further knowledge of the vascular pathways associated with it. The present investigation was carried out with this object in mind.

* Present address: Department of Zoology, University of Tasmania.

Materials and methods

Since *Lacerta muralis* had been chosen for experimental work upon the function(s) of the lacertilian pineal complex, a complete anatomical study of the vascular system was carried out in this species. In addition, however, a number of other species were available, and in these the pineal venous system only was studied. A total of five species was used: *Lacerta muralis* and *Lacerta viridis* (Family Lacertidae), *Chalcides tridactylus* (Family Scincidae), *Agama cyanogaster* (Family Agamidae), and *Varanus niloticus* (Family Varanidae).

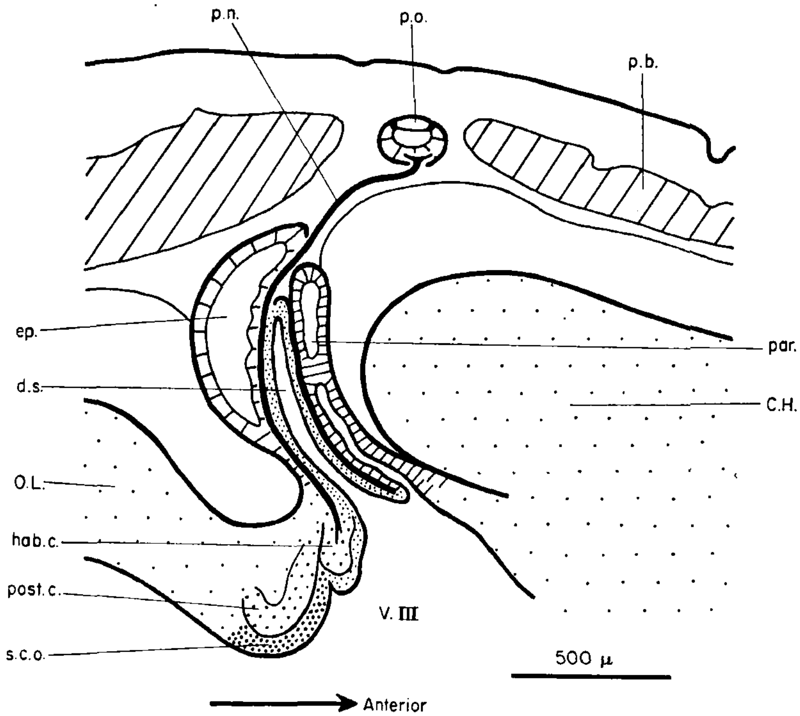

FIG. 1. Diagrammatic reconstruction of the pineal complex in *Lacerta muralis*, drawn in sagittal section. C.H., Cerebral hemisphere; d.s., dorsal sac; ep., epiphysis; hab.c., habenular commissure; O.L., optic lobe; par., paraphysis; p.b., parietal bone; p.n., parietal nerve; p.o., parietal organ; post. c., posterior commissure; s.c.o., subcommissural organ; V. III, third ventricle.

The arterial supply to the pineal complex was best studied by injection of red latex solution into the blood system via the ventricle of the heart, followed by subsequent dissection. The venous system could readily be traced using 10 μ sections of formalin-fixed heads, stained with haematoxylin and eosin. In addition the modification by Knox (1954) of the benzidine technique for staining brain capillaries was also found to be useful. Material treated by this technique was sectioned at 10 to 12 μ.

Results

The general anatomy of the pineal complex in *Lacerta muralis* is summarized in Fig. 1. In an antero-posterior sequence the complex consists of the paraphysis, the dorsal sac, the parietal organ and the epiphysis. These structures are all derived as outgrowths of the diencephalic roof above the third ventricle. In addition several nervous elements are associated with the complex. These consist of the parietal nerve, the habenular ganglia and commissure, the posterior commissure, and the subcommissural organ.

The arterial system in ***Lacerta muralis***

(Fig. 2)

The arteries supplying blood to the pineal complex are derived from the bilateral posterior cerebral artery which itself arises directly from the internal carotid artery of each side of the head.

