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Scanning electron microscopic study of the posterior ciliary veins in domestic ungulates

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Vascular corrosion casts of 12 equine, 15 bovine and 50 porcine eyes were studied scanning electron microscopically for the presence of posterior ciliary veins. These veins drain a postequatorial segment of the choroid and emerge near the posterior bulbar pole. They complement the four vorticose veins that emerge near or at the equatorial zone of the eyeball and the slender choroidoretinal veins that drain the peridiscal area of the choroid. Posterior ciliary veins were observed in all equine and bovine eyes examined. In these species they presented a large variation in size, number and position. In contrast, posterior ciliary veins were only present in two porcine eyes where they were represented by one and two vessels, respectively. The morphology and variability of these vessels is illustrated and their nomenclature and functional significance are discussed.

key words: ophthalmology, angiology, veins, choroid, horse, ox, pig

INTRODUCTION

The venous outflow of the choroid in domestic animals is mainly provided by the four vorticose veins that emerge near or at the equatorial area of the eyeball. The morphology of these veins has been described in detail for all domesticated mammalian species including herbivores [1,9], carnivores [4,10] and pigs [6]. The vorticose veins are complemented by much smaller veins that drain the peridiscal segments of the choroid and leave the eyeball near the posterior bulbar pole, where they anastomose with the retinal venules. These peridiscally emerging veins have been designated by various names such as *short posterior ciliary veins* [4], *cilioretinal veins* [2] and *choroidoretinal veins* [6]. The latter term will be used further below in this text, because of its conformity to the nomenclatory rules defined by official veterinary anatomical nomenclature [5,6]. These choroidoretinal veins are most obvious in the dog [4] and cat [10], and have also been observed in the porcine eye [6]. In contrast, they have not been described in elaborate classic studies on the equine [1] and bovine [9] ocular vasculature, and neither are they mentioned in recent anatomical and ophthalmologic literature dealing with these species. However, the ancient anatomical study of the equine eye by Bach [1] contains an illustration showing a large innominate vein which emerges far posterior to the vorticose veins but is too far remote from the optic disc area to be considered as a choroidoretinal vein. To our knowledge the presence of such a particular vessel, which is apparently complementary to the vorticose and choroidoretinal veins, has not been confirmed afterwards in veterinary literature. Therefore the present study was performed in order to gather information about the presence and the characteristics of these vessels, which will be further referred to by the name *posterior ciliary veins.*

MATERIAL AND METHODS

This scanning electron microscopic (SEM) study was performed on vascular corrosion casts of 12 equine, 15 bovine and 50 porcine eyes. The animals were of various breeds and ages, and were subjected to eu-

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thanasia for reasons other than ocular disease. Immediately after death they were exsanguinated and the cranial blood vessels were flushed with a saline solution through a catheter inserted in the maxillary arteries (horses) or the common carotid arteries (oxen and pigs). Subsequently the orbital vasculature was filled by the same approach with pigmented methylmethacrylate (Batson's No. 17, Polysciences Ltd., St Goar, Germany). After polymerisation for 8 h, the orbital contents were macerated by immersion in a 25% solution of potassium hydroxide at room temperature during 72 h, whereafter the corrosion casts were rinsed in water and air-dried. Peribulbar blood vessel casts were dissected for exposing the choroidal vasculature under a Wild M7A stereomicroscope (Heerbrugg, Switzerland). The bulbar casts were mounted with double-sided adhesive tape on aluminium stubs, sputter-coated with platinum (Auto Fine Coater JFC-1300 JEOL, Tokyo, Japan) and examined by means of a JEOL JSM 5600 LV (Tokyo, Japan) scanning electron microscope in high vacuum mode at 10 kV.

RESULTS

Posterior ciliary veins were present in all equine and bovine eyes but were inconstant in the porcine eyes. They collected a variable amount of postequatorial choroidal veins that were located in the watershed zones between the vorticose veins and emerged postequatorially through the sclera (Fig. 1). The size, number and position of these veins were subject to considerable variation.

