

## EIMERIA CHINCHILLAE DE VOS & VAN DER WESTHUIZEN, 1968 AND OTHER EIMERIA SPP. FROM THREE SOUTH AFRICAN RODENT SPECIES

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### ABSTRACT

DE VOS, A. J. & DOBSON, LYNNE D. *Eimeria chinchillae* De Vos & Van der Westhuizen, 1968 and other *Eimeria* spp. from three South African rodent species. *Onderstepoort J. vet. Res.*, 37 (4), 185-190 (1970).

*Eimeria chinchillae* De Vos & Van der Westhuizen, 1968, an organism originally described from the chinchilla and subsequently shown to be transmissible to other rodents, was found to occur naturally in *Rhabdomys pumilio* (Sparman, 1784) in South Africa. The morphology of the oocysts, the site of development of the endogenous stages and the prepatent period of the infection were similar to those of *E. chinchillae* obtained from chinchillas and transmitted experimentally to *R. pumilio*. The identity of the organism was confirmed by the successful infection of chinchillas.

Three additional *Eimeria* spp. were found in *R. pumilio*. Oocysts of *Eimeria pumilioi* n. sp. measured 18 by 12  $\mu$ , those of *Eimeria rhabdomysis* n. sp., 13 by 12  $\mu$  and those of *Eimeria pretoriensis* n. sp., 24 by 19  $\mu$ . Two *Eimeria* spp. were also found in *Praomys (Mastomys) natalensis* (Smith, 1834). Oocysts of *Eimeria mastomysis* n. sp. measured 27 by 21  $\mu$  and those of *Eimeria theileri* n. sp. 20 by 17  $\mu$ . A single *Eimeria* sp., *Eimeria otomyis* n. sp., was found in *Otomys irroratus* (Brants, 1827). The oocysts measured 20 by 15  $\mu$ .

### INTRODUCTION

*Eimeria chinchillae* De Vos & Van der Westhuizen, 1968 has been reported from chinchillas in Southern Africa (De Vos & Van der Westhuizen, 1968; De Vos, 1970) but is apparently unknown in other parts of the world. Recently it was found to be transmissible to seven other rodent species, six of which occur in South Africa (De Vos, 1970). In an attempt to determine whether *E. chinchillae* occurred naturally in these rodents, wild specimens of the four most susceptible species, viz. *Rhabdomys pumilio* (Sparman, 1784), *Otomys irroratus* (Brants, 1827), *Praomys (Mastomys) natalensis* (Smith, 1834) and *Mus musculus* Linnaeus, 1758, were trapped and examined for oocysts.

### MATERIALS AND METHODS

During a six week period a total of 62 *R. pumilio*, 32 *O. irroratus*, 22 *P. (M.) natalensis* and 10 *M. musculus* were trapped at four different sites near the Veterinary Research Institute, Onderstepoort, Pretoria district.

The entire intestinal tract of each animal was removed, ground in a mortar and strained through wire mesh sieves, and the finer particles were washed by repeated sedimentation. Each sample was then examined for oocysts after centrifugation in a saturated salt solution. Samples that contained oocysts were incubated at 28°C in a 2 per cent potassium dichromate solution to allow the oocysts to sporulate. Coccidia-free chinchillas were dosed with specimens containing oocysts of one or more of the seven different *Eimeria* spp. found in the rodents. The faeces of the chinchillas were examined daily for 14 days for the presence of oocysts. The *Eimeria* sp. found in *R. pumilio* were transmitted to coccidia-free *R. pumilio* in an attempt to determine their prepatent periods and sites of development. Faecal samples from these animals were examined daily for oocysts for 8 days after infection. The animals were then killed and autopsied. All measurements were made with an ocular micrometer and these together with photomicrographs served as aids for drawing the oocysts.

### RESULTS

#### *R. pumilio*

A total of 21 out of the 62 animals examined was found to be infected with one or more of four different *Eimeria* spp. The oocysts of one species were morpho-

logically indistinguishable from those of *E. chinchillae* but the other three were different. For this reason, together with the host specificity of most *Eimeria* spp. and the fact that *E. chinchillae* is apparently the only *Eimeria* sp. found in *R. pumilio* so far, the latter three species are regarded as being new to science.

#### *E. chinchillae*

*Incidence of infection:* Oocysts of *E. chinchillae* were found in the intestinal contents of 2 out of the 62 animals (3 per cent).

