SOME COCCIDIA FROM THE GALL-BLADDER AND INTESTINE OF THE TEIID LIZARD *AMEIVA AMEIVA AMEIVA* AND THE GECKO *HEMIDACTYLUS MABOUIA* IN NORTH BRAZIL

LAINSON R.* & PAPERNA I.**

Summary :

A study has been made of the endogenous development of two eimeriid Coccidia in the teiid lizard *Ameiva ameiva*, which were previously considered by Carini (1932) to be conspecific with *Eimeria rochalimai* and *Eimeria boveroi* Carini & Pinto, 1926, described in the gecko *Hemidactylus mabouia*. It has been shown that this is not so, and the two parasites of *A. ameiva* have been named *Choleoeimeria carinii* n.sp. and *Acroeimeria pintoi* n.sp. A description is also given of the endogenous stages of the two eimeriid coccidians previously described in *Hemidactylus mabouia*. The one from the gall-bladder is renamed *Choleoeimeria rochalimai* (Carini & Pinto, 1926) nov. comb., and a redescription is made of *Eimeria boveroi*. The shortcomings of diagnosis based solely on morphology of the oocysts are discussed, particularly with regards the eimeriids of reptiles.

KEY WORDS : *Ameiva ameiva, Hemidactylus mabouia,* lizards, *Choleoeimeria carinii* n.sp., *Acroeimeria pintoi* n. sp., *Choleoeimeria rochalimai* nov. comb., *Eimeria boveroi,* Brazil.

Résumé : COCCIDIES DE LA VÉSICULE BILIAIRE ET DE L'INTESTIN DU LÉZARD *AMEIVA AMEIVA AMEIVA* ET DU GECKO *HEMIDACTYLUS* DANS LE NORD DU BRÉSIL

Le développement endogène de deux coccidies Eimeriidae a été étudié chez le lézard Ameiva ameiva, *qui étaient auparavant considérées par Carini (1932) comme conspécifiques d'*Eimeria rochalimai *et* Eimeria boveroi *Carini & Pinto, 1926, décrites chez le gecko* Hemidactylys mabouia. *Il est montré que tel n'est pas le cas, et les deux parasites de* A. ameiva *sont nommés* Choleoeimeria carinii *n. sp. et* Acroeimeria pintoi *n. sp. Une description des stades endogènes des deux coccidies précédemment décrites chez* Hemidactylus mabouia *est également donnée. Celle de la vésicule biliaire est renommée* Choleoeimeria rochalimai *(Carini & Pinto, 1926) nov. comb., et une redescription de* Eimeria boveroi *est effectuée. Les défauts d'un diagnostic uniquement basé sur la morphologie des oocystes sont discutés, notamment pour ce qui est des Eimerridae des reptiles.*

MOTS CLÉS : Ameiva ameiva, Hemidactylus mabouia, *lézards,* Choleoeimeria carinii *n.sp.,* Acroeimeria pintoi *n.sp.,* Choleoeimeria rochalimai *nov.comb.,* Eimeria boveroi, *Brésil.*

INTRODUCTION

In 1926, Carini & Pinto described the oocysts of two coccidians from the gecko *Hemidactylus mabouia* in São Paulo, south Brazil. One of them was found in the bile and named *Eimeria rochalimai*; the other, named *Eimeria boveroi*, was found only in the faeces and consequently considered to develop in the intestine. The authors described and figured the oocysts but the only reference to endogenous stages concerned the latter parasite, in the description of which it was said that "*Em cortes do intestino... observamos formas endocellulares que acreditamos serem da E. boveroi*".

Later, Carini (1932) discussed the nature of three different oocysts he found in the intestinal contents of the teiid lizard *Ameiva ameiva*, again in São Paulo. One of these was clearly a species of *Isospora,* which he named *I. ameivae*. Two others, however, superficially resembled the oocysts of *E. rochalimai* and *E. boveroi* and he concluded that they were, in fact, conspecific with these two parasites of the gecko.

In 1989 Paperna & Landsberg erected two new generic names for eimeriid parasites of reptiles which undergo a peculiar mode of development in their host epithelial cells. *Choleoeimeria* occupies the distal part of the biliary epithelial cells, which become hypertrophied and displaced to the surface of the epithelium, while *Acroeimeria* develops immediately beneath the brush-border of the intestinal epithelial cell and, within the displaced host cell, bulges out above the surface of the intestinal mucosa. The oocysts of both genera possess 4 sporocysts which, like species of reptilian *Eimeria*, are devoid of a Stieda body and contain 2 sporozoites (McAllister & Upton, 1989; and this paper).

In the present study we describe the oocysts and endogenous stages of two new species of coccidia from *Ameiva ameiva*, one in the gall bladder and the

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other in the small intestine. It is suggested that it was probably the oocysts of these parasites that Carini (1932) saw in the same lizard in São Paulo and mistakenly considered to be conspecific with *E. rochalimai* and *E. boveroi* of the gecko *Hemidactylus mabouia*. Redescriptions are given of these two parasites in *H. mabouia* from Pará, with re-allocation of *E. rochalimai* to the genus *Choleoeimeria*.

MATERIALS AND METHODS

Bile specimens were obtained by puncture of the gall bladder with a finely drawn-out glass pipette and examined for the presence of oocysts under a coverslip. Faecal material was removed from the rectum, suspended in 2.0 % (w/v) aqueous potassium dichromate solution ($K_2Cr_20_7$) and maintained as thin layers in a small, covered Petri-dish kept at room temperature (23-24 °C). Oocysts and sporocysts were measured by normal light microscopy with a × 100 neofluar objective, × 8 eyepieces and an ocular micrometer.

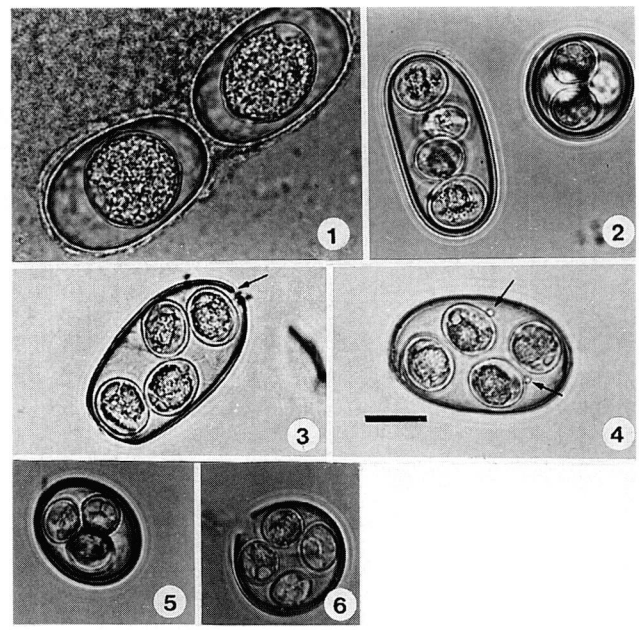
For histology, infected gall bladders and small pieces of intestine were fixed in 10.0 % neutral buffered formalin and embedded in glycol-methacrylate (GMA, Agar Scientific Ltd., Stansted, UK). Sections (2.0-3.0 µm thick) were cut with a Sorval JB4 glass knife microtome and stained either in Meyer's haemalum-eosin or, after post-fixation in aqueous Bouin's fluid, with Giemsa (Paperna & Lainson, 1995). All measurements are in µm. Photomicrographs were prepared using a Zeiss Photomicroscope III and Kodak TMX 100 film.