In horses, the number of posterior ciliary veins ranged from one single branch to as many as 9 slender veins which emerged separately, with an average number of 5 veins per eye. The luminal diameter of the veins measured on vascular casts varied from less than 0.1 mm to 0.5 mm. One or more posterior ciliary veins were always observed in the dorsal watershed zone between the dorsomedial and dorsolateral vorticose veins (Figs. 2–5). These constant but variably shaped veins drained territories that were supplied by the corresponding dorsal posterior ciliary artery. In seven horses, one or two ventral posterior ciliary veins were located in the ventral watershed zone, i.e. between the ventromedial and ventrolateral vorticose veins. These slender veins drained a rather small peridiscal choroidal area supplied by the ventral posterior ciliary artery and the choroidoretinal arteries (Fig. 6). Additional posterior ciliary veins were observed in the lateral watershed zones between the dorso- and ventrolateral vorticose veins in five eyes, and in the medial watershed zone between the dorso- and ventromedial vorticose veins in four eyes. These lateral and medial posterior ciliary veins were slender and emerged near the branches of the short posterior ciliary arteries entering the choroid (Fig. 7).

A similar distribution of posterior ciliary veins was observed in the bovine eyes. One or more veins were present in the dorsal, ventral and horizontal watershed zones between the vorticose veins in each eyeball. They varied in number and size, ranging from a single vessel with a diameter of more than 1 mm (Figs. 8–9) to several slender veins emerging between the ramifying or coiled branches of the short posterior ciliary arteries (Figs. 10–11). After piercing the sclera, most of these vessels discharged as separate veins into the ophthalmic venous plexus (Figs. 8–9A), but in one particular case the emerging vein curved anteriorly and anastomosed with the retrobulbar stem of the dorsolateral vorticose vein (Fig. 9B).

In contrast to the equine and bovine eyes, posterior ciliary veins were inconstant in the porcine eyes. They were observed only in two out of 50 eyes. The

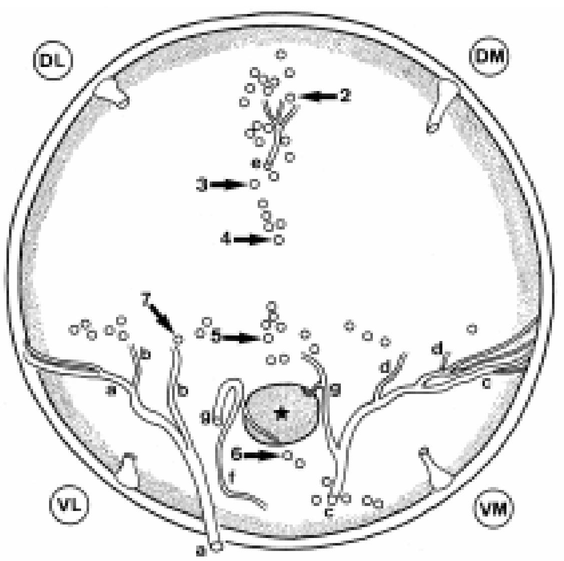

Figure 1. Compilation drawing based on 10 equine eyes illustrating the position of the posterior ciliary veins (small circles) emerging from the choroid in the watershed zones between the vorticose veins. This schematic caudal view of the left eye shows the contours of the eyeball (outer border line), the choroid (shaded inner border line) and the optic disc (asterisk). Particular posterior ciliary veins that are identified by numbers (2–7) are illustrated in the next figures bearing the same numbers; a — lateral long posterior ciliary artery; b — lateral short posterior ciliary arteries; c — medial long posterior ciliary artery; d — medial short posterior ciliary arteries; e — dorsal posterior ciliary artery; f — ventral posterior ciliary artery; g — choroidoretinal arteries; DL — dorsolateral vorticose vein; DM — dorsomedial vorticose vein; VL — ventrolateral vorticose vein; VM — ventromedial vorticose vein.

