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Vascularization of the Pineal Gland in the Crow

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ABSTRACT. The blood vascularization in the pineal gland of the crow was investigated in detail using a vascular corrosion cast technique and by scanning electron microscopy. The pineal gland received two afferent arteries on either side, each artery arising from the *A. cerebralis caudalis* (CC) which supplied its branches to the hemisphere. The pineal gland of the crow was so highly vascularized as to be suggestive of its high metabolic and endocrine activities. The efferent veins drained into the *Sinus occipitalis* and the *Sinus sagittalis dorsalis*. There was a direct vascular connection between capillaries of the stalk of the gland and those of the *Plexus choroideus*.—KEY WORDS: blood supply, crow, pineal gland.

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The avian pineal gland is characterized by its functional as well as morphological features which are intermediate between those of the mammalian and the reptilian glands. The vascularization of the avian pineal glands has so far been examined by light microscopy, but not by scanning electron microscopy (SEM), in spite of extensive SEM observations in other animals such as the common tree shrew [4], rat [6–8] and lizard [11]. Accordingly, it would be of interest to investigate the vascularization in the avian pineal gland using a cast-preparation technique which provides us with a three-dimensional aspect to visualize it in detail. The present study dealt with the crow pineal gland.

A total of 30 adult crows of both sexes were used. After anesthesia with chloroform, the pulsating heart was exposed. As the crow has no or degenerated right *A. carotis interna*, a polyethylene tube was inserted into the left *A. carotis interna* through the left ventricle to perfuse vessels in the head with saline. Immediately after draining the blood off, Mercox (Dainippon Ink and Chemicals Co., Tokyo) or latex (Neoprene Latex Co., Tokyo) was injected into the head through the same tube. After complete polymerization of the injected resin, the head was cut off and was immersed *in toto* in NaOH solution (0.5–3%) at 60°C for digestion of the tissues. Following maceration of soft tissues, the specimen was washed gently in running water. The cast specimen was air-dried, coated with gold, and examined by a scanning electron microscope (JSM-35C, JEOL Co., Tokyo). Some other resin-injected specimens were immersed in 10% formalin solution without maceration. The brain tissues of these specimens were removed and their arterial systems were observed under a binocular dissecting microscope. For observation of the venous system of the head in another series of specimens, latex was injected retrogradely through the *Vena jugularis*.

The pineal body of the crow lay between the cerebral hemispheres and the cerebellum, and extended ventrally toward the third ventricle.

Arterial system: The left *A. carotis interna* ascended the ventral aspect of the neck to divide into right and left branches. Each branch gave off the *A. carotis externa* before entering the cranial cavity. Then, after entering the cranial cavity, the rostral ramus of the *A. carotis interna* on either side gave off the *A. cerebralis caudalis* (CC). Both of the CC extended along the dorsal longitudinal fissure to the *A. interhemispherica* which supplied many branches to the hemispheres. The CC further gave off the *A. cerebellaris dorsalis* which supplied branches to the dorsal side of the cerebellum.

To the pineal gland, two afferent arteries were distributed on either side. One of them (*A. meningealis caudalis*) originated from the CC at the caudal side of the hemisphere and coursed dorsally to branch on the pineal body. This vessel is the main trunk supplying capillaries into the pineal gland and passing through the gland to reach the meninx (Fig. 1). The other one (*Ramus pinealis*) was small and originated from the CC before *A. meningealis caudalis* near its branching point from the *A. carotis interna*. This small artery coursed on the caudal side of the pineal stalk and supplied capillaries toward the stalk and the caudal part of the gland. This artery did not supply any capillaries to the meninx.

Capillary system (Fig. 2): The afferent branches of the pineal gland from the *A. meningealis caudalis* and *Ramus pinealis* were embedded in the parenchyma of the pineal body and stalk. In the parenchyma, they branched repeatedly to make a dense vascular network. The network in the stalk was not so dense as that in the body. Some capillaries in the stalk expanded ventrally and

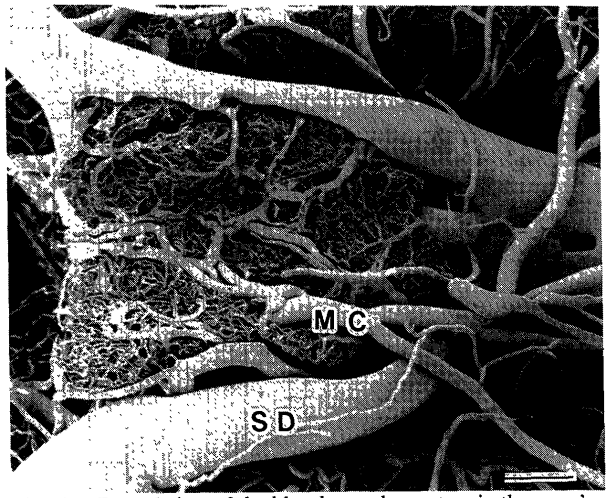

Fig. 1. Dorsal view of the blood vascular system in the crow's pineal gland. *Arteria meningealis caudalis* (MC) passes through the body. Bar = 500 μm. SD: *Sinus sagittalis dorsalis*.