*Oocyst morphology* (Fig. 1): They were ovoidal, subspherical or spherical in shape with a smooth light brown wall approximately 1.0  $\mu$  thick. The wall apparently consisted of a single layer only. A micropyle was absent but some of the ovoidal oocysts were somewhat flattened at one or both poles. Asymmetrical oocysts were not uncommon. A polar granule was seen in most of the oocysts but an oocyst residuum was absent. Fifty oocysts measured 15 to 24  $\mu$  by 13 to 21  $\mu$  with an average of 19 by 17  $\mu$ . Their length-width ratios ranged from 1.0 to 1.3, mean 1.13.

Sporulated oocysts contained four sporocysts, each containing two sporozoites. The sporocysts were ellipsoidal or ovoidal in shape with a Stieda body situated at one end. A finely granular compact sporocyst residuum was present, usually near the centre of the sporocyst. The sporocysts measured 10 to 13  $\mu$  by 5 to 8  $\mu$  with an average of 11 by 7  $\mu$ . Their length-width ratios ranged from 1.4 to 2.0, mean 1.66. The sporozoites were elongated with one end rounded and tapered towards the other. A refractile globule was present in the rounded end of each sporozoite. Ten sporozoites had an average length of 8  $\mu$ .

*Sporulation time:* Oocysts of *E. chinchillae* were fully sporulated after 72 hours at 28°C.

*Prepatent period:* The first oocysts were seen in the faeces 7 days after infection.

*Location in intestine:* Development stages were especially prevalent in the wall of the caecum and colon but were also seen in the small intestine.

*Attempt to infect chinchillas:* Successful. Typical *E. chinchillae* oocysts were passed by the chinchillas from Day 8 after oral infection.