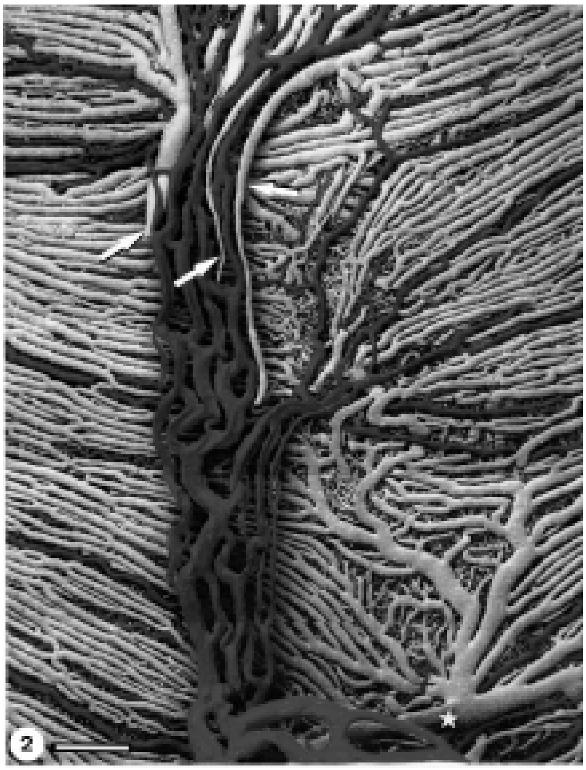

Figure 2. Caudal view of an equine choroidal vascular cast showing one relatively large (asterisk) and several slender posterior ciliary veins (arrows) emerging from the watershed zone between the dorsolateral choroidal veins (to the left) and the dorsomedial choroidal veins (to the right). Notice the close association between the posterior ciliary veins and the branches of the dorsal posterior ciliary artery (painted in red) entering this area. Scale bar = 1 mm.

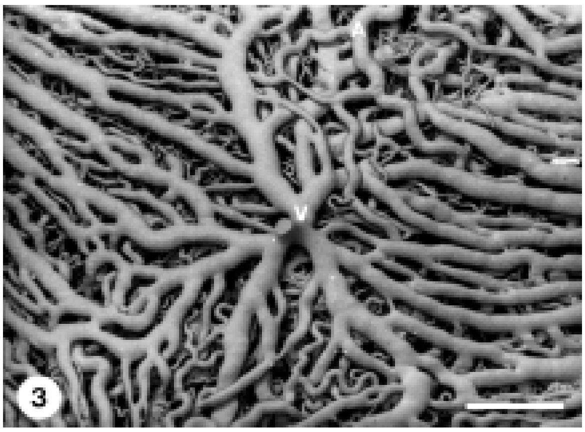

Figure 3. Single posterior ciliary vein (V) emerging from the dorsal watershed zone in an equine eye in close association with a posterior ciliary artery (A) entering the same area. Scale bar = 1 mm.

first case was a 7-month-old Vietnamese miniature pig with a 0.2 mm wide vein which left the choroid 2 mm ventrolateral to the optic disc margin, pierced the sclera and discharged into a choroidoretinal vein

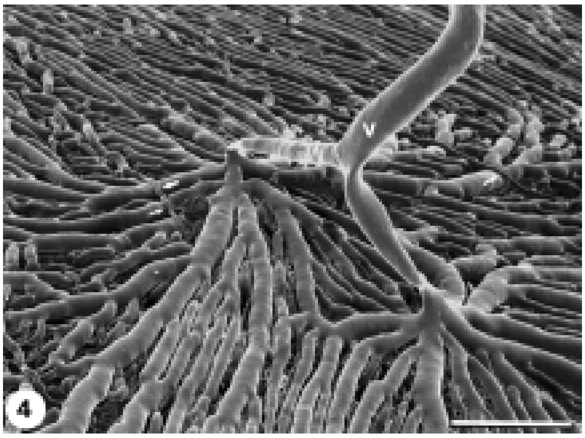

Figure 4. Double-branched posterior ciliary vein (V) emerging from the dorsal watershed zone in an equine eye. Arrows indicate choroidal arteries crossing over some of the venous branches. Scale bar = 1 mm.