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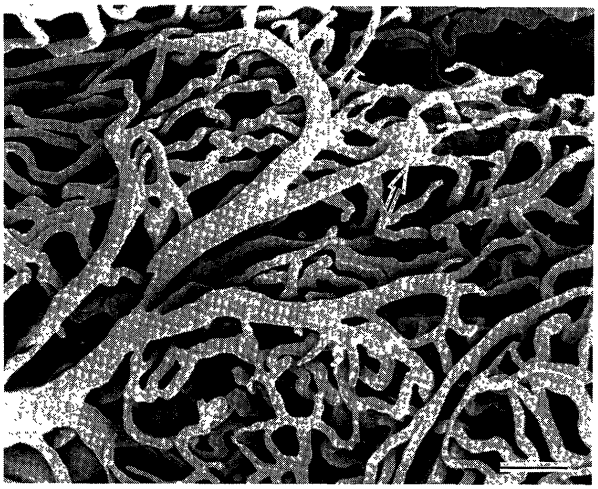

Fig. 2. Capillary bed of the pineal gland. The afferent artery (arrow) is embedded in the parenchyma and ramifies into capillaries to form a fine network. Bar = 100 μm.

anastomosed with capillaries of the *Plexus choroideus* of the third ventricle (Fig. 3).

Venous system: Venous drainage occurred via fine veins on the overall surface of the gland. These veins drained to the *Sinus sagittalis dorsalis* at the lateral and rostral parts of the gland (Fig. 1) and to the *Sinus occipitalis* at the caudal part of the gland. The *Sinus occipitalis* coursed ventrally along both sides of the cerebellum and joined the *Vena jugularis*.

The rise of the afferent arteries of the pineal gland from the CC in the crow is at least consistent with the rise reported in the other birds [1, 2, 12]. In the white-crowned sparrow, the afferent artery of the pineal gland is a single branch as *Ramus pinealis* [12] from the CC, and it seems that this artery corresponds to the small artery in the crow as shown in the present study. This artery seems to be absent in the chicken [3]. Instead, in the chicken, the *A. meningealis caudalis*, a branch of the cranial ramus of the left *A. carotis interna*, serves as a main afferent artery of the pineal gland [3] as seen in the crow. In the crow, this artery is the main trunk supplying capillaries into the pineal gland and passing through the gland to reach the meninx. However, it seems that, in the white-crowned sparrow, this artery does not pass through the pineal gland [12].

The avian pineal gland discharges melatonin that controls the reproductive function and locomotor activity. The melatonin concentration in cerebrospinal fluid (CSF) changes with a circadian rhythm [9]. It has been reported that the melatonin release in the crow depends on the light-dark cycle and that the released amount of melatonin increases during nighttime [10]. Pineal secretion possibly controls the permeability of the *Choroid plexus* and the formation of CSF [5]. In the rat, there is no direct vascular connection between the pineal gland and the *Plexus choroideus* of the third ventricle [7]. In contrast, in the crow, the capillary plexus of the pineal stalk anastomoses with that of the *Plexus choroideus*. The present study by

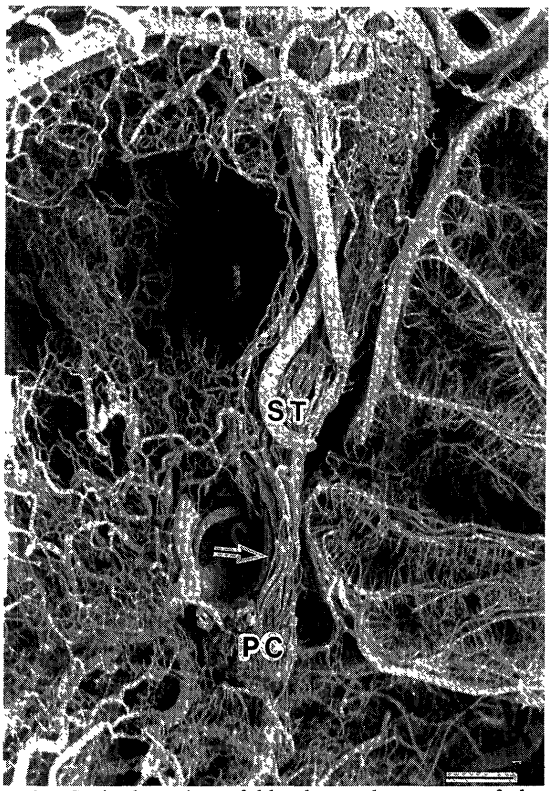

Fig. 3. Sagittal section of blood vascular system of the pineal gland. The capillary plexus of the pineal stalk (ST) is connected with that of the *Plexus choroideus* (PC) via anastomoses (arrow). Bar = 1,000 μm.

SEM failed to demonstrate the exact direction of the blood flow in this anastomosis. However, if the blood could flow from the pineal body to the *Plexus chorioideus*, some amount of the pineal secretion would be released into the third ventricle with CSF.

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