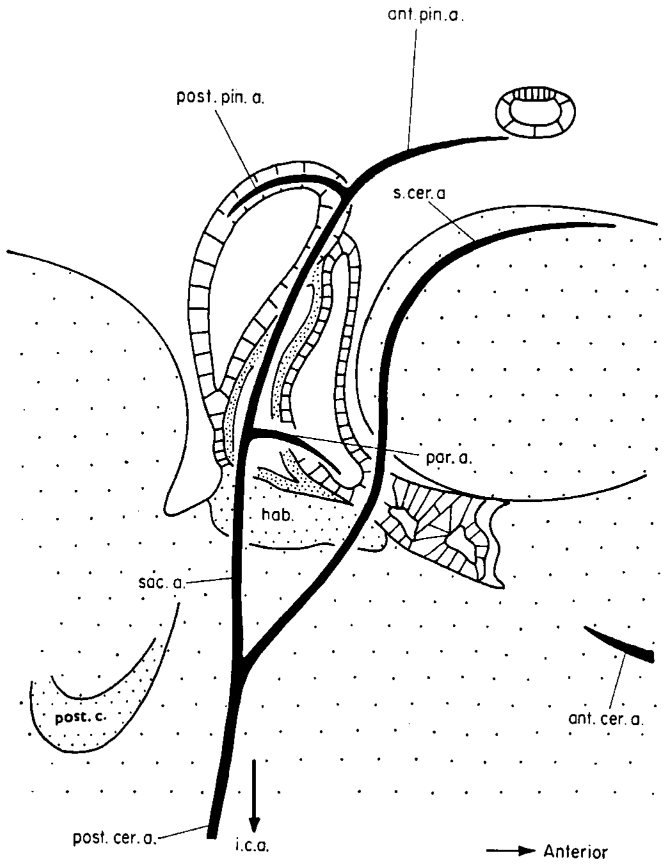

FIG. 2. The arterial supply to the pineal complex in *Lacerta muralis*, sagittal reconstruction. hab., Habenular ganglion; post. c., posterior commissure; ant. cer. a., anterior cerebral artery; ant. pin. a., anterior pineal artery; i.c.a., internal carotid artery; par. a., paraphyseal artery; post. cer. a., posterior cerebral artery; post. pin. a., posterior pineal artery; sac. a., saccular artery; s. cer. a., superior cerebral artery.

Shortly after the posterior cerebral artery passes inwards between the optic lobe and cerebral hemisphere, it bifurcates. One branch, the superior cerebral artery, continues in an antero-dorsal direction over the posterior surface of the cerebral hemisphere. The other branch continues upwards as the saccular artery, supplying blood to the dorsal sac and paraphysis. At the level of the base of the epiphysis this artery gives off a small paraphyseal artery, whilst at the distal end of the epiphysis the saccular artery is directed posteriorly as the posterior pineal artery. On the left side only it continues as the anterior pineal artery to the pineal organ.

The intercerebral region is supplied by a branch of the anterior cerebral artery.

*The venous system in **Lacerta muralis***

(Fig. 3)

There is a very well developed drainage system associated with the pineal complex. The various veins all drain into the large median sinus longitudinalis which runs above the roof of the brain immediately below the meninges.