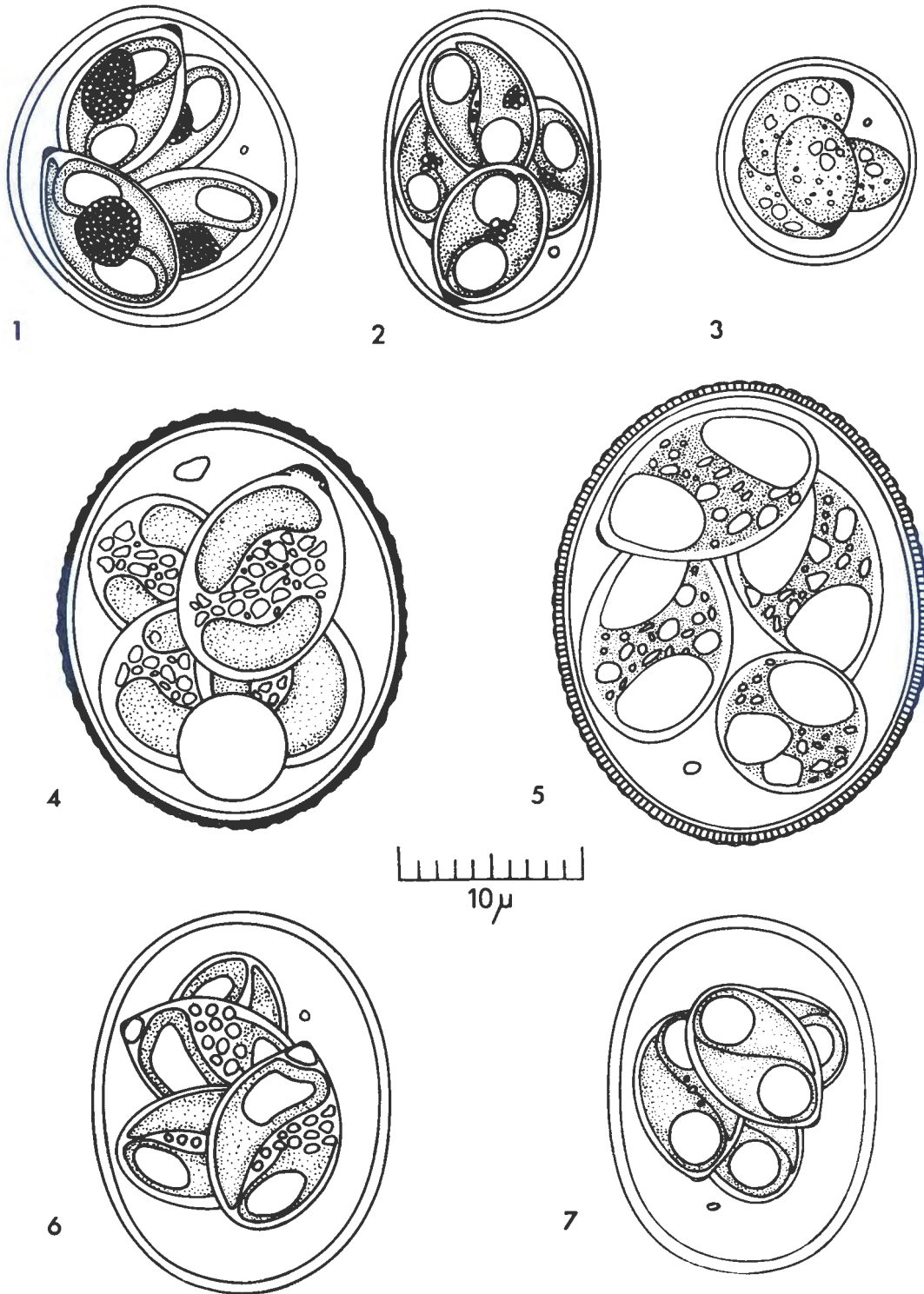


PLATE 1 Sporulated oocysts of seven *Eimeria* spp. from three South African rodents.

1. *Eimeria chinchillae*
2. *Eimeria pumilioi* n. sp.
3. *Eimeria rhabdomyis* n. sp.
4. *Eimeria pretoriensis* n. sp.
5. *Eimeria mastomyis* n. sp.
6. *Eimeria theileri* n. sp.
7. *Eimeria otomyis* n. sp.

1 to 4 are from *Rhabdomys pumilio*, 5 and 6 from *Praomys (Mastomys) natalensis* and 7 from *Otomys irroratus*

*Eimeria pumilioi* n. sp.

**Incidence of infection:** Oocysts of *E. pumilioi* were found in the intestinal contents of 18 out of the 62 animals (29 per cent).

**Oocyst morphology** (Fig. 2): They were predominantly ellipsoidal in shape but subspherical and cylindrical forms were also present. The wall was smooth, colourless, approximately 1.0  $\mu$  thick and apparently consisted of a single layer only. A micropyle was not observed. A polar granule was seen in most of the oocysts but an oocyst residuum was absent. Fifty oocysts measured 15 to 21  $\mu$  by 10 to 14  $\mu$  with an average of 18 by 12  $\mu$ . Their length-width ratios ranged from 1.2 to 1.7, mean 1.44.

Sporulated oocysts contained four sporocysts, each containing two sporozoites. The sporocysts were usually broadly ellipsoidal in shape. A Stieda body was present at one end. The sporocyst residuum consisted of a few granules that were usually grouped together. Twenty-five sporocysts measured 7 to 10  $\mu$  by 4 to 7  $\mu$  with a mean of 9 by 6  $\mu$ . Their length-width ratios ranged from 1.2 to 2.5, mean 1.66. The sporozoites were approximately 8  $\mu$  in length with one end pointed and the other broad and rounded. The broad end of one sporozoite was usually adjacent to the pointed end of the other in the sporocyst. A clear refractile globule was situated in the broad end of each sporozoite.

**Sporulation time:** Oocysts of *E. pumilioi* were fully sporulated after 48 hours at 28°C.

**Prepatent period:** Oocysts were first noticed in the faeces 4 days after infection.

**Location in intestine:** *E. pumilioi* occurred mainly in the caecum and colon and, to a lesser extent, in the small intestine.

**Attempt to infect chinchillas:** Unsuccessful.

*Eimeria rhabdomyis* n. sp.

**Incidence of infection:** Oocysts of *E. rhabdomyis* were found in the intestinal content of 1 out of the 62 animals (2 per cent).

**Oocyst morphology** (Fig. 3): They were spherical to subspherical in shape with a smooth colourless wall approximately 0.7  $\mu$  thick. A micropyle was not observed and the wall appeared to consist of a single layer only. An oocyst residuum was absent but a polar granule was observed in most of the oocysts. Fifty oocysts measured 10 to 14  $\mu$  by 9 to 13  $\mu$  with an average of 13 by 12  $\mu$ . Their length-width ratios ranged from 1.0 to 1.2, mean 1.08.

Sporulated oocysts contained four sporocysts, each of which harboured two sporozoites. The sporocysts were ellipsoidal to ovoidal in shape with a Stieda body present at one end. The sporocyst residuum consisted of granules dispersed throughout the sporocyst. The sporozoites were not clearly discernible and no refractile globules were observed. Twenty-five sporocysts measured 6 to 7  $\mu$  by 4 to 6  $\mu$  with an average of 7 by 5  $\mu$ . Their length-width ratios ranged from 1.3 to 1.7, mean 1.49.