RESULTS

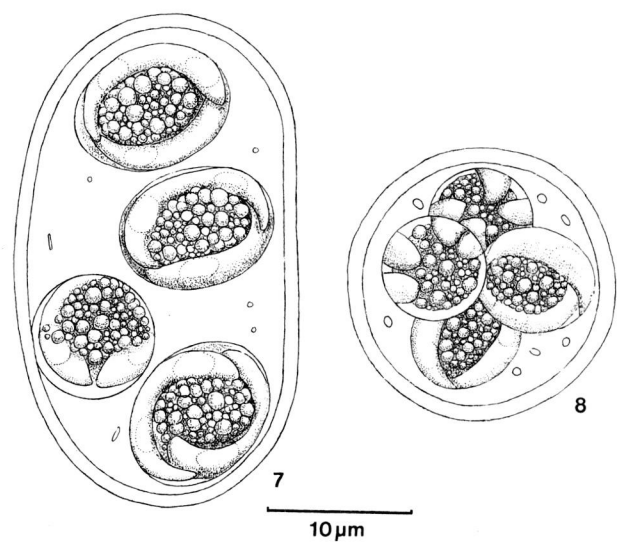
CHOLEOEIMERIA CARINII N. SP. (Figs 1-4; 7; 9-20)

Syn. *Eimeria rochalimai* Carini & Pinto, 1926, ex *Ameiva ameiva*, in part.

Description of the oocyst (Figs 1-4; 7). Mature forms (50 measured) 32.0 × 17.8 (30.0-35.0 × 17.5-19.4), shape-index 1.8 (1.6-2.0), ellipsoidal to cylindrical, the latter shape sometimes slightly curved. Oocyst wall a smooth, apparently single layer about 1.0 thick, which is colourless and with no micropyle or striations. No oocyst residuum or polar body, but with the frequent presence of one to several small granules which are usually in Brownian movement. Sporocysts (50 measured) broadly ellipsoidal to subspherical, 11.0 × 8.8 (10.0-11.2 × 8.0-9.4), shape-index 1.2 (1.0-2.0), with no Stieda body or other localized thickening of the wall. Sporozoites with conspicuous anterior and posterior refractile bodies and curved around a bulky sporocyst residuum.

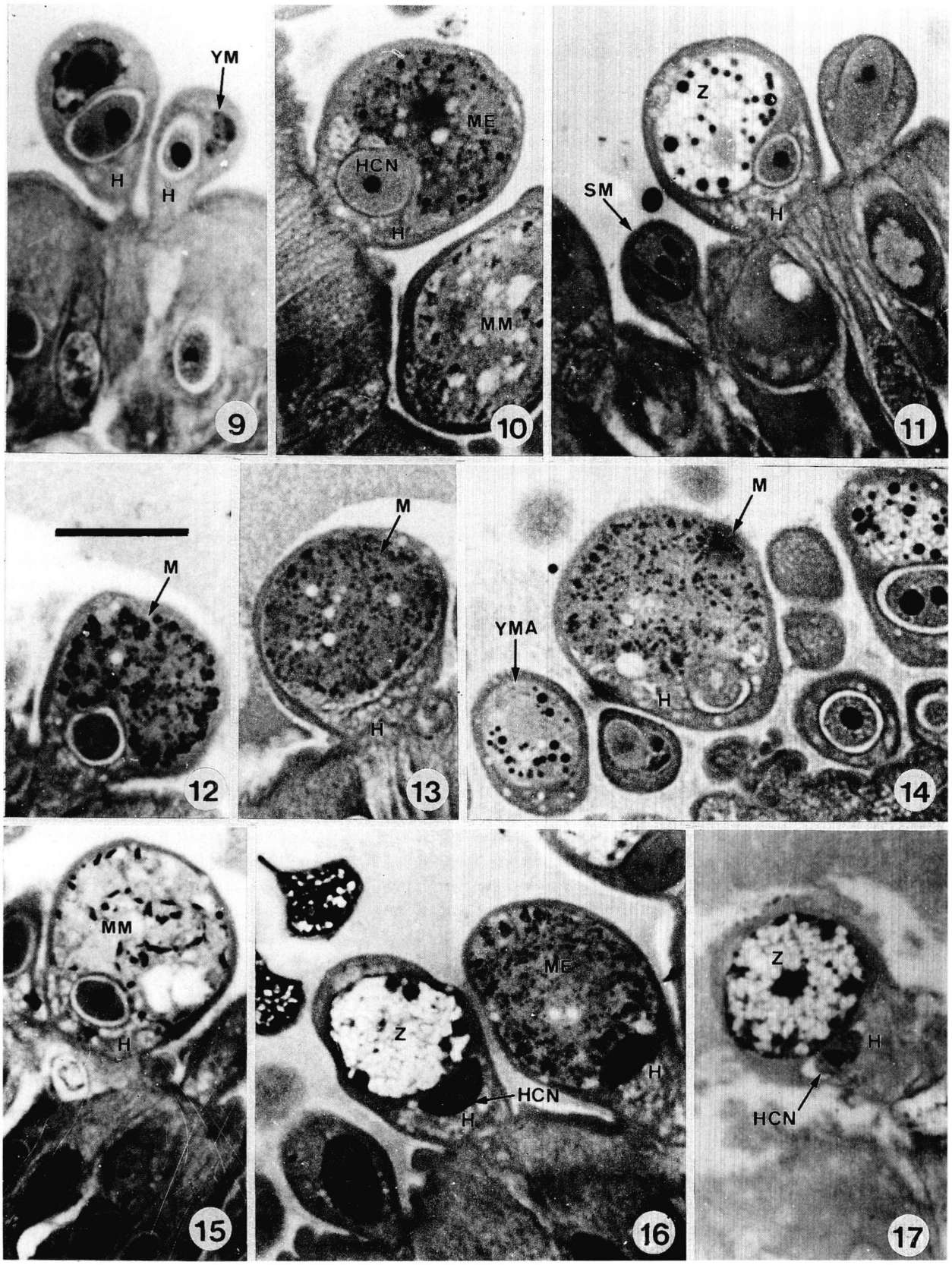


Figs 1-6. Coccidia infecting the lizard *Ameiva a. ameiva* in north Brazil. Fig. 1. Unsporulated oocysts of *Choleoeimeria carinii* n. sp. in a fresh preparation of the gall-bladder contents. Fig. 2. Mature oocysts of *C. carinii* (left) and *Acroeimeria pintoi* n. sp. (right) in the faeces. Figs 3 and 4. Mature oocysts of *C. carinii* in the gall-bladder contents. The oocyst in Fig. 3 has broken, showing the wall to be composed of a single layer (arrow). That in Fig. 4 shows two of several small granules, commonly in Brownian movement (arrows). Figs 5 and 6. Mature oocysts of *A. pintoi* in the faeces. That in Fig. 6 is broken: the wall is of a single layer. Bar = 10.0 µ.