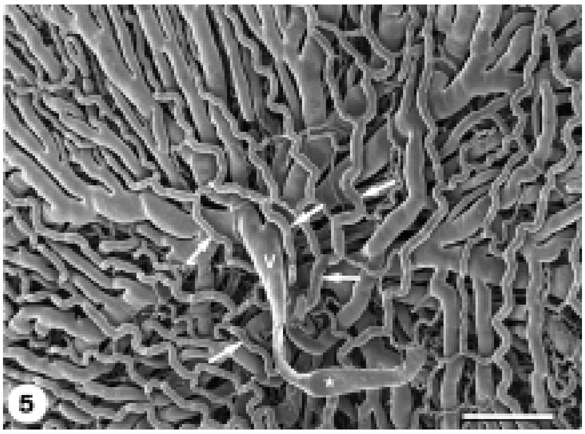

Figure 5. Posterior pole area of an equine choroidal vascular cast presenting a posterior ciliary vein (V) surrounded by coiled choroidal arterial branches (arrows) given off by a choroidoretinal artery that has been removed in order to expose the flattened intra- and extrascleral segments of the vein (asterisk). Scale bar = 1 mm.

after collecting a slender episcleral vein (Fig. 12). The other case was a 1-month-old Belgian landrace piglet having a similar dorsal posterior ciliary vein and a much smaller ventral counterpart vein, which both emerged from the peridiscal area of the choroid and discharged into the choroidoretinal veins.

DISCUSSION

This study demonstrates that the ocular vascular tunic of large domestic animals contains particular choroidal veins that emerge postequatorially from the eyeball and are complementary to the vorticose and choroidoretinal veins. The existence of these vessels was suggested more than a century ago in an illustration of the equine eye [1], but has not been

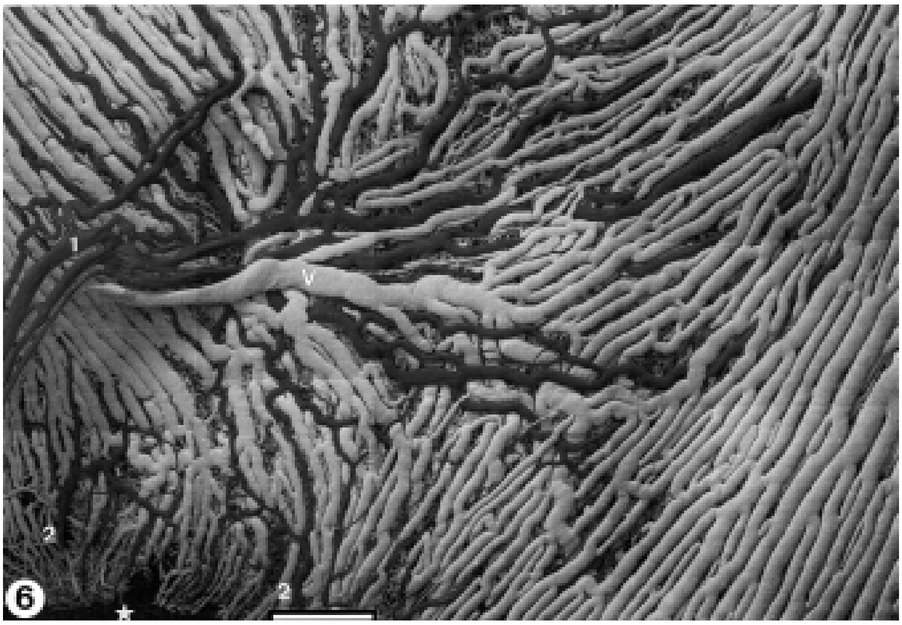

Figure 6. Large posterior ciliary vein (V) emerging from the equine choroid ventral to the optic disc border (asterisk) and draining a choroidal segment supplied by the ventral posterior ciliary artery (1) and branches of choroidoretinal arteries (2). Scale bar = 1 mm.

