Morphological description of *Isospora alyousifi* nom. n. for *I. acanthodactyli* Alyousif et Al-Shawa, 1997 (Apicomplexa: Eimeriidae) infecting *Acanthodactylus schmidti* (Sauria: Lacertidae) in Saudi Arabia

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Abstract: To date, three species of *Isospora* Schneider, 1881 have been described from lizards of the genus *Acanthodactylus* Wiegmann. Two of these, although representing separate species parasitizing two different hosts, *Acanthodactylus boskianus* Daudin in Egypt and *A. schmidti* Haas in Saudi Arabia, were described under the name *Isospora acanthodactyli*. The third species is *Isospora abdallahi* Modrý, Koudela et Šlapeta, 1998 from *A. boskianus* in Egypt. In the present study, *Isospora alyousifi* nom. n. is proposed to accommodate *Isospora acanthodactyli* Alyousif et Al-Shawa, 1997 (homonym of *I. acanthodactyli* Sakran, Fayed, El-Toukhy et Abel-Gawad, 1994) and its redescription based on newly collected material is provided.

Keywords: homonymy, redescription, oocysts, endogenous stages, coccidia, sandy fringed-toed lizard, Riyadh

Lacertid lizards of the genus *Acanthodactylus* Wiegmann are widely distributed from West Africa to the Middle East (Harris and Arnold 2000, Harris et al. 2003, Rifai et al. 2003). Apicomplexan parasites of the genus *Isospora* Schneider, 1881 were first reported from lacertid lizards of the genus *Acanthodactylus* by Sakran et al. (1994), who described *Isospora acanthodactyli* from *Acanthodactylus boskianus* Daudin in Egypt and *A. schmidti* Haas in Saudi Arabia, were described under the name *Isospora acanthodactyli*. The third species is *Isospora abdallahi* Modrý, Koudela et Šlapeta, 1998 from *A. boskianus* in Egypt. In the present study, *Isospora alyousifi* nom. n. is proposed to accommodate *Isospora acanthodactyli* Alyousif et Al-Shawa, 1997, is proposed and the species is redescribed on the basis of new material.

**RESULTS**

Of the 40 adult sandy fringed-toed lizards *Acanthodactylus schmidti* examined in this study, eight shed oocysts in their faeces. Initially, the examined faeces contained non-sporulated oocysts, oocysts in the early stages of sporulation and a few fully sporulated oocysts. The majority of recovered oocysts became fully sporulated within 12 hours at 25 ± 1°C when placed in 2.5% (w/v) aqueous potassium dichromate solution. The sporulated oocysts from all the examined lizards were found to belong to the genus *Isospora* and appeared to be of the same species. Below we present a morphological description of the oocysts and endogenous stages of this coccidian, which is considered conspecific with *Isospora acanthodactyli* Alyousif et Al-Shawa, 1997, which is a homonym of *I. acanthodactyli* Sakran, Fayed, El-Toukhy et Abel-Gawad, 1994. To avoid this homonymy, a new name, *I. alyousifi*, is proposed and the species is redescribed on the basis of new material.

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**Isospora alyousifi** nom. n.

**Oocysts.** Oocysts spherical to subspherical, 24.5 ± 2.5 (17–29) × 21 ± 2.5 (16–26), with length/width ratio of 1.11 (1.06–1.2) (Figs. 1–8, 16). Oocyst wall yellow, smooth, bi-layered, 1.5 (1.2–1.6) thick, composed of thicker outer layer (about two thirds of total thickness – Fig. 2) and smooth inner layer (about one third of total thickness – Fig. 6). Micropyle, oocyst residuum and polar granules absent. Sporocysts ovoidal, 13.5 ± 1.5 (8–16) × 9 ± 1.5 (6–11), with smooth, single-layered wall, 0.5 thick; length/width ratio of 1.4 (1.1–1.7) (Fig. 8). Stieda body (Fig. 1) as well as sporocyst residuum present; residuum composed of numerous granules of nearly same size (Fig. 5). Sporozoites elongate with spherical anterior and posterior refractile bodies (Fig. 7).

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**Figs. 1–16.** Isospora alyousifi nom. n. from the intestine of Acanthodactylus schmidti. 1–8. Mature oocysts showing the wide size range and steady increase in size from the smaller to the larger oocysts. The oocyst surrounded with the outer layer (OL) and inner layer (IL) membrane, containing two sporocysts (S), each with Stieda body (SB), sporocyst residuum (SR) and four sporozoites (Sp). 9–15. Endogenous development and endogenous stages. 9, 10. Early meronts (M) and nucleus shifted to one pole of enterocytes (N). 11. Developing meront (M). 12. Mature meront (M). 13. Macrogamonts (Ma) with wall-forming bodies arranged at the periphery (arrows) and a centrally located nucleus (N). 14. Macrogamonts (Ma) with a large number of small nuclei. 15. Zygote (young oocyst) (Zy) surrounded by thin envelope (arrows). Scale bars: 1–8 = 10 µm, 9–15 = 5 µm.
Endogenous stages. Observed within nuclei of enterocytes in posterior segment of small intestine. In heavily infected lizards endogenous stages also found in anterior intestine. Nuclei shifted to one pole in infected cells (Figs. 9, 10). As development of endogenous stages progressed, nuclei became gradually consumed and transformed into thin envelope around parasite (Fig. 15). Early trophozoites spherical (Figs. 9, 10), 3–5 in diameter. Developing meronts also spherical, 6–8 in diameter (Fig. 11). Mature meronts subspherical to ovoid, 11–13 × 6–8 (Fig. 12). Macrogamonts subspherical, 7–9 × 5–7, distinguished by large number of small nuclei (Fig. 13). Macrogamonts ovoid to elliptical, 18–20 × 6–9, identified by wall-forming bodies arranged at periphery and by centrally located nucleus (Fig. 14). Zygotes (young oocysts) spherical, 12–14 in diameter (Fig. 15).