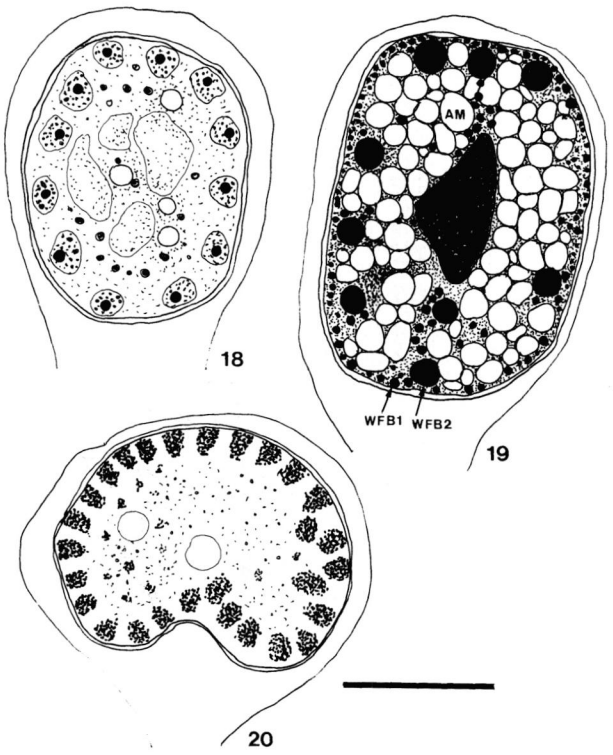


Figs 7-8. Coccidia of the lizard *Ameiva a. ameiva*. Line drawings of the mature oocysts of *Choleoeimeria carinii* (7) and *Acroeimeria pintoi* (8).

Endogenous stages (Figs. 9-20). Merogony and gametogony stages develop in the epithelial cells of the gall-bladder in the manner characteristic of the genus *Choleoeimeria* (Paperna & Landsberg, 1989). The parasites



Figs 9-17. Development of *Choleoeimeria carinii* in the gall-bladder epithelium of the lizard *Ameiva a. ameiva*. The distal part of the infected cells becomes hypertrophied and, together with the displaced host cell nucleus, bulges out into the lumen of the gall-bladder. H = host cell; HCN = host cell nucleus; ME = unsegmented meronts; M = almost mature microgamonts; MM = mature microgamont shedding microgametes; SM = small, segmented meront; YM = young meront; YMA = young macrogamont; Z = zygotes, or young oocysts. Bar = 10.0 µm.



Figs 18-20. Line-drawings of *Choleoeimeria carinii* in epithelial cells of the gall-bladder epithelium of the lizard *Ameiva a. ameiva*. Fig. 18. Developing meront with 12 peripherally disposed nuclei, each with a conspicuous nucleolus. Fig. 19. Zygote (or young oocyst). Fig. 20. Microgamont, with 28 peripherally arranged nuclei. AM = amylopectin granules; WFB 1 = small wall-forming bodies; WFB 2 = large wall-forming bodies. Bar = 10.0 µm.

are localized in the distal part of the host cells which are hypertrophied and displaced into the lumen of the gall bladder above the epithelium surface. The infected cell maintains its attachment to the basal membrane by its proximal end. Its nucleus remains the same size as that of the uninfected cells, but moves outwards together with the distal end of the cell and the parasite. When there is multiple infection of a single epithelial cell, one parasite usually outgrows the other: multiple infection, however, was rarely seen.

The youngest meronts seen measured 6.5 × 2.6 and contained only one or two nuclei (Fig. 9). Mature meronts, before segmentation, measured 26.0-30.0 × 15.0-25. In cross-section 12-19 nuclei were visible, each with a conspicuous nucleolus and arranged peripherally: the cytoplasm contained some vacuoles and numerous dense granules of various size (Figs 10, 16, 18). Meronts that had segmented into merozoites measured from 23-26 × 18-21 and, as calculated from those cut obliquely, produced a similar number of merozoites. There is some evidence that there is at least one generation of meronts which produce a much smaller number of merozoites (Fig. 11). Young microgamonts with few nuclei measure up to 22.0 × 13.0 in cross-section and the nuclei have no visible nucleolus. More mature forms reach from 25-30 × 18-27 in size and contain from 40-60 nuclei (Figs 12-14, 20). In cross-sections the mature microgamont was estimated to produce over 40 microgametes: such forms measure from 25-36 × 20-31 (Fig. 15). Young macrogamonts are round, and measure up to 13.0 × 13.0: with their growth to approximately 22.0-25.0 × 15.0-18.0, small and large wall-forming bodies appear (Fig. 14). Finally, the zygotes (or young oocysts) measure from 24.0-26.0 × 18.0 and are packed with amylopectin granules (Figs 11, 16, 17, 19). Mature oocysts are released and accumulate in the bile (Figs 3, 4).

Sporulation: endogenous. Either in the lumen of the gall-bladder or in the intestinal contents, prior to being voided in the faeces.

Host: *Ameiva a. ameiva* (Linnaeus) (Reptilia: Squamata: Teiidae).

Locality: Capanema, Pará State, north Brazil.

Prevalence: oocysts were detected in the bile of 4 out of 20 lizards examined (20 %). Concomitant infections occurred with *Acroeimeria pintoi* n. sp. (3) and *Isospora ameivae* (1).

Pathology: All the infected lizards appeared healthy, in spite of heavy infection and considerable damage to the gall-bladder epithelium, as seen in histological sections.

Etymology: The parasite is named after the late Professor A. Carini.

Remarks: Our measurements of the oocysts of *C. carinii* n. sp., are similar to those given by Carini & Pinto (1926) for those they described as *E. rochalimai* in *H. mabouia* (32.0 × 17.8 *vs.* 30.6 x 16.8), with the same shape-index of 1.8. On the other hand, the sporocysts of *C. carinii* have a mean measurement of 11.0 × 8.8 (shape-index 1.2) compared with 9.0 × 7.5 (shape-index 1.2) for those of *C. rochalimai* (this paper), or 8.0-9.0 as given by Carini & Pinto for the parasite under the name of *E. rochalimai*. A notable difference in the oocysts of the two parasites is the frequent presence of a single, round or oval polar body in the oocyst of *C. rochalimai* compared with the several, smaller granules seen in that of *C. carinii*. Differences are perhaps more striking, however, in the endogenous stages of the two species. Multiple infection of the gall bladder epithelial cells by *C. carinii* is very rare and displacement of the infected cells is restricted to just above the intact epithelium. In contrast, multiple invasion of the epithelial cells is of common occurrence in infections with *C. rochalimai* in *Hemidactylus*, where the cells frequently contain two or even three parasites and are much more prominently

displaced from the epithelial layer. Finally, we have the impression that the mature microgamonts of *C. carinii* are smaller than those of *C. rochalimai*, although the macrogamonts of the two species are much the same size.

ACROEIMERIA PINTOI N. SP. (Figs 2, 5, 6, 8, 21-36)

Syn. *E. boveroi* Carini & Pinto, 1926, ex *Ameiva ameiva*. In part.

Description of the oocyst (Figs 2, 5, 6, 8). Mature forms (50 measured) 18.0 × 17.0 (15.0-20.0 × 14.0-19.0), shape-index 1.0 (1.0-1.1), spherical to subspherical. Oocyst wall a single, smooth, colourless layer about 1.25 thick, with no micropyle or striations. There is no polar body, but the frequent presence of a few small, scattered granules. Sporocysts (50 measured) 7.8 × 7.3 (7.6-8.5 × 6.2-7.4), shape index 1.0 (1.0-1.4), broadly ellipsoidal and with no Stieda body or other thickening of the sporocyst wall. Sporozoites have at least one refractile body and curve around a prominent residuum of granules and small globules.