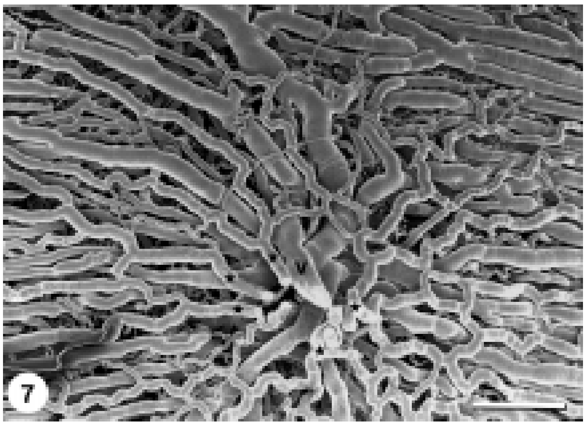

Figure 7. Posterior ciliary vein (V) emerging caudally from the lateral watershed zone of the equine choroid. The vein stem is surrounded by several arterial branches (asterisks) of a lateral short posterior ciliary artery that has been cut for better exposure of the vein. Scale bar = 1 mm.

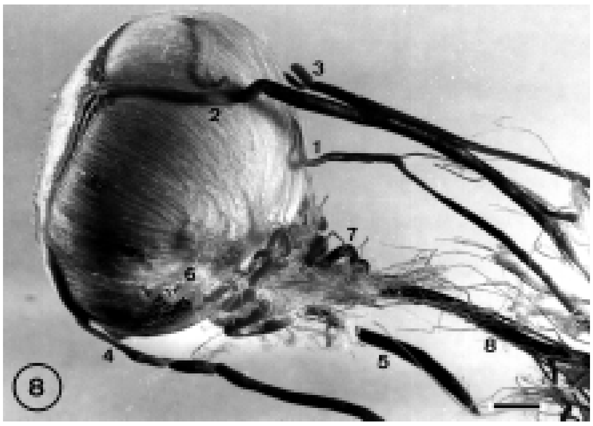

Figure 8. Lateral stereomicroscopic view of the choroidal vascular cast of a left bovine eye showing a large posterior ciliary vein (1) emerging from the dorsal watershed zone between the dorsolateral (2) and dorsomedial (3) vorticose veins. Other blood vessels labelled are the ventrolateral (4) and ventromedial (5) vorticose veins as well as the lateral (6) and medial (7) long posterior ciliary arteries which arise from the major bulbar artery, i.e. the anastomotic branch between the external and internal ophthalmic arteries (8). Scale bar = 5 mm.

documented since. In the present study, however, such veins were observed in all eyes of horses and oxen that were examined, as well as in a minority of the porcine eyes. In contrast, the authors could find no evidence for the presence of such vessels in feline and canine eyes neither by reviewing the literature reports nor by studying a high number of vascular corrosion casts from these species. The fact that these veins were constantly present in the large equine and bovine eyeballs suggests that they fulfil a functional demand by providing an additional outflow route for the high volume of choroidal blood in these species. Such a function is fully in line with the observation that these vessels are positioned in between the vorticose and choroidoretinal veins and form numerous anastomoses with both sets of veins.