**Sporulation time:** Oocysts of *E. rhabdomyis* were fully sporulated after 48 hours at 28°C.

**Prepatent period:** Oocysts were first noticed in the faeces 4 days after infection.

**Location in intestine:** *E. rhabdomyis* occurred in the caecum and colon.

**Attempt to infect chinchilla:** Unsuccessful.

*Eimeria pretoriensis* n. sp.

**Incidence of infection:** Oocysts of *E. pretoriensis* were found in the intestinal contents of 2 out of the 62 animals (3 per cent).

**Oocyst morphology** (Fig. 4): They were broadly ellipsoidal in shape. The wall was approximately 1.5  $\mu$  thick and consisted of two layers. The outer layer was thicker, light brown in colour, and had a roughened surface while the inner layer was smooth and colourless. A micropyle was not observed. A polar granule and an oocyst residuum were present. The latter consisted of one to three, or rarely more, clear spherical bodies with an average diameter of 7  $\mu$ . Fifty oocysts measured 18 to 27  $\mu$  by 16 to 22  $\mu$  with an average of 24 by 19  $\mu$ . Their length-width ratios ranged from 1.1 to 1.5, mean 1.23.

Sporulated oocysts contained four sporocysts, each containing two sporozoites. The sporocysts were broadly ellipsoidal, tapering slightly towards one end where a distinct Stieda body was situated. A large sporocyst residuum, which consisted of coarse granules, was present which made study of the sporozoites very difficult. Twenty-five sporocysts measured 8 to 12  $\mu$  by 5 to 8  $\mu$ , with an average of 10 by 7  $\mu$ . Their length-width ratios ranged from 1.1 to 1.7, mean 1.37.

**Sporulation time:** Oocysts of *E. pretoriensis* were fully sporulated after 5 days at 28°C.

**Prepatent period:** The first oocysts were noticed in the faeces 5 days after infection.

**Location in intestine:** *E. pretoriensis* occurred throughout the entire length of the small intestine but was especially prevalent in the ileum.

**Attempt to infect chinchillas:** Unsuccessful.

*P. (M.) natalensis*

Oocysts resembling those of *E. chinchillae* were not found in *P. (M.) natalensis* but oocysts of 2 other *Eimeria* spp. were observed in 5 out of the 22 animals that were examined. One of them has apparently not been described before. The other species, however, was morphologically similar to an unnamed *Eimeria* sp. briefly described from this host (syn. *Mus coucha*) by Fantham (1926).

*Eimeria mastomyis* n. sp.

**Incidence of infection:** Oocysts of *E. mastomyis* were found in 2 out of the 22 animals (9 per cent).

**Oocyst morphology** (Fig. 5): They were broadly ellipsoidal in shape with a finely punctated wall approximately 1.5  $\mu$  thick, and composed of two layers. The outer layer was light brown in colour and radially striated while the inner layer was colourless. An oocyst residuum was absent but a polar granule was observed in most of the oocysts. Fifty oocysts measured 24 to 32  $\mu$  by 20 to 23  $\mu$  with an average of 27 by 21  $\mu$ . Their length-width ratios ranged from 1.2 to 1.5, mean 1.29.

Sporulated oocysts contained four sporocysts, each harbouring two sporozoites. The sporocysts were ellipsoidal in shape and a Stieda body was situated at one end. The large sporocyst residuum consisted of coarse, loosely arranged granules which made study of the sporozoites virtually impossible. Two large refractile globules were, however, visible at each end of the sporocysts. Twenty-five sporocysts measured 13 to 15  $\mu$  by 7 to 9  $\mu$  with an average of 14 by 8  $\mu$ . Their length-width ratios ranged from 1.5 to 1.9, mean 1.65.

**Sporulation time:** Oocysts of *E. mastomyis* were fully sporulated after 72 hours.



*Prepatent period:* Not determined.

*Location in intestine:* Not determined.

*Attempt to infect a chinchilla:* Unsuccessful.

*Eimeria theileri* n. sp.

*Incidence of infection:* Oocysts of this organism, named after Sir Arnold Theiler, were found in the intestinal contents of 4 out of the 22 animals (18 per cent).