Endogenous stages (Figs 21-36). "Epicytoplasmic", with the characters of the genus (Paperna & Landsberg, 1989). Merogonic and gametogonic stages develop immediately beneath the microvillous (brush) border of the intestinal epithelium. The parasite lies within a parasitophorous vacuole in the host cell, which is displaced and bulges out above the epithelial surface (Fig. 21). Below the parasitophorous vacuole the host cell cytoplasm expands as the volume of the parasite increases, giving rise to a stalk-like structure (Figs 28,32-34). In cross- section this may appear to be sub-divided in a similar way to that seen in a number of other epicytoplasmic coccidia (Paperna & Landsberg, 1989; Paperna, 1995). Its structural nature is as yet poorly understood. The smallest stages (meronts or gamonts) seen in sections were 2.6 in diameter. Dividing meronts with 5-8 nuclei measured up to 6.0 × 6.5, while segmented meronts ranged from 9.1 × 6.5 to 15.6 × 6.5 as seen in cross-sections, and produced 14-26 merozoites of 5.2 × 1.0 (Figs 22, 23, 31). Immature microgamonts with up to 45 peripherally disposed nuclei measured 9.1-13.0 × 7.1-10.4 (Figs 24, 34), and mature forms shedding about the same number of microgametes were 9.75-13.0 × 9.75-10.4 (Figs 25, 35). Young macrogamonts, containing only a few vacuoles or inclusions, ranged from 6.5 × 5.2 to 9.8 × 6.5 (Figs 26, 32, 33). Mature macrogamonts and zygotes, from 13.0-15.6 × 9.1-11.7 in size, were packed with amylopectin granules and contained conspicuous wall-forming bodies of large size (Figs 27, 36). Oocysts still attached to the epithelium measured 14.3-16.9 × 10.4-13.0 (Fig. 28), while detached oocysts in the gut lumen were 18.2-23.4 × 11.7-13.0 (Fig. 29).

Sporulation: exogenous, after 24-48 hours outside the host.

Type host: *Ameiva a. ameiva*.

Type locality: Capanema, Pará State, north Brazil.

Prevalence: Of 20 lizards examined, 17 (85 %) were infected. Concomitant infections occurred with *Choleoeimeria carinii* n. sp. (3) and *Isospora ameivae* (1).

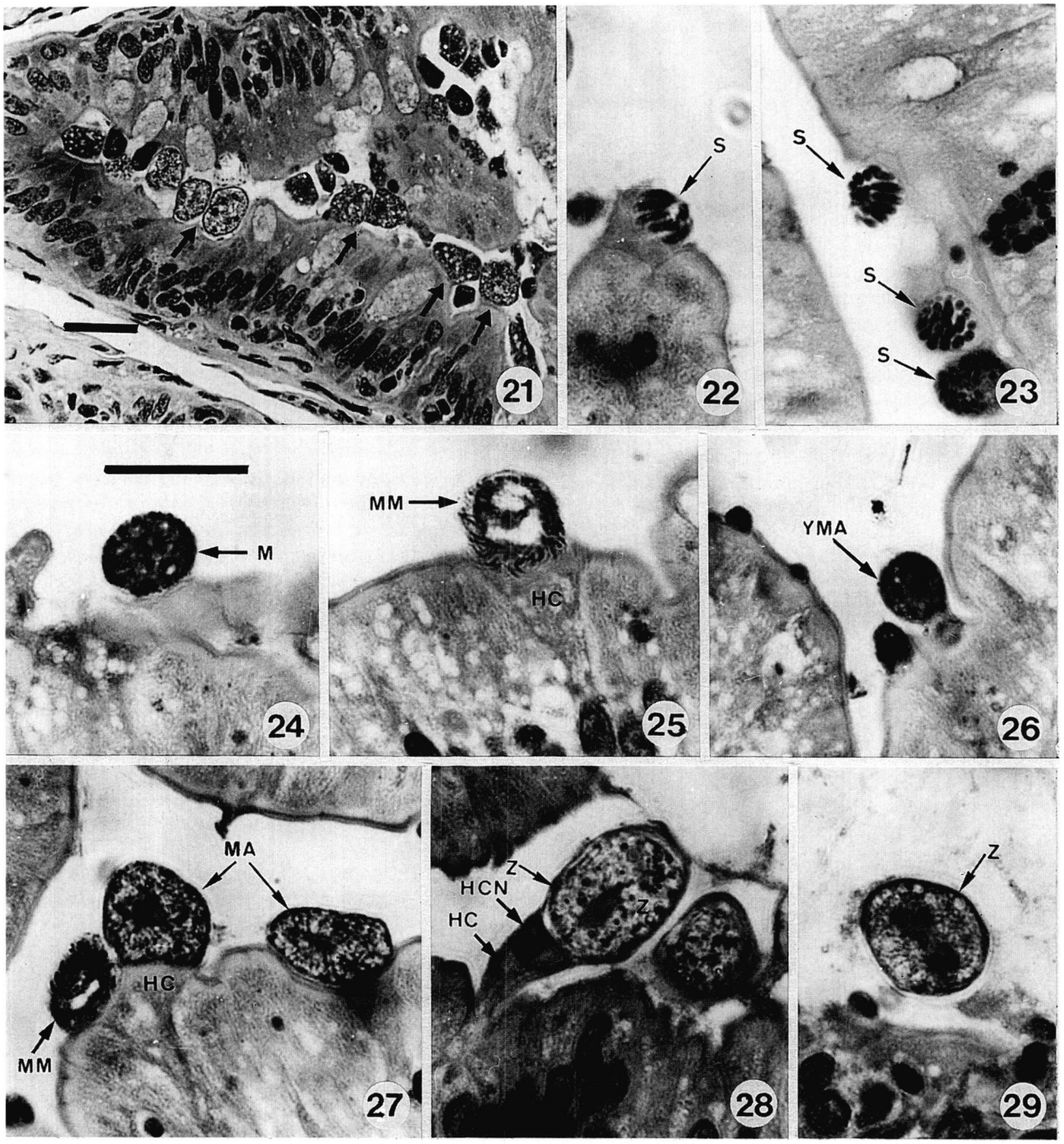
Pathology: Outwardly all the lizards appeared to be in good health, including those with heavy infections.

Etymology: The specific name is derived from that of the Brazilian parasitologist, the late Dr. C. Pinto.