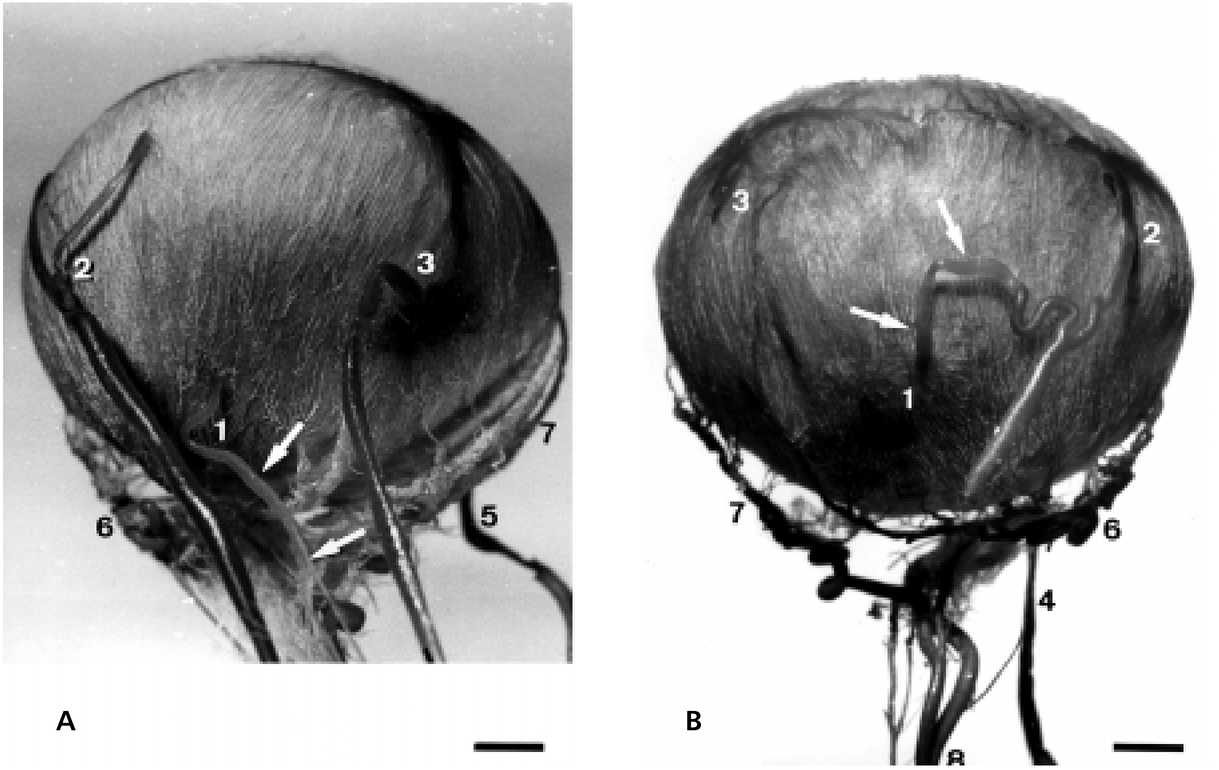

Figure 9. A) Dorsal stereomicroscopic view of the posterior ciliary vein (1) of the vascular cast of the left bovine eye illustrated in Fig. 8, showing the separate extrabulbar course of the emerging posterior ciliary vein (arrows). Same legend as in Fig. 8; Scale bar = 5 mm.
B) Dorsal stereomicroscopic view of the vascular cast of a right bovine eye showing a posterior ciliary vein (1) which emerges from the same area as in Fig. 9A but bends anteriorly (arrows) after leaving the eyeball to join the extrabulbar stem of the dorsolateral vorticose vein (2).