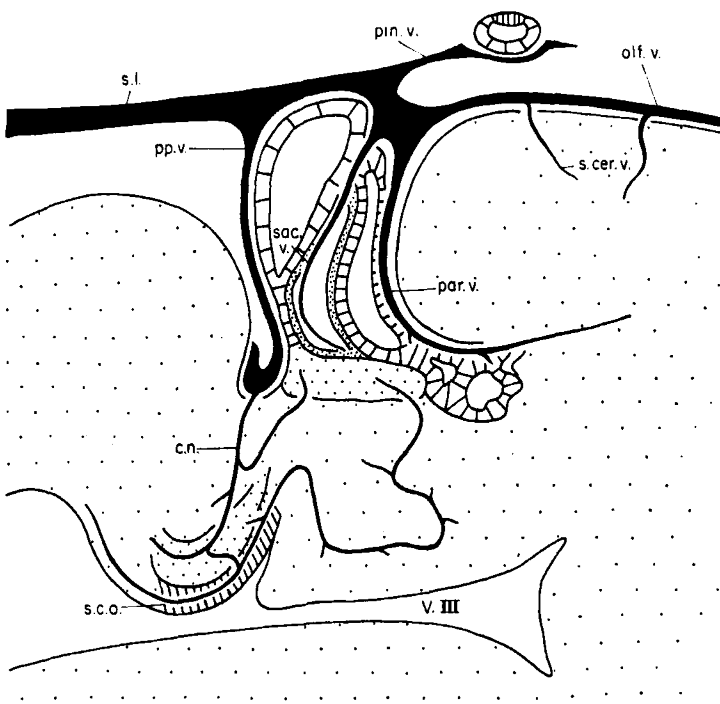

FIG. 3. The venous system in the pineal complex of *Lacerta muralis*—sagittal reconstruction.

s.c.o., Subcommissural organ; V. III, third ventricle; c.n., capillary network; olf. v., olfactory vein; par. v., paraphyseal vein; pp. v., parapineal vein; pin. v., pineal vein; sac. v., saccular vein; s. cer. v., superior cerebral vein; s.l., sinus longitudinalis.

Anteriorly there is a large median paraphyseal vein originating between the cerebral hemispheres. This vein collects blood from the capillary network of the paraphysis and drains into the sinus longitudinalis at the junction of this sinus with the bilateral olfactory veins.

Shortly behind the paraphyseal vein the bilateral saccular vein, which drains the dorsal sac and the anterior wall of the epiphysis, enters the sinus.

The median pineal vein enters the sinus above the distal tip of the epiphysis. It forms a circle around and beneath the "eye" and collects blood both from this organ and from the connective tissue and meninges directly anterior to it.

Immediately behind the roof of the epiphysis the median parapineal vein joins the sinus longitudinalis. This vein originates in the fusion of a number of veins lying on the surface of the optic lobes. In addition to serving the epiphysis, the parapineal vein also receives blood from an extensive capillary system draining the habenular, posterior, and subcommissural regions.

The venous system in the pineal complex of other lizards

The other species studied closely resemble *Lacerta muralis* in their arrangements for pineal drainage. Consequently only the differences observed are included in this account: such differences appear to be restricted to the saccular vein(s).

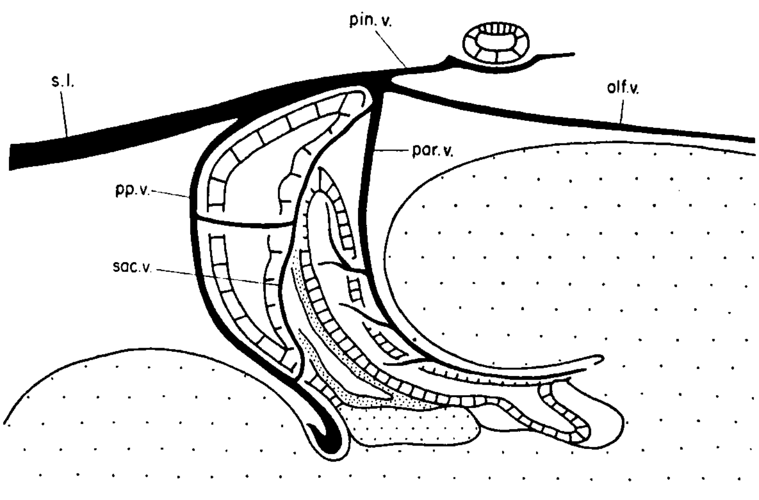

FIG. 4. The venous system in the pineal complex of *Lacerta viridis*, sagittal reconstruction. Labelling as for Fig. 3.

Chalcides tridactylus* and *Varanus niloticus

In these two species the venous system differs from that of *Lacerta muralis* in the possession of a single, median saccular vein which drains upwards into the sinus longitudinalis, as does the bilateral saccular vein of *Lacerta*. The vein is smaller in *Varanus* than in *Chalcides*.

Agama cyanogaster

The saccular vein here is bilateral, as in *Lacerta muralis*, but drains downwards into the parapineal vein.

Lacerta viridis (Fig. 4)

In this species there is an exceptionally good venous system.