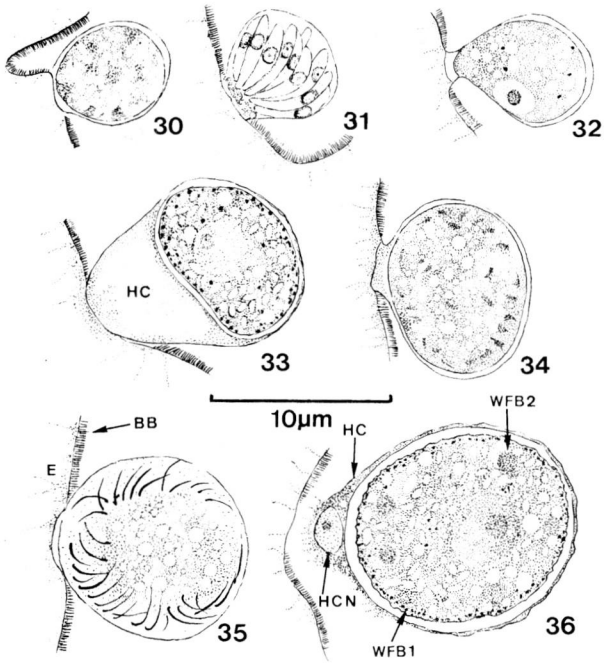
Remarks: In the present study this coccidian is clearly differentiated from *E. boveroi* by its epicytoplasmic endogenous stages characteristic of the genus *Acroeimeria*. In addition, although the oocysts and sporocysts of both parasites are very similar, there is a difference in the sporulation time. That of *E. boveroi* is 24-48 hours after the oocysts are shed in the faeces, whereas many of the oocysts of *A. pintoi* are passed already mature and those that are incomplete in their development mature within a few hours. The oocysts of *E. ameivae* Lainson, 1968, described from *Ameiva undulata* in Belize, are somewhat larger than those of *A. pintoi*. They measure 22 × 20 (21-23 × 19-21) and mature in 4 days outside the host: the spherical sporocysts average 9.5. *E. cnemidophori* Carini, 1941, was described from the teiid lizard *Cnemidophorus lemniscatus* in south Brazil: its oocysts are morphologically very similar to those of *A. pintoi*, but their sporulation time was given as 4 days. The endogenous stages of the two latter parasites remain unknown.

REDESCRIPTION OF *CHOLEOEIMERIA ROCHALIMAI* (CARINI & PINTO, 1926) NOV. COMB., IN PART. (Figs 37-45)

Redescription of the oocyst (Figs 37, 38, 45). Mature forms (50 measured) 29.1 × 17.8 (26.2-31.2 × 16.2-18.7), shape-index 1.6 (1.3-1.7), ellipsoidal to broadly cylindrical. Oocyst wall a single, smooth, colourless layer approximately 1.0 thick and with no striations or micropyle. No oocyst residuum, but a single spherical to ovoid polar body about 1.2 is frequently present. Sporocysts (50 measured) broadly pear-shaped, 9.0 × 7.5 (8.7-10.0 × 6.2-7.5), with no Stieda body or other thickening of the wall at the more pointed end. In most of the sporocysts the bulky residuum obscures the sporozoites, which are recurved at one end, and prevented us from confirming the presence of refractile bodies. Neither were we able to detect the bi-valved structure of intact sporocysts characteristic of the genus *Choleoeimeria* (Paperna & Landsberg, 1989). Occasional oocysts, however, were seen to contain disrupted spo-



Figs 21-29. *Acroeimeria pintoi* in the intestinal epithelium of the lizard *Ameiva a. ameiva*. Development is immediately below the brush-border of the ileum. Fig. 21. Low-power view, showing displacement of the infected cells onto the surface of the epithelium (arrows). Figs 22-29. Higher magnification of the endogenous stages: bar = 20 µm. Figs. 22,23. Mature, segmented meronts. Fig. 24. Almost mature microgamont. Fig. 25. Mature microgamont shedding microgametes. Fig. 26. Young macrogamont. Fig. 27. A mature microgamont and two well developed macrogamonts. Fig. 28. A zygote on the stalk-like extension of the host cell cytoplasm. Fig. 29. A zygote (or young oocyst) released into the lumen of the intestine. HC = host cell; HCN = host cell nucleus; MA = mature macrogamonts; M = developing microgamont; MM = mature microgamonts, shedding microgametes; S = segmented meronts; YMA = Young macrogamont; Z = zygotes (or young oocysts).



Figs 30-36. Line-drawings of the endogenous stages of *Acroeimeria pintoi* in the epithelium of the small intestine of *Ameiva a. ameiva*. Fig. 30. Developing meront. Fig. 31. Segmented meront. Figs 32, 33. Developing macrogamonts. Fig. 34. Nearly mature microgamont. Fig. 35. Mature microgamont shedding microgametes. Fig. 36. Zygote (or young oocyst), shed into the gut lumen with the host cell remnants still attached. BB = brush-border of the small intestine; HC = host cell; HCN = host cell nucleus (in many cases the host cell nucleus is no longer visible); WFB 1 = small wall-forming bodies; WFB 2 = large wall-forming bodies.

rocysts and liberated sporozoites, consistent with such morphology.

Endogenous stages (Figs 39-44). Merogony and gametogony in the epithelial cells of the gall bladder with characters of the genus, as given in the above description of *C. carini* n. sp. The hypertrophied host cells frequently contain two or more parasites (Figs 39-43), but one parasite usually outgrows the other(s). The host cells maintain connection with the basal membrane of the epithelium while their enlarged, infected ends aggregate on the epithelial surface, frequently one on top of another (Figs 39, 42, 43). The meronts contain some cytoplasmic vacuoles and numerous dense granules of variable size (Figs 40, 43). Those mature, segmented forms seen reached 29 × 13 in size, and up to 75 merozoites were counted in cross-sections. The nuclei of the young, developing microgamont lack a visible nucleolus. Immature forms measuring 26-37 × 17-19 in cross section possessed 40-60 nuclei (Fig. 40), and mature microgamonts, shedding over 100 microgametes, measured 28-36 × 24-30. Macrogamonts range in size from 17 × 15-25 × 13 and gradually become filled with small and large wall-forming bodies. Subsequent zygotes (or early oocysts) measure 16.9-19.5 × 9.1-13.0: they become loaded with amylopectin granules (Figs 40, 43, 44), and the type II wall-forming bodies coalesce into very large bodies with heterogenous contents (Fig. 44) The late zygote stages assume a broadly ellipsoidal shape (average 24.7 × 11.7) and gradually become released from the host tissue. Detached mature and immature oocysts are found floating in the bile, and in some geckos the number may be extraordinarily large (Fig. 37).

Sporulation: endogenous. Either in the gall-bladder lumen or in the intestinal contents.

Type host: *Hemidactylus mabouia* (Moreau de Jonnès): (Reptilia: Squamata: Gekkonidae)

