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Annals and Magazine of Natural History: Series 6

Publication details, including instructions for authors and subscription information:
<http://www.tandfonline.com/loi/tnah12>

LVII.—Remarks upon a species of *Coccidium* infesting *Perichæta*

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Published online: 12 Oct 2009.

To cite this article: Frank E. Beddard .A. (1888) LVII.—Remarks upon a species of *Coccidium* infesting *Perichæta*, Annals and Magazine of Natural History: Series 6, 2:12, 433-439, DOI: [10.1080/00222938809487512](https://doi.org/10.1080/00222938809487512)

To link to this article: <http://dx.doi.org/10.1080/00222938809487512>

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THE ANNALS

AND

MAGAZINE OF NATURAL HISTORY.

[SIXTH SERIES.]

No. 12. DECEMBER 1888.

LVII.—*Remarks upon a Species of Coccidium infesting Perichæta.* By FRANK E. BEDDARD, M.A., Prosector to the Zoological Society of London, Lecturer on Biology at Guy's Hospital.

[Plate XV.]

THE notes which I publish in this paper are very incomplete, inasmuch as they are the outcome of a study of spirit-preserved material only. But as the material in question shows with perfect clearness certain characteristic features in the structure and development of this *Coccidium*, and as it is not at all likely that I shall have the opportunity of studying the living worms which are the host of the Gregarine, I think it better to publish such new facts as I have noted down. Moreover, this is, I believe, the first record of the presence of *Coccidia* in any Annelid, or at any rate in any earthworm; and it is always important to ascertain how far the range of certain genera of Gregarines is limited to certain groups of animals which are their hosts.

In the account of the Gregarines by Prof. Bütschli, in vol. i. of Bronn's 'Klassen und Ordnungen des Thierreichs,' a valuable summary is given of the distribution of Gregarines; it is there
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stated that *Coccidia* are only found parasitic in Vertebrates, Myriopods, Turbellaria, and Mollusks; I am able now to extend this statement, and to add earthworms to the list of animals which are known to harbour *Coccidia*. I have made a practice of examining all the earthworms which pass through my hands for Gregarines; I have never as yet detected *Coccidia* in any genus except *Perichaeta*; in two species of that genus I have noticed these Gregarines, viz. in *Perichaeta novæ-zelandiæ** and in *P. armata*†; in both species they occupied the same part of the body, viz. the perivisceral cavity.

In both cases the *Coccidium* differs in certain particulars from any *Coccidium* that has been hitherto described; it seems also possible that the *Coccidium* which infests *Perichaeta novæ-zelandiæ* belongs to a different species from that which infests *Perichaeta armata*; upon this point, however, I cannot be certain.

I could discover only a few examples of *Coccidium* in *Perichaeta novæ-zelandiæ*, and therefore some stages may have been wanting which would, if present, have shown the species to be identical with that inhabiting the body of *Perichaeta armata*. The characteristic Gregarine of the first-mentioned *Perichaeta*‡ was so numerous that there was perhaps no room for the *Coccidium* to multiply very freely.

On the other hand, the *Coccidium* of *Perichaeta armata*, when it occurred at all, which was very rarely, was extremely abundant; I have been able therefore to get together some drawings, which are reproduced in Pl. XV., and which illustrate some of the principal phases in the life-history of the *Coccidium*. The majority of the figures in the plate illustrate the *Coccidium* of *Perichaeta armata*; fig. 16 refers to the *Coccidium* of *Perichaeta novæ-zelandiæ*.

In both cases the parasite has the form which is characteristic of *Coccidium*, that is to say it is oval or rather egg-shaped, with slightly flattened sides. Certain individuals, for example those represented in figs. 10, 11, are hardly distinguishable from *Coccidium oviforme*§. The cell-contents are granular, with very coarse granules, and there is no differentiation into endo- and ectoplasm; the cyst-membrane is distinctly double in some cases (fig. 9), less distinctly double in others (fig. 10).

* I have not yet described this species, which I owe to the kindness of Mr. W. Smith, of Ashburton, New Zealand.

† The specimens of this worm, in which the *Coccidium* occurs, were kindly sent to me from Borneo by Mr. Everett.

‡ See P. Z. S. 1888, pt. iii.

§ For an account of this parasite see 'The Parasites of Man' (Leuckart), translated by W. E. Hoyle, Edinburgh: p. 203 *et seq.*

Micropyle.—At one end of the cyst in all individuals is a structure which I identify with what has been termed by Waldenberg* (its discoverer) and Leuckart† a “micropyle.” The micropyle, however, in the *Coccidium* of *Perichæta armata* is rather different from that of *C. oviforme*.

In *C. oviforme* the micropyle is stated to be an extremely fine pore and to be situated at one pole of the cyst.

Schneider‡ has described a structure in the cyst-membrane of *Orthospora propria* which appears to correspond to the micropyle; it does not, however, appear from Schneider’s description to be a pore, but a slight bulging of the cyst-wall inwards at one extremity of the cyst.