*Oocyst morphology* (Fig. 6): They were subspherical to ellipsoidal in shape with a smooth colourless wall approximately  $1.0 \mu$  thick. A micropyle was not observed and the wall appeared to consist of a single layer only. An oocyst residuum was absent but a polar granule was observed in many of the oocysts. Fifty oocysts measured  $16$  to  $25 \mu$  by  $14$  to  $20 \mu$  with an average of  $20$  by  $17 \mu$ . Their length-width ratios ranged from  $1.1$  to  $1.4$ , average  $1.21$ .

Sporulated oocysts contained four sporocysts, each containing two sporozoites. The sporocysts were ellipsoidal in shape with a Stieda body and substiedal body situated at one end. A sporocyst residuum was present and consisted of loose, coarse granules. Twenty-five sporocysts measured  $9$  to  $12 \mu$  by  $5$  to  $8 \mu$  with an average of  $11$  by  $6 \mu$ . Their length-width ratios ranged from  $1.4$  to  $1.9$ , mean  $1.64$ . The sporozoites were rounded at one end and tapered towards the other. The rounded end of one sporozoite usually lay next to the pointed end of the other in the sporocyst. A clear refractile globule was situated in the rounded end of each sporozoite. Twenty sporozoites had an average length of  $8 \mu$ .

*Sporulation time:* Oocysts of *E. theileri* were fully sporulated after 48 hours at  $28^\circ\text{C}$ .

*Prepatent period:* Not determined.

*Location in intestine:* Not determined in this study but the organism reported by Fantham (1926) occurred in the jejunum and ileum.

*O. irroratus*

No oocysts resembling those of *E. chinchillae* were detected in *O. irroratus* but another apparently undescribed *Eimeria* sp. was found in 2 out of the 32 animals that were examined.

*Eimeria otomyis* n. sp.

*Incidence of infection:* Oocysts were observed in the intestinal contents of 2 out of the 32 animals (6 per cent).

*Oocyst morphology* (Fig. 7): Oocysts were predominantly ellipsoidal in shape, but subspherical forms were also seen. The wall was smooth, colourless, approximately  $1.0 \mu$  thick and apparently consisted of a single layer only. A micropyle and oocyst residuum were not observed but a polar granule was seen in most cases. Fifty oocysts measured  $15$  to  $23 \mu$  by  $13$  to  $16 \mu$  with an average of  $20$  by  $15 \mu$ . Their length-width ratios ranged from  $1.1$  to  $1.7$ , mean  $1.34$ .

Sporulated oocysts harboured four sporocysts, each containing two sporozoites. The sporocysts were ellipsoidal in shape with a Stieda body at one end. A sporocyst residuum was absent in most cases and, when present, consisted only of a few small granules. Twenty-five sporocysts measured  $9$  to  $11 \mu$  by  $6$  to  $8 \mu$  with an average of  $10$  by  $7 \mu$ . Their length-width ratios ranged from  $1.4$  to  $1.8$ , mean  $1.59$ . The sporozoites were rounded at one end and tapered markedly towards the other. The rounded end of one sporozoite was usually adjacent to the pointed end of the other in the sporo-

cyst. A clear refractile spherical globule was situated in the rounded end of each sporozoite. Twenty sporozoites had an average length of  $7 \mu$ .

*Sporulation time:* Oocysts were fully sporulated after 48 hours at  $28^\circ\text{C}$ .

*Location in intestine:* Not determined.

*Prepatent period:* Not determined.

*Attempts to infect chinchillas:* Unsuccessful.

*M. musculus*

No oocysts were found in any of the 10 animals that were examined.

## DISCUSSION

The morphological features and the sporulation time of the *E. chinchillae*-like oocysts found in *R. pumilio* did not differ from the original description of this organism. Moreover, the site of development of the endogenous stages and the prepatent period of the infection were the same as those described by De Vos (1970) for *E. chinchillae* in experimentally infected *R. pumilio*. The identity of the organism was finally confirmed by the successful infection of chinchillas.

The two *R. pumilio* found to be harbouring *E. chinchillae* were trapped in localities that were not closely associated with chinchillas. This, together with the lack of host-specificity of *E. chinchillae* and the fact that coccidiosis of chinchillas is apparently unknown in other parts of the world, seem to indicate that *E. chinchillae* is in fact primarily a parasite of wild South African rodents. Because of the presence of chinchilla farms in the Pretoria district, the possibility that the wild rodents became infected from chinchillas cannot be excluded with absolute certainty, but it seems very unlikely.

The significance of these findings is, as local chinchilla breeders have long suspected, that the occurrence of coccidiosis in chinchillas may depend on the presence of wild rodents in the chinchilla houses. The same viewpoint is held by Lawrence (Veterinary Research Laboratory, Salisbury, Rhodesia, personal communication, 1968). He observed a severe outbreak of coccidiosis in chinchillas in Rhodesia that coincided with an explosive increase in the numbers of wild rodents in the area.