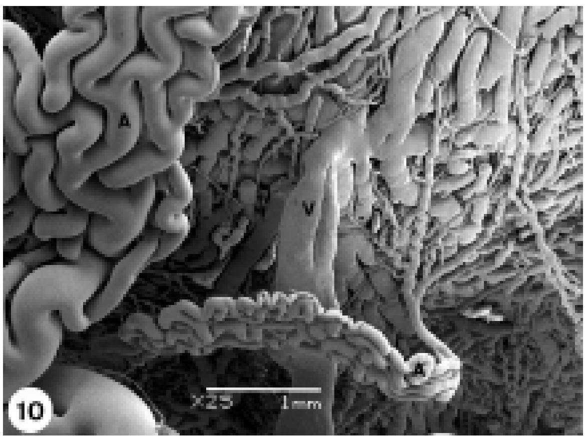

Figure 10. Large posterior ciliary vein (V) emerging from the dorsal watershed zone in a choroidal vascular cast of a bovine eye. Observe the numerous coiled arterial clusters of short posterior ciliary arteries (A) entering the same area. Scale bar = 1 mm.

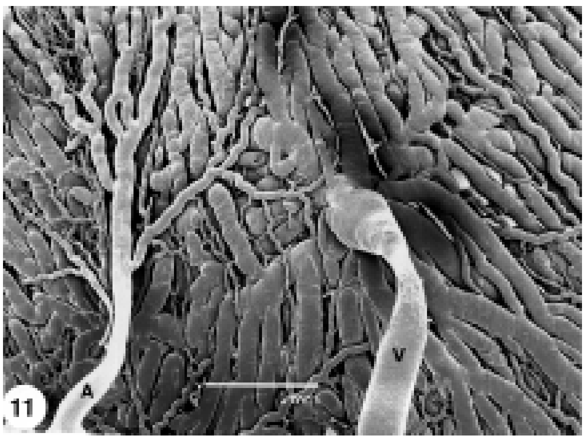

Figure 11. Postequatorial segment of the medial watershed zone in a choroidal vascular cast of a bovine eye showing a posterior ciliary vein (V) emerging caudal and parallel to a short posterior ciliary artery (A). Scale bar = 1 mm.

The iconographic documentation of the post-equatorially emerging choroidal veins clearly illustrates that the size, number and position of these vessels are subject to considerable variation. Despite this variability, however, the high frequency of these veins indicates that they might be functionally and clinically important for draining the blood from the choroid. Because of their location in the choroidal watershed zones, i.e. between adjacent vorticose veins or between the vorticose and choroidoretinal

Figure 12. Choroidal vascular cast of a Vietnamese miniature pig showing a posterior ciliary vein (V) which emerges 2 mm ventral to the optic disc margin (asterisk). The extrascleral segment of the vein (arrowheads), which is incompletely filled with casting medium, receives an episcleral vein (arrow). A short posterior ciliary artery (A) enters and ramifies in the adjacent peridiscal area of the choroid. Scale bar = 1 mm.

veins, the posterior ciliary veins provide anastomotic pathways for shunting blood towards ischaemic choroidal areas in cases of vascular occlusion. The importance of such venous anastomoses between the various choroidal segments has been demonstrated in experimental animal studies [7] as well as in human patients [3].

No proper terminology for the postequatorially emerging choroidal veins has been found in the few morphologic papers describing bulbar angiology in domestic animals [1] nor in official veterinary anatomical nomenclature [5]. Yet it is recommended to have a specific name for these vessels because of their frequency and their functional potential. In conformity with the proposal for designating the corresponding arteries as 'posterior ciliary arteries' [8], we suggest designating these particular veins as 'Vv. ciliares posteriores'. This terminology would only require a minor adaptation of the official anatomical nomenclature [5] which actually contains only the less specific term 'Vv. ciliares'. By adding distinguishing adjectives to this term it would be possible to differentiate between the 'Vv. ciliares anteriores', which drain the anterior ocular segments including the scleral venous plexus, and the 'Vv. ciliares posteriores', which emerge postequatorially from the eyeball. The introduction of these separate terms is in line with the official nomenclature used for the corresponding arteries [5] and is recommended in view of the different functional and clinical significance of both types of veins.

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