Bütschli considers that probably this “*stigma*” upon the cyst of *Orthospora* corresponds to the so-called micropyle of *Coccidium*. I observed in one specimen of *Coccidium* (fig. 10) a slight thickening at one end of the cyst which projected into the interior, and which agrees very closely with Schneider’s figures§ of the “*stigma*” of *Orthospora*; but I never noticed any such relation between the “*stigma*” and the cell-contents as he has figured|| and described.

In *Coccidium* from *Perichæta armata* there is always, with very rare exceptions, such as that just mentioned, a micropyle which differs considerably from that of *C. oviforme* or of *Orthospora*. In the first place (*cf.* figs. 1, 2, 3, &c.) its position is not constant; it may be situated (fig. 1) at one pole, but as frequently it is placed at one side more (fig. 15) or less (fig. 2) remote from the pole. The appearance of this structure, which I have termed a micropyle because that is the generally received term, is such that I am inclined to agree with Schneider in believing it *not* to be a perforation of the cyst-membrane at all. My specimens of this *Coccidium* are mounted in glycerine, so that their position can be changed at will by pressing with a needle upon the cover-glass. When the position of the *Coccidium* upon the slide is such that the micropyle is seen in profile it presents the appearances represented in figs. 2, 8, 9, 15. These figures illustrate what the preparations seem to teach, *viz.* that the so-called micropyle is simply a bulging in of the cuticle, perhaps due to a separation of part of the internal cuticular lamella

* “Zur Entwicklungsgeschichte der Psorospermien,” Arch. pathol. Anat. Bd. xl. (1867) p. 435.

† *Loc. cit.*

‡ “Sur les *Psorospermes oviformes* ou *Coccidies*,” Arch. Zool. Exp. t. ix. (1881) p. 387.

§ *Loc. cit.* pl. xxii. fig. 4 *b*, and figs. 5, 6, 7, 8, 10.

|| *Loc. cit.* pl. xxii. fig. 4 *c*.

caused by reagents. The boundary-line of the micropyle is perfectly continuous with the inner margin of the cyst-membrane, and there is no appearance, at the point where the clear spherical body is in contact with the cyst-membrane, of any perforation of the latter. This structure is so very much larger in this species than in *Orthospora*, that this statement can be made with greater confidence, and it does not appear to me likely that the preservation of the specimens in alcohol is likely to have confused the relations of these parts, which are entirely chitinous. The appearance of such an individual as that represented in fig. 1 gives some colour to the view that the structure in question is a funnel-shaped invagination of the cyst-membrane which opens into the interior of the cyst; but it is simply due to the optical effects produced by the position of the *Coccidium*.

In other cases, where the micropyle is seen from above (fig. 12) it presents the appearance of a free oil-globule contained within the cyst. The second difference then between the so-called micropyle of *Orthospora* and *Coccidium perichætæ* (as I may term the species, perhaps both of them, which are described in the present paper), is its very much greater size in the latter.

The third difference is that there are frequently two of these structures present in a single cyst (see fig. 4); in these cases they are not placed at opposite poles; they may be occasionally so placed, but I have noticed plenty of instances where they are not. This fact will at once recall the apparently similar structure of *Eimeria falciformis*, in which Eimer* has noted the presence of two micropyles placed one at each pole of the somewhat oval cyst. These structures have not been described or figured by Schneider in his account† of *Eimeria nova*.

Cyst-membranes.—There are clearly two cyst-membranes present in *Coccidium perichætæ*‡; the inner membrane is much thicker in young stages than the outer membrane, which is at that time very thin (fig. 9). Fig. 6 appears to show a third, innermost, membrane, but I believe this appearance to be due to the optical effect produced at a certain focus by the inner membrane.

The most remarkable difference, however, between the cyst-membranes in this species and in *Coccidium oviforme* is

* See Bütschli, Bronn's 'Thierreich,' Bd. i. Protozoa, pl. xxxviii. fig. 2b.

† *Loc. cit.* p. 397.

‡ These statements, as well as those about the micropyle, refer only to the parasite of *Perichæta armata*.

that the outer cyst-membrane, instead of disappearing as the cyst ripens *, not only persists, but increases greatly in importance. I have observed various stages in the increase in thickness of this membrane, which are illustrated in figs. 9, 2, 5, 6, 12, 15; it finally comes to project beyond the two poles of the cyst for a very considerable distance (fig. 15), sometimes equal or nearly equal to the length of the cyst. Although this membrane increases so greatly in thickness, especially at the two poles, it remains of a very delicate consistency and is extremely transparent. It bears no little resemblance to the thick transparent outer cyst-membrane of *Gamocystis* and *Clepsidrina*†. Occasionally (fig. 15) concentric lines, perhaps indicating the deposition of successive layers, are visible.

It is important to observe (fig. 15) that in these advanced stages the micropyle has not any relation whatever to the outer cyst-membrane, which is a further argument against regarding this structure as an aperture.

It often happened that two cysts, each limited by its own inner membrane, were enclosed partly (fig. 8) or entirely (fig. 13) in a common outer membrane.