The paraphysis is very vascular and a plexus of capillaries drains from it into the paraphyseal vein. The saccular vein is bilateral and connects both with the parapineal vein ventrally and with the paraphyseal vein dorsally, immediately before the junction of this latter vein with the sinus longitudinalis. In addition to the complete drainage loop which is thus formed around the epiphysis, there may also exist one or more cross-connections between the saccular and parapineal veins.

Discussion

The terminology employed here is derived from that of Dendy (1909) with the addition of the term median paraphyseal vein introduced by Steyn (1958).

It is probable that the pineal complex is involved in hormone production (Swain, 1966), and the abundant pineal circulation described above would certainly be well placed to receive and transport such material. The arterial supply described for *Lacerta muralis* is similar to that found in other species (Dendy, 1909; Steyn, 1958). The supply is, in all cases, derived from the internal carotid arteries and, except in the case of *Cordylus polyzonus* (Steyn, 1958), is obtained via the posterior cerebral arteries. The differences found in the species so far studied have been summarized elsewhere (Swain, 1966); in view of the lack of comparative information it is not possible to draw worthwhile conclusions from them and they will not be considered here. However, it may be noted that the arterial system present in *Lacerta muralis* more closely approaches that found in *Sphenodon punctatus* (Dendy, 1909) than that of the two South African species studied by Steyn.

Similarly the venous system associated with the pineal complex also appears to be based on the same pattern in all species. Differences here are restricted mainly to the saccular vein(s), and a complete anatomical series presents itself in this respect. Thus the vein is bilateral in *Lacerta muralis*, *Lacerta viridis*, and *Agama cyanogaster*, whilst in *Varanus niloticus* and *Chalcides tridactylus* it is single and median. It may drain upwards, directly into the sinus longitudinalis as in *Lacerta muralis*, *Chalcides tridactylus*, and *Varanus niloticus*, or downwards into the parapineal vein as in *Agama cyanogaster*, or it may form a complete loop around the epiphysis as in *Lacerta viridis*. It is not yet possible to say whether this range of epiphyseal drainage is related to any differences in functional importance in the different species concerned.

It is very probable that an extremely close functional relationship exists between the subcommissural organ and the epiphysis (Swain, 1966). In view of this possibility the capillary drainage network described for *Lacerta muralis* may be of considerable significance as a pathway linking these two organs. Such a network is not confined to *Lacerta muralis*; it has been observed in all the species employed in the present study although the details of the capillary pathways have not been mapped out.

It may finally be noted that capillaries frequently enter the sensory epithelium of the epiphysis and are therefore readily able to transport secretory material to and from this organ. In contrast, however, capillaries do not enter the parietal organ, and in view of the presence of a parietal nerve, at least in some species, coupled with the observation that the secretory activity of the organ is greatly reduced in comparison with that of the epiphysis (Swain, 1966), it is probable that the function of the parietal organ is largely sensory rather than secretory.

Summary

There is an abundant blood circulation associated with all parts of the pineal complex in *Lacerta muralis*. In particular there is an extensive capillary system which drains the habenular, posterior, and subcommissural regions and which could serve to integrate subcommissural and pineal activities.

Interspecific variation in the pineal venous system appears to be limited to the location and extent of the saccular vein.

The pineal blood system would provide an efficient pathway for the transport of secretory material into and out of the complex.

I am most grateful to Dr Brenda Murray for her encouragement throughout this and related work.

REFERENCES

Beddard, F. E. (1905). A contribution to the knowledge of the encephalic arterial system in Sauropsida. *Proc. zool. Soc. Lond.* **1905 (2):** 59–70.

Bruner, H. L. (1907). On the cephalic veins and sinuses of reptiles, with description of a mechanism for raising the venous blood pressure in the head. *Am. J. Anat.* **7:** 1–117.

Dendy, A. (1909). The intracranial vascular system of *Sphenodon*. *Phil. Trans. R. Soc.* (B) **200:** 403–426.

Knox, G. A. (1954). The benzidine staining method for blood vessels. *Stain Technol.* **29:** 139–142.

Steyn, W. (1958). The pineal circulation in some lizards. *S. Afr. J. Sci.* **54:** 143–147.

Swain, R. (1966). *Studies on the structure and function of the parietal complex in Lacertilia.* Ph.D. thesis, University of Birmingham.