The canary *Serinus canaria* (Passeriformes: Fringillidae) as a new host for *Isospora bioccai* in Mexico

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ABSTRACT

*Isospora bioccai* (Cringoli and Quesada 1991) (Protozoa, Apicomplexa, Eimeriidae) is reported and described from captive canaries *Serinus canaria* forma *domestica* (Linnaeus 1758) in Mexico. The oöcysts are subspherical, 25.5 × 23.5 μm, with smooth, bilayered wall, ∼1.3 μm thick. Micropyle absent, oöcyst residuum absent, and polar granule present, 4–8 rice-grain-shaped. Sporocysts are ovoidal, 16.7 × 10.5 μm. Stieda body knob-like and substieda body trapezoidal of irregular base. Sporocyst residuum is composed of granules of different sizes. Sporozoites are vermiform with one refractile body and a nucleus. Gamogony was seen in the duodenum. In addition to new locality, this is the first description of *I. bioccai* from *S. canaria*.

1. Introduction

*Serinus* (canaries) is a genus of finches belonging to the Fringillidae family of birds, mostly confined to Africa and the Mediterranean Basin (Arnaiz-Villena et al., 1999). Particularly, *S. canaria* (Linnaeus 1758) is native from the Canary Island and now is widely kept in captivity in most areas of the world (IUCN, 2017). In Mexico, canaries *S. canaria* are available at pet shops and through bird traders, called pajarreros, which is a local name given to the trade (derived from pájaro, the Spanish word for bird) (Roldán-Clará et al., 2017). The aim of this study was the description of *I. bioccai* from *S. canaria* in Mexico.

![Oöcyst of Isospora bioccai. A & B. Photomicrographs. Scale-bar: 10 μm.](https://doi.org/10.1016/j.ijppaw.2018.11.004)
Table 1
Comparative morphology of *Isospora* sp. recorded from Fringillidae.