Sporulation.—In *Coccidium oviforme* the first preliminary to sporulation is the condensation of the protoplasmic contents of the cyst into a rounded mass. This I have not discovered in *Coccidium perichæta*, or, rather, I have not observed any great differences in this particular between various individuals with a still undivided mass of protoplasm. The condition, however, of the material (preserved in alcohol) is probably responsible for this; but in any case there does not appear to be any formation of a membrane enclosing the spores, as in *Cyclospora* ‡.

Various stages in the division of the protoplasm are shown in figs. 4, 3, 8, 9, 13, 12, 15, and these stages are an almost unbroken series, showing the division into a large number of sporoblasts. The increase in number of the sporoblasts does not bear any definite relation to the increase of the outer cyst-membrane. In some individuals the outer cyst-membrane had attained to a high development, while the protoplasmic contents of the cyst were still undivided (fig. 7). On the other hand, figs. 8 and 9 illustrate two individuals in which the outer cyst-membrane was inconspicuous, while the cell-contents had already divided into several masses. I have not succeeded in tracing the formation of spores any further than to this point.

* Bütschli, *loc. cit.* pl. xxxvii. figs. 11 *a* and *b*.

† Schneider, "Contributions à l'histoire des Gregariens &c.," Arch. Zool. Exp. t. iv. (1875).

‡ Schneider, *loc. cit.* pl. xxii. figs. 23–38.

The division of the cell-contents into a large number of sporoblasts is a fact of some little importance with regard to the affinities of the *Coccidia*, to which group the present species seem without doubt to belong.

The oviform psorosperms, including *Coccidium* and Schneider's genus *Orthospora*, as well as *Eimeria* and *Cyclospora*, which differ in having a circular form, are distinguished from other Gregarines (1) in being intracellular parasites, for the greater part of their life and even in the latest stages parasitic in the tissues of their host; they are never free-living: (2) in the fact that they only produce a limited number of spores—one to four.

In *Klossia* and *Benedenia* (which Schneider does not regard as distinct from *Klossia*) the number of spores is much greater; but they agree with the other Coccidiidæ in their mode of life and are generally referred to that family. In the phenomenon of their sporulation, which may perhaps be related to their greater size, they agree with other Gregarines, and they form therefore an intermediate group between *Coccidium* &c. and the Monocystidæ.

This affinity between the Coccidiidæ and the Monocystidæ is rendered closer by the fact that Coccidium perichætæ, which is a typical oviform Coccidium, produces a large number of spores like the free-living Gregarinidæ. It also resembles certain of the latter, e. g. Gamocystis, in the great development of the outer cyst-membrane.

With regard to the *Coccidium* from *Perichæta novæ-zelandiæ* I have observed the formation of a large number of sporoblasts (fig. 16); but I have not noticed the thick outer cyst-membrane. As has been already stated, the formation of spores in the *Coccidium* from *Perichæta armata* does not advance *pari passu* with the development of the outer membrane; it may be therefore that I did not succeed in observing any individuals in which the outer cyst-membrane was developed, but that there were others not observed by me in which it was to be found.

I have stated at the commencement of this paper that in both species of *Perichæta* the *Coccidium* occurred in the body-cavity; I certainly met with the *Coccidium* from *Perichæta novæ-zelandiæ* in this situation in company with a large species of Gregarine which I have described elsewhere*. I cannot be so certain about *Perichæta armata*, as the intestine of the worm from which I obtained my specimens was ruptured. In both cases, however, the *Coccidia* may very

* "Note on a new Gregarine," Proc. Zool. Soc. 1888, pt. iii.

possibly have been contained in the tissues lining the coelom ; but of this fact I cannot be absolutely certain.

Summary.

The most important facts recorded in this paper are the following:—

- (1) *Coccidium* occurs in the Oligochæt *Perichæta*.
- (2) In two species of *Perichæta* from different parts of the world (i. e. *P. novæ-zelandiæ* from New Zealand and *P. armata* from Borneo) the same species, or at least closely allied species, occur which differ from other forms.
- (3) The cyst-membrane is double and the outer membrane is of very great thickness, though extremely transparent.
- (4) There is a conspicuous "micropyle" (often two) which does not appear to be a perforation of the cyst-membrane, but merely a local bulging, perhaps due to reagents.
- (5) The protoplasm of the parasite breaks up into a large number of spores.

EXPLANATION OF PLATE XV.

Lettering:—*a*, inner cyst-membrane ; *b*, outer cyst-membrane ; *c*, micropyle ; *d*, protoplasmic contents ; *d'*, sporoblasts.

Figs. 1-13, 15. *Coccidium* from *Perichæta armata*.

Fig. 14. *Gregarina*, sp. ? , found in company with *Coccidium* in *Perichæta armata*.

Fig. 16. *Coccidium* from *Perichæta novæ-zealandiæ*.

LVIII.—On the Foraminiferal Genus *Orbitoides* of d'Orbigny. By H. J. CARTER, F.R.S. &c.

THERE are several discoid fossils among the Nummulites which, having a central plane covered in on each side by a more or less convex crust, look so much like Nummulites that, without close inspection, they would appear to present no difference ; and these in totality have been named "*Orbitoides*" by d'Orbigny, whose diagnosis, together with typical