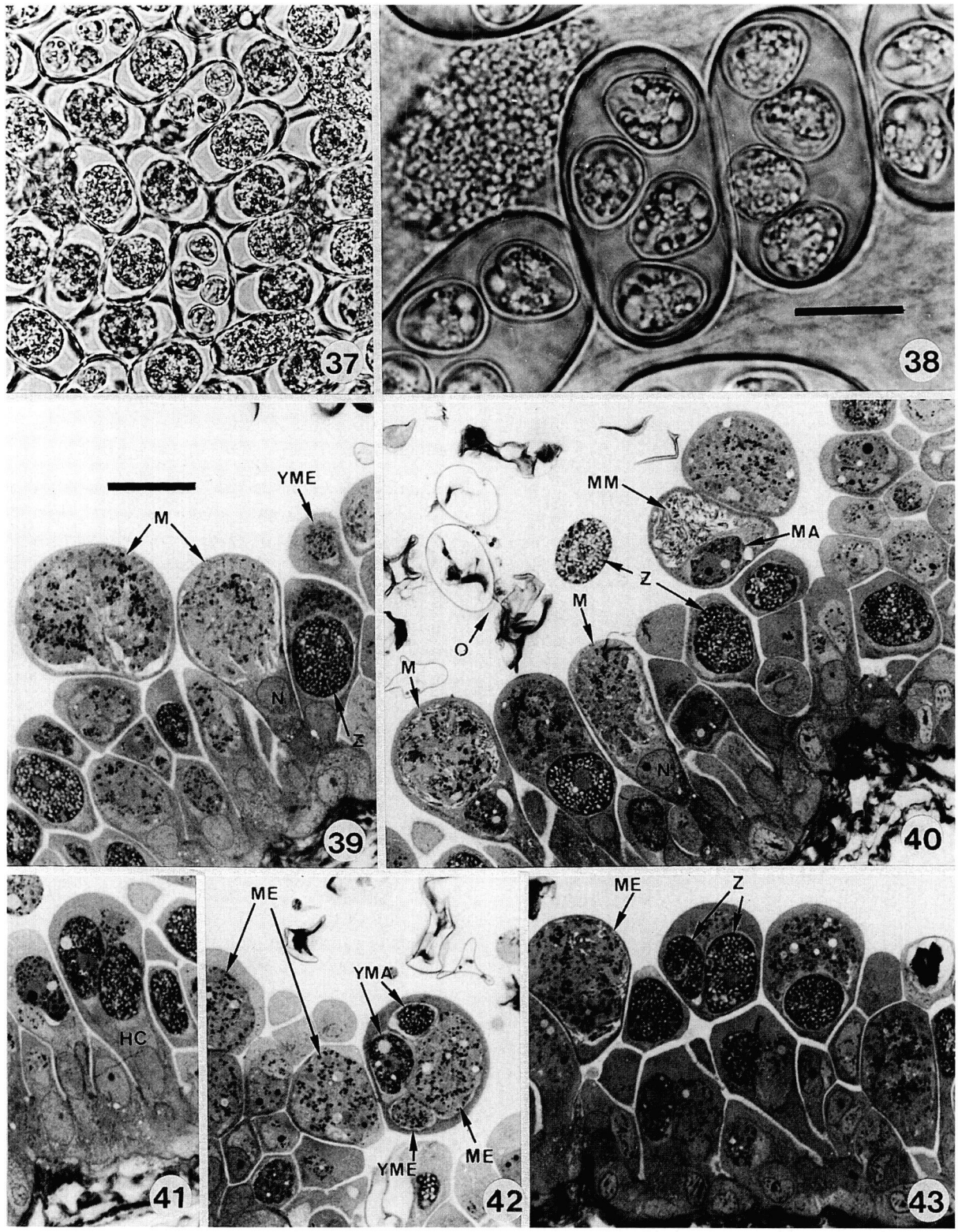
Type locality: the infected geckos examined by Carini & Pinto (1926) were from the State of São Paulo, south Brazil. Those of the present study were from Capanema and Belém, State of Pará, north Brazil.

Prevalence: 14 of 23 geckos examined were infected (61.0 %). Concomitant infections were seen with *Eimeria boveroi*, only (10), *Isospora hemidactyli*, only (3), and both of these parasites (1).

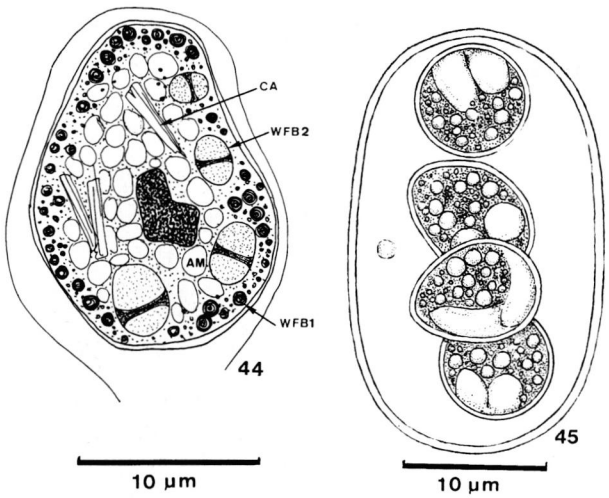
Pathogenicity: all the infected animals appeared to be in good health, although histology clearly showed considerable destruction of the gall-bladder epithelium. Macroscopically, the gall-bladder of heavily infected lizards is conspicuously white in colour.

Remarks: Carini & Pinto (1926) make no mention of the presence of a polar body in the oocyst and considered its wall to have 3 layers. Otherwise there is a close agreement between the description they give of the oocyst of *E. rochalimai* in *H. mabouia* from São Paulo and that given here for oocysts from the same species of gecko in north Brazil, and we have no doubt that we are dealing with the same parasite. Optical illusions make it most difficult to determine the structure of the intact oocyst wall: from our study of numerous crushed and broken ones, however, we conclude that there is but a single layer. The Brazilian authors did not include the endogenous stages in their description, and the nature of these has led us to transfer this coccidian from the genus *Eimeria*, in which they originally placed it, to the genus *Choleoeimeria* Paperna & Lindsberg, 1989. Similar oocysts described from the gall bladder of *H. mabouia* caught in Cameroon, Africa, by Upton *et al.*, (1992) were identified as *E. rochalimai*. They were, however, slightly smaller than those of this parasite (29.6 × 16.8, range 28.0-31 × 15.0-18.0) and had a shape-index that was considerably different (1.37, range 1.27-1.58). The endogenous stages were not described.

The frequency of multiple infection of the gall bladder epithelial cells by *C. rochalimai* and aggregation of the infected cells in superimposed layers above the epi-



Figs 37-43. *Choleoeimeria rochalimai* (Carini & Pinto, 1926) nov. comb., in the gecko *Hemidactylus mabouia*. Fig. 37. Large number of sporulated and unsporulated oocysts in the gall-bladder contents. Fig. 38. Mature oocysts: bar = 10 µm. Figs 39-43. Development in the gall-bladder epithelium: bar = 10 µ. Note the large number of multiple infections in the epithelial cells, which are hypertrophied and bulge out above the epithelial surface. HC = host cell; N = host cell nucleus; M = almost mature microgamonts; MA = macrogamont; ME = , undivided meronts; MM = mature microgamont shedding microgametes; O = remnants of oocyst; YMA = young macrogamonts; YME = young meronts; Z = zygotes, or young oocysts.



Figs 44, 45. Line-drawing of the zygote (or young oocyst) of *Choleoeimeria rochalimai* in the gall-bladder epithelium of the gecko *Hemidactylus mabouia* (44) and a mature oocyst, as seen in the faeces (45). AM = amylopectin granules; CA = canaliculi; WFB 1 small wall-forming bodies; WFB 2 = large wall-forming bodies.

thelium surface differentiates the parasite distinctly from *C. carinii* n. sp. (this paper), the only other choleoeimerian of neotropical lizards that has been fully described to date.