| Host | *Carduelis atrata* (La Fresnaye & D'Orbigny) | *Carduelis carduelis* (L.) | *Carduelis tristis* (L.) | *Carduelis chloris* (L.) |
|------|---------------------------------------------|----------------------------|-------------------------|-------------------------|
| Species | *I. atrata* Rossiet al. (1996) | *I. carduelis* Gottschalk (1969) | *I. lacazei* Labbé (1893) | *I. gryphoni* Olson et al. (1998) | *I. chloris* Anwar (1966) | *I. daszaki* Ball et al. (2012) |
| Locality | Italy (imported from Peru, Bolivia, and Argentina) | Germany | England, Spain | Canada | England, Spain | England |
| Reference | Rossiet al. (1996) | Gottschalk (1969) | Anwar (1966); Romero-Rodriguez (1973) | Olson et al. (1998) | Anwar (1966) | Ball et al. (2012) |
| Oöcyst | | | | | | |
| Shape | spherical or sub spherical | sub spherical | sub spherical | spherical to sub spherical | ellipsoidal | spherical to sub spherical |
| Wall | bi-layered | bi-layered | one-layered | bi-layered | bi-layered | bi-layered |
| Length | 19.4–23.5 (21.0) | 24.69–30.94 (28.19) | 20.30–34.0 (26.8) | 28.0–34.0 (30.7) | 17.3–33.2 (25.4) | 16.8–25.2 (20.3) |
| Width | 18.5–22.0 (20.3) | 20.94–26.25 (23.88) | 18.0–30.0 (24.5) | 25.0–33.0 (29.2) | 16.6–30.0 (22.3) | 16.8–22.4 (18.8) |
| Length/Width ratio | 1.0–1.06 (1.03) | 1.0–1.5 (1.1) | 1.05 | 1.08 | 1.07–1.1 (1.08) | |
| Polar granule | +, (rarely 2), oval | + | +, 1 to 3 splinter-like | 2–4 rice-grain-shaped | +, 2 or more ovoidal | – |
| Oöcyst residuum | – | – | – | – | – | – |
| Sporocyst | | | | | | |
| Shape | ovoid | ellipsoidal | ovoid | pyriform | pyriform | |
| Length | 17.5–18.94 (18.8) | 17.34 | 15.0–19.0 | 15.0–23.0 (22.2) | 13.5–18.5 (15.3) | 12.6–18.2 (14.8) |
| Width | 9.5–11.0 (10.3) | 11.15 | 9.0–12.0 | 12.0–14.5 (13.4) | 8.3–12.2 (9.4) | 8.4–11.2 (9.4) |
| Length/Width ratio | 1.76–1.88 (1.82) | 1.7 | 1.6 | 1.7 | 1.6 | |
| Stieda body | flattened | present | present | small | present | opaque |
| Sub-Stieda body | rounded | present | compact | indistinct | present | opaque |
| Residuum | compact/diffuse | diffuse or compact | | cluster of scattered granules | diffuse | |
| Chloris (Carduelis) sinica | | | | | | |
| Prunella v. (L.) | | | | | | |
| Linaria (Carduelis) cannabina (L.) | | | | | | |
| Looops visetans (Gmelin) | | | | | | |
| *I. mcquistioni* Cringoli and Quesada (1991) | *I. biocca* Cringoli and Quesada (1991) | *I. fringillae* Yakimoff and Gousseff (1938) | *I. atrata* Quesada and Cringoli (1990) | *I. cannabina* Quesada and Cringoli (1990) | *I. loxops* Levine et al. (1980) |
| Italy | Azerbaijan | Italy | Germany | Italy | Hawaii |
| Cringoli and Quesada (1991) | Cringoli and Quesada (1991) | Cringoli and Quesada (1991) | | | Levine et al. (1980) |
| Oöcyst | | | | | | |
| Shape | spherical to sub spherical | spherical | sub spherical | sub spherical | spherical or sub spherical | |
| Wall | bi-layered | bi-layered | one-layered | bi-layered | bi-layered | |
| Length | 24.0–28.5 (26.0) | 22.0–26.0 (24.0) | 16.0–24.0 (21.2) | 20.8–29.0 (25.1) | 22.19–29.69 (26.13) | 243–26.24 (26.3) |
| Width | 20.0–23.6 (22.6) | 21.0–25.8 (23.6) | 1.02 | 18.5–22.0 (21.5) | 20.94–26.56 (23.88) | 232–24.3 (24.1) |
| Length/Width ratio | +, 1 (rarely 2 or 3) | +, 4 to 10 elongated | + | +, 1 (rarely 2) elongated | + | 2.4–5 elongated |
| Polar granule | – | – | – | – | – | – |
| Sporocyst | | | | | | |
| Shape | ellipsoidal | ovoid | ellipsoidal | ellipsoidal | ovoid | |
| Length | 16.0–19.8 (18.1) | 18.6–20.0 (19.5) | 17.4–22.0 (20.9) | 17.4–20.0 (19.1) | 16.0–17.0 (16.0) | |
| Width | 11.0–12.0 (11.4) | 10.0–12.4 (11.6) | 10.4–11.6 (10.8) | 10.4–11.6 (10.8) | 10.4–11.6 (11.5) | 12.0–13.0 (13.0) |
| Length | 1.59 | 1.68 | 1.93 | 1.66 | 1.66 | |
| bottlecap-shaped | niple-like | knob-like | knob-like | knob-like | knob-like | |
| slightly convex base | trapezoidal | rounded | trapezoidal, irregular base | | | |
| compact | diffuse | compact | | | diffuse | |