The possibility of clinical coccidiosis occurring in chinchillas is enhanced by their extreme susceptibility to infection with *E. chinchillae*. As few as 10,000 oocysts may cause death in adult chinchillas (De Vos, unpublished observations) whereas 100,000 are not fatal to *R. pumilio* (De Vos, 1970).

This report is apparently the first on the natural occurrence of *Eimeria* spp. in *R. pumilio*. The oocysts of the four *Eimeria* spp. differ from each other morphologically. *E. chinchillae* is often ovoidal in shape, *E. pumilioi* is more elongated and sometimes cylindrical in shape, *E. rhabdomyis* is smaller than the others and spherical or subspherical in shape and *E. pretoriensis* is larger and has an oocyst residuum and roughened wall composed of two layers. Only *E. chinchillae* is transmissible to chinchillas.

Two *Eimeria* spp. have been described from *Praomys*, viz. an unnamed *Eimeria* sp. from *P. (M.) natalensis* (see above) by Fantham (1926) and *Eimeria praomysis* Levine, Bray, Ivens & Gunders, 1959 from *Praomys tullbergi rostratus* (Miller, 1900) [syn. *Rattus (Praomys) tullbergi rostratus*]. The only information available on the morphology of the oocysts of the

former is that they are oval in shape and measured 16 to 21  $\mu$  by 15 to 16  $\mu$ . These data correspond with those of *E. theileri*. *E. theileri* differs from *E. praomyxis* by the presence of a substiedal body in the sporocysts and the smooth colourless nature of the walls of its oocysts. *E. mastomyxis* differs from *E. theileri* and *E. praomyxis* in being larger and having a wall composed of two layers of which the outer is punctated and radially striated.

*E. chinchillae* has been transmitted successfully to *P. (M.) natalensis* according to De Vos (1970). Both *E. theileri* and *E. mastomyxis*, however, differ from *E. chinchillae* on the morphology of their oocysts. The former lacks ovoidal oocysts and has a substiedal body in the sporocysts while the latter is larger with a punctated wall composed of two layers. Neither *E. theileri* nor *E. mastomyxis* are transmissible to chinchillas.

This report on *E. otomyxis* is apparently the first on the natural occurrence of an *Eimeria* sp. in *Otomys* but *E. chinchillae* has been transmitted to *O. irroratus* experimentally (De Vos, 1970). *E. otomyxis* differs from *E. chinchillae* in being typically ellipsoidal in shape. No ovoidal forms were seen. Chinchillas were not susceptible to infection with *E. otomyxis*.

In general the morphology of the oocysts of the six new *Eimeria* spp. described above resembles those of other *Eimeria* spp. of rodents. An oocyst residuum was seen in only one of the species while a sporocyst residuum was consistently present in five species and less often in the sixth. On reviewing the information on more than 160 *Eimeria* spp. of rodents, Levine & Ivens (1965) noted the presence of an oocyst residuum in 45 per cent and a sporocyst residuum in 89 per cent of cases. A distinct Stieda body was present in all of the six new species and a substiedal body was seen in *E. theileri*. It resembles a similar body described from *Eimeria utabensis* Ernst, Hammond & Chobotar, 1968 but is slightly less distinct.

#### SUMMARY

*E. chinchillae*, an organism originally described from the chinchilla and subsequently shown to be

transmissible to other rodents, was found to occur naturally in *R. pumilio* in South Africa. The morphology of the oocysts, the site of development of the endogenous stages and the prepatent period of the infection were similar to those of *E. chinchillae* obtained from chinchillas and transmitted experimentally to *R. pumilio*. The identity of the organism was confirmed by the successful infection of chinchillas.

Three other *Eimeria* spp. were also found in *R. pumilio*. Oocysts of *E. pumilioi* measured 18 by 12  $\mu$ , those of *E. rhabdomyis*, 13 by 12  $\mu$  and those of *E. pretoriensis*, 24 by 19  $\mu$ . Two *Eimeria* spp. were also found in *P. (M.) natalensis*. Oocysts of *E. mastomyxis* measured 27 by 21  $\mu$  and those of *E. theileri*, 20 by 17  $\mu$ . A single *Eimeria* sp., *Eimeria otomyxis* was found in *O. irroratus*. The oocysts measured 20 by 15  $\mu$ .

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