REDESCRIPTION OF *EIMERIA BOVEROI* CARINI & PINTO, 1926 (Figs 46-60)

Redescription of the oocyst (Figs 52, 60). Mature forms (50 measured) 19.7 × 18.2 (15.0-21.2 × 15.0-21.2), shape-index 1.1 (1.0-1.2), spherical to subspherical. Oocyst wall a single, smooth, colourless layer about 1.0 thick with no striations and no micropyle. No oocyst residuum. We had great difficulty in detecting a polar body, probably because it most frequently adheres to the wall of one of the sporocysts. In the very few oocysts in which it was free and clearly visible, it was round to ovoid and measured about 2.0 at its greatest diameter (Fig. 60). In some oocysts it had seemingly disintegrated into a small number of granules and tenuous threads. Sporocysts (50 measured) 8.3 × 7.3 (7.5-9.4 × 6.2-7.5), shape-index 1.1 (1.0-1.4), broadly ellipsoidal to nearly spherical and with no Stieda body or other localized thickening of the wall. The bulky sporocyst residuum is often in the form of an ovoid mass of fine granules: this largely obscures the sporozoites and for this reason we were unable to confirm the presence of refractile bodies.

Endogenous stages (Figs 46-51, 53-59). Development in the small intestine is characteristic of the intestinal *Eimeria* species, i.e. within the cytoplasm of the epithelial cells ("intracytoplasmic") and with no development comparable to that of *Acroeimeria*. All stages of the parasite are localized in the distal part of the host cell, on the lumen-side of the nucleus (Figs 46-51). As seen in sections the young meronts measure from 4.0 × 1.0 to 8.0 × 5.0 and contain a few nuclei. Segmenting meronts measure 9.0-13.0 × 7.0-9.0 with an estimated number of 6-12 merozoites, as counted in cross sections (Figs 46, 47, 53). Rounded microgamonts, with up to 64 peripherally disposed nuclei, possessed a highly vacuolated cytoplasm and reached a size of 13.0 × 9.0 (Figs 48, 54). Mature forms were within the same size range and shed a maximum of 40 microgametes (Figs 49, 56). Young macrogamonts of approximately 5.0-7.5 × 4.0-5.5 are recognized by their large nucleus, with a conspicuous nucleolus (Figs 49, 55): with growth they may assume an elongate shape, up to 16.0 × 6.0 in size (Figs 50, 57). Zygotes (Figs 51, 58, 59) measure up to 13.0-16.0 × 5.8-10.4. They contain small (type 1) and large (type 2) wall-forming bodies, canaliculi, and a moderate number of amylopectin granules.

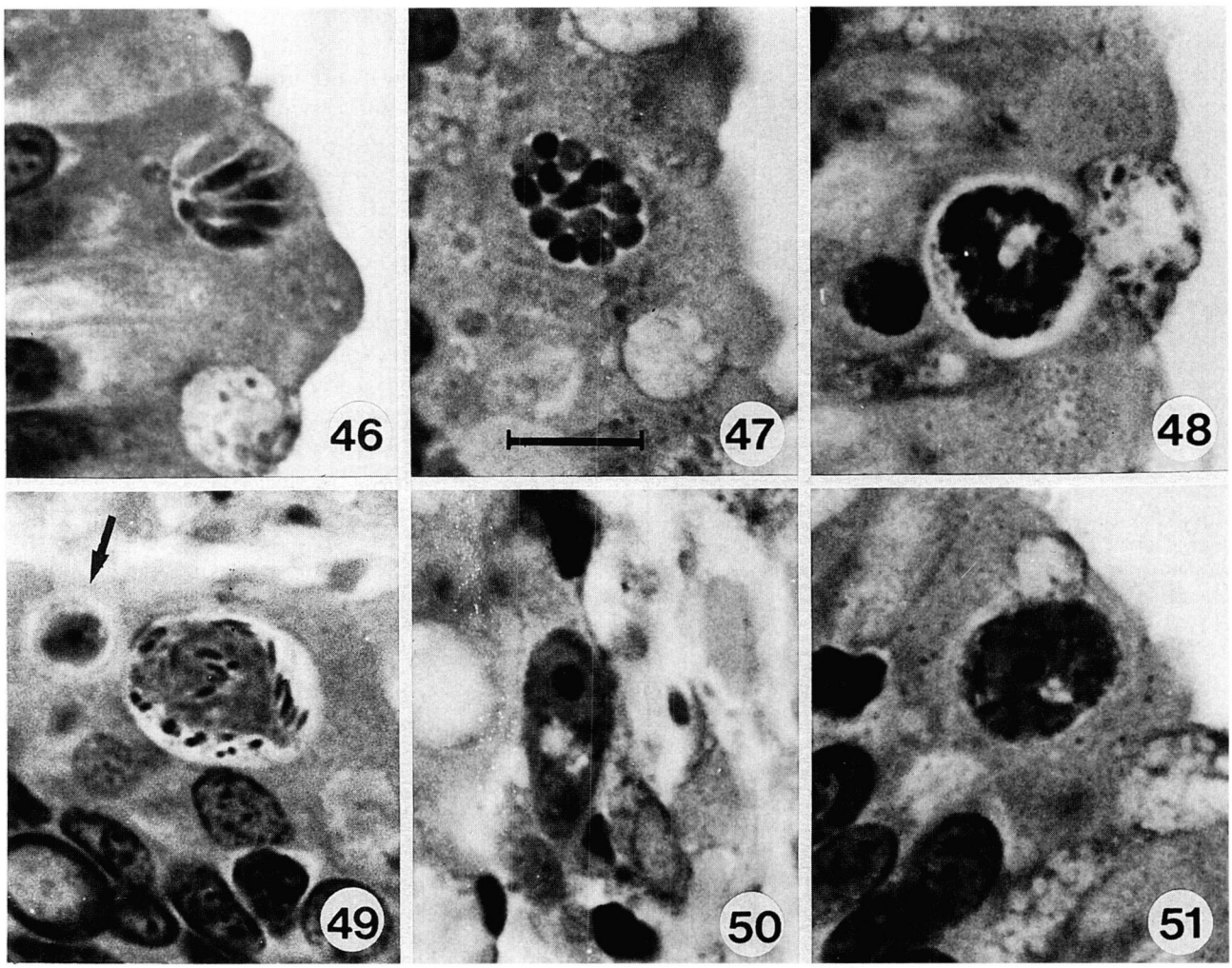
Type host: *Hemidactylus mabouia*.

Type locality: Original description, of oocysts only, by Carini & Pinto (1926) in geckos from the State of São Paulo, south Brazil. Present redescription from geckos in Capanema and Belém, State of Pará, north Brazil.
Sporulation: The oocysts may be mature or at the sporoblastic stage when passed in the faeces: the latter reach full maturity within a few hours outside the host.

Prevalence: Of the 23 *H. mabouia* examined, 12 (52 %) were infected. Concomitant infection with *C. rochalimai* was noted in 4 geckos, and with *Isospora hemidactyli* in 3.

Pathogenicity: freshly caught, infected geckos showed no outwards signs of disease, even when simultaneously infected with *C. rochalimai* or *I. hemidactyli*.

Remarks: Although Carini & Pinto (1926) make no mention of the presence of a polar body, and no comment regarding sporulation time, we postulate that the parasite we record here in *H. mabouia* from Belém is conspecific with *E. boveroi* previously described in the same host species from São Paulo by these authors. McAllister & Upton (1989) reported the presence of *E. boveroi* in *H. mabouia* from Mexico and recorded the very different sporulation time of 3 days: they made no study of the endogenous stages. Paperna & Landsberg (1989) described a species of the genus *Acroeimeria* infecting *H. mabouia* in South Africa and regarded it as conspecific with *A. lineri* (description of oocysts only by McAllister, Upton & Freed, 1988) infecting the Middle East gecko *H. turcicus* in Israel, as well as in introduced specimens of the same gecko in the USA.