Type host: Acanthodactylus schmidt Haas.

New material deposited: Photomicrographs and slide with histological sections are deposited at the Zoology Department Museum, College of Science, King Saud University, Riyadh, Saudi Arabia (Coll. No. I/30/2012).

Sporulation: Exogenous and majority of recovered oocysts became fully sporulated within 12 hours at (25 ± 1°C).

Site of infection: Endogenous stages developed within the nuclei of the enterocytes.

Prevalence: 20% (8/40) in the Thomama area (24°41’N, 46°42’E) in Riyadh City, Saudi Arabia.

Etymology: The specific epithet is given in honour of Mohamed Alyousif, who first described the species.

**DISCUSSION**

The oocysts of all members of the genus *Isospora* possess two sporocysts with four sporozoites in each and a single polar Stieda body (Barta et al. 2005). Descriptions of new isosporan species are traditionally based solely on oocyst morphology (e.g., Pellerdy 1974, Upton et al. 2001). In the 1990’s, photomicrographic documentation became common (Duszyński 1999). However, this oocyst-based classification has proven problematic. The risk of identifying some eimerian coccidians solely by the morphology of their oocysts and sporocysts has been discussed by numerous authors (see Finkelman and Paperna 2011). One set of issues in species identification, therefore, is an over-reliance of oocyst morphology for identification purposes, combined with inadequate sample sizes. Three species of *Isospora* have been described from lizards of the genus Acanthodactylus. These species are *I. abdallahi* Modrá, Koudela et Šlapeta, 1998, *I. acanthodactyli* Sakran, Fayad, El-Toukhya et Abdul-Gawad, 1994, and *I. alyousifi* Modrá, Koudela et Šlapeta, 1998.

**Table 1.** Comparative descriptive measurements (in μm) of *Isospora alyousifi* nom. n. with morphologically similar species.

<table>
<thead>
<tr>
<th>Species/Reference</th>
<th>Host</th>
<th>Oocyst size</th>
<th>Oocyst shape and SI*</th>
<th>Sporocyst size</th>
<th>Sporocyst shape and SI*</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Isospora abdallahi</em></td>
<td>Acanthodactylus boskianus</td>
<td>25.8 (24.5–29.0) × 13.4 (8–16)</td>
<td>Spherical or subspherical</td>
<td>15.4 (14–16) × 1.07 (1.00–1.16)</td>
<td>Ovoid</td>
</tr>
<tr>
<td>Modrá, Koudela et Šlapeta, 1998</td>
<td>Acanthodactylus boskianus</td>
<td>23.9 (23.0–25.5) × 9.4 (9–10)</td>
<td>Spherical</td>
<td>9.3 (7.4–10.4) × 0.9 (0.8–1.0)</td>
<td>Ovoid</td>
</tr>
<tr>
<td><em>Isospora acanthodactyli</em> Sakran, Fayad, El-Toukhya et Abdul-Gawad, 1994</td>
<td>Acanthodactylus boskianus</td>
<td>17.2 (16.4–18.8) × 9.4 (9–10)</td>
<td>Spherical</td>
<td>9.3 (7.4–10.4) × 0.9 (0.8–1.0)</td>
<td>Ovoid</td>
</tr>
<tr>
<td><em>I. alyousifi</em></td>
<td>Acanthodactylus schmidt</td>
<td>27.9 (25.1–29.0) × 11.6 (11.2–12.6)</td>
<td>Spherical</td>
<td>11.6 (11.2–12.6) × 1.09 (1.03–1.30)</td>
<td>Ovoid</td>
</tr>
<tr>
<td>Al-Shawa, 1997 (= <em>I. alyousifi</em></td>
<td>Acanthodactylus schmidt</td>
<td>25.5 (22.7–27.8) × 8.0 (7.5–8.4)</td>
<td>Spherical</td>
<td>8.0 (7.5–8.4) × 1.32 (1.27–1.54)</td>
<td>Ovoid</td>
</tr>
<tr>
<td><em>I. alyousifi</em> nom. n. (present study)</td>
<td>Acanthodactylus schmidt</td>
<td>24.6 (17.0–29.0) × 13.4 (8–16)</td>
<td>Spherical</td>
<td>13.4 (8–16) × 1.11 (1.06–1.20)</td>
<td>Ovoid</td>
</tr>
</tbody>
</table>

*SI: shape index (length/width ratio)
and *I. alyousifi* nom. n. (syn. *I. acanthodactyli* Alyousif et Al-Shawa, 1997) (Table 1). *Isospora abdallahi* differs in having a thicker oocyst wall and the ranges of measurements of oocysts and sporocysts never overlap those of *I. alyousifi*. Although *I. acanthodactyli* looks similar to *I. alyousifi*, its oocyst wall is 2.2–3.8 µm thick compared to 1.5 µm only in *I. alyousifi* and the length of their oocysts and sporocysts does not overlap.

Alyousif and Al-Shawa (1997) overlooked the original description of *I. acanthodactyli* by Sakran et al. (1994) and used the same name for an apparently distinct species, the name of which thus became unavailable as homonym of the former one. A new name, *I. alyousifi*, is proposed and the species is redescribed based on new material from the same host, with similar size of oocysts and sporocysts, and identical other features as those of *I. acanthodactyli* Alyousif et Al-Shawa, 1997.

**Acknowledgments.** The authors extend their appreciation to the Deanship of Scientific Research at King Saud University for funding the work through the research group project number RGP-VPP-004.

**REFERENCES**


Received 14 May 2012

Accepted 31 July 2012