Figs 46-52. *Eimeria boveroi* Carini & Pinto, 1926, in the gecko *Hemidactylus mabouia*: Figs 46-51. Endogenous stages as seen in sections of the small intestine. Figs 46,47. Mature, segmented meronts. Fig. 48. Dividing microgamont. Fig. 49. Mature microgamont shedding microgametes, and a young macrogamont (arrow). Fig. 50. A premature, elongated macrogamont. Fig. 51. Mature macrogamont (zygote?). Bar = 10.0 µm.

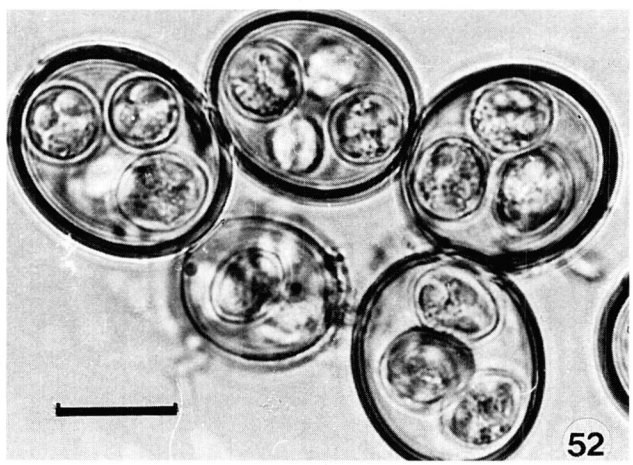
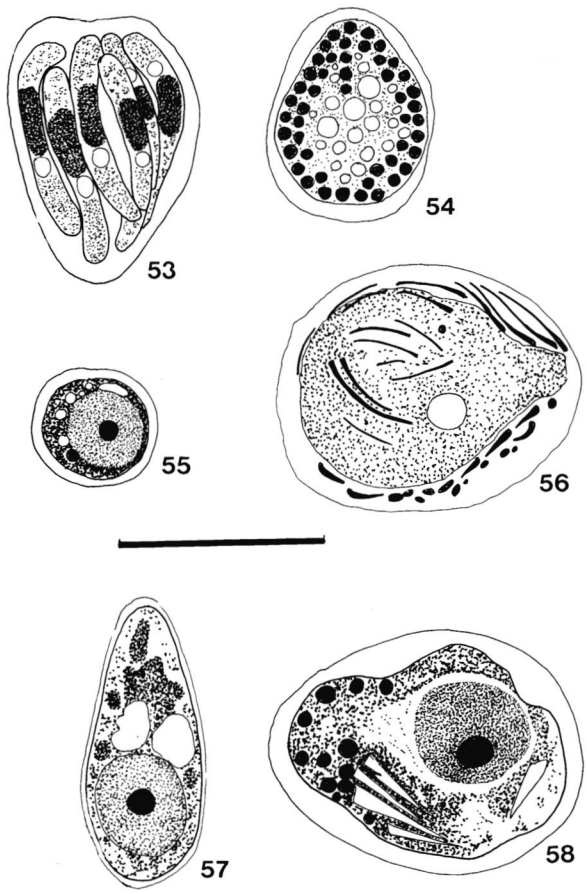


Fig. 52. – Mature oocysts in the faeces: note the variation in size. Bar = 10.0 µm.

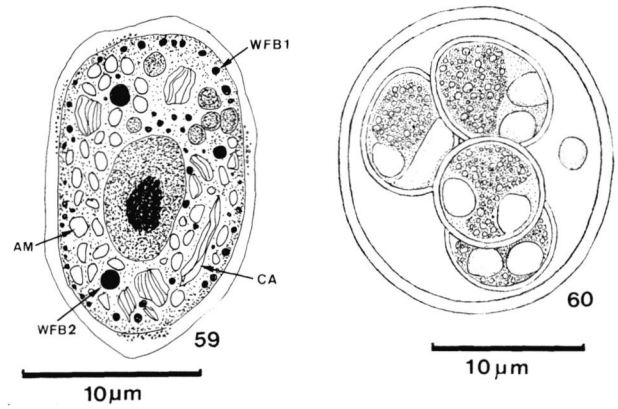
DISCUSSION

The results of the present study support our belief that the same species of coccidia are unlikely to occur in hosts belonging to different families, in this case the Teiidae and the Gekkonidae, as was suggested by Carini (1932).

The intestinal parasites described here in *Ameiva a. ameiva* and *Hemidactylus mabouia* illustrate very well the different modes of intracellular development of two eimeriid genera found in reptiles – epicytoplasmic in *Acroeimeria* and intracytoplasmic in *Eimeria* sensu lato. The parasites described from the gall bladder of the two lizard species are congeneric (belonging to the genus *Choleoeimeria*), but they have distinctive characters enabling their separation into valid species.



Figs 53-58. – *Eimeria boveroi*. Line-drawings of endogenous stages in histological sections of the small intestine. Fig. 53. Mature, segmented meront. Fig. 54. Young microgamont. Fig. 55. Young macrogamont. Fig. 56. Mature microgamont, shedding microgametes. Fig. 57. Growing, elongated macrogamont. Fig. 58. Mature macrogamont (or zygote), with wall-forming bodies appearing. Bar = 10 µm.



Figs 59, 60. – *Eimeria boveroi*. Line-drawings of a late stage zygote in the intestinal epithelium of the gecko, *H. mabouia* (59), and a mature oocyst in the faeces (60). AM = amylopectin granule; CA = canaliculi; WFB 1 = small wall-forming bodies; WFB 2 = large wall-forming bodies.

The shortcomings of differential diagnosis based solely on the size and structural characters of the oocysts and sporocysts have been frequently discussed (Parker & Duszynski, 1986; Frenkel *et al.*, 1987; Aquino-Shuster *et al.*, 1990; Finkelman & Paperna, 1994) and a prime example is that of the reptilian eimeriids, where it is impossible to be sure of the generic status of many parasites without reference to the endogenous stages. Unfortunately this has not been done in many descriptions of these parasites.

Paperna & Landsberg (1989) drew attention to key features which distinguish all described reptilian species of *Eimeria* from those of avian and mammalian hosts: namely, that their sporocysts lack Stieda and sub-Stieda bodies, and that their oocyst wall is thin and soft.

While many reptilian coccidia can now be conveniently grouped into the genera *Acroeimeria* and *Choleoeimeria* by their epicytoplamic development, the taxonomic status of others which do not undergo such development (e.g. *Eimeria* sensu lato) requires further consideration. Generic divergence of reptilian eimeriid coccidia, as illustrated by a comparative ultrastructural study of *Eimeria boveroi*, *Acroeimeria pintoi* and *Choleoeimeria rochalimai* is to be discussed in a separate paper (Paperna & Lainson, in preparation).

Finally, oocysts of *Isospora* encountered in the faeces of several specimens of *A. a. ameiva* and *H. hemidactyli* during the present study are considered to be those of *I. ameivae* Carini, 1932 and *I. hemidactyli* Carini, 1936 respectively. A redescription has been given of these parasites, with particular reference to their endogenous stages (Lainson & Paperna, 1999).

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