(continued on next page)
| Host          | Pyrrhula pyrrhula (L.) | Serinus canaria (L.)<sup>b</sup> | Serinus canaria (L.)<sup>e</sup> | Serinus serinus (L.) | Spinus thybetus (Hume) |
|--------------|------------------------|----------------------------------|--------------------------------|----------------------|------------------------|
| Species      | I. perronciti Carpano (1937) | I bioccai Cringoli and Quesada (1991) | I. canaria Box (1975) | I. serini Angao (1932) | I. noronti Papparella and Cringoli (1991) |
| Locality     | Egypt                  | Mexico                           | USA, Brazil                     | USA                  | Australia              |
| Reference    | Carpano (1937)         | Present study                    | Box (1975); Berto et al. (2013) | Box (1975); Box (1977) | Yang et al. (2015)     |
|              |                        |                                  |                                |                      | Papparella and Cringoli (1991) |
|              |                        |                                  |                                |                      | Perrucci et al. (1998)  |
| Oöcyst       | sub-spherical          | sub-spherical                    | spherical or sub-spherical      | spherical to sub-spherical | spherical or sub-spherical |
| Shape        |                        |                                  |                                |                      |                        |
| Wall         | bi-layered             | bi-layered                       | one-layered                    | bi-layered           | bi-layered             |
| Length       | 15.0–25.0              | 24.0–27.0 (25.5)                 | 21.0–27.0 (24.4)               | 13.0–23.0 (20.1)     | 19.7–23.2 (21.9)       |
| Width        | 22.0–25.0              | 19.0–25.0 (23.5)                 | 13.0–23.0 (19.2)               | 22.0–24.8 (23.5)     | 18.5–22.0 (20.0)       |
| Length/Width ratio | 1.0–1.1 (1.1)         | 1.0–1.2 (1.1)                    | 1.09                           | 1.07                 | 1.00–1.14 (1.007)      |
| Polar granule | –, +, 2–8 rice-grain-shaped | +, broadly bar shaped           | +                              | +                    | +, 1 oval              |
| Oöcyst residuum | –                     | –                                | –                              | –                    | –                      |
| Sporocyst    |                        |                                  |                                |                      |                        |
| Shape        | ovoid                  | ellipsoidal                      | lemon-shaped                   | ellipsoidal          | ellipsoidal            |
| Width        | 16.0–20.0 (17.6)       | 13.0–16.0 (15.2)                 | 17.8–20.2 (18.9)               | ellipsoidal          | ellipsoidal            |
| Length/Width ratio | 1.6–1.8 (1.7)   | 10.0–12.0 (10.6)                 | 8.0–11.0 (9.4)                 | 8.1–10.4 (9.4)       | 15.0–18.5 (16.1)       |
| Stieda body  | TRAPEZOIDAL, IRREGULAR BASE | PROMINENT                       | BARELY DISCERNIBLE             | CRESCENT-SHAPED      | TRAPEZOIDAL, UNDULATED LOWER PROFILE |
| Residuum     | diffuse                | CLUSTER OF SCATTERED GRANULES    | DIFFUSE OR COMPACT GRANULES    | LIGHT AND DARK SCATTERED GRANULES | CLUSTER OF SCATTERED GRANULES |

**Table 1 (continued)**

- **A** Also recorded I. chloridis and I. lacazei.
- **B** Also recorded in *Passer domesticus* (L.).
- **C** Polar granule: +, present; -, absent.
- **D** Oöcyst residuum: +, present; -, absent.
- **E** Also recorded I. chloridis and I. lacazei.
2. Materials and methods

2.1. Bird sampling

Twelve captive canary *Serinus canaria* were investigated as part of a routine parasitology study in a pet shop at Toluca Valley (19°17′32″N; 99°39′14″W), Mexico. Fecals samples were placed in a plastic vial containing 2.5% potassium dichromate solution (K₂Cr₂O₇ 1:6 (v/v)) and observed in a light microscope (Duszynski and Wilber, 1997).

2.2. Microscopic analysis

To investigate the site of infection, one canary was euthanized (AVMA, 2013; NOM-033-SAG/ZOO-2014), and the following organs and tissues were collected from the bird: trachea, lungs, liver, stomach and intestines. These viscera samples were placed in a plastic vial containing 2.5% potassium dichromate solution (K₂Cr₂O₇) 1:6 (v/v) and observed in a light microscope (Duszynski and Wilber, 1997).

3. Results

Four canaries (33.3%) shed oocysts in the faeces. Initially, the oocysts were non-sporulated, but approximately 70% of the oocysts were sporulated at day two (under the conditions used in this study).

Oocyst (n = 35) were subspherical, 24.1 – 27.2 × 22.0–25.1 (25.5 × 23.5); length/width (L/W) ratio 1.0 – 1.1 (1.1). Wall bi-layered, 1.0–1.1 (1.1) thick, outer layer smooth, c. 1/3 of total thickness. Micropyle absent, oocyst residuum absent and polar granule present, 4–8 rice-grain-shaped (Fig. 1A). Sporocysts (n = 35) 2, ellipsoidal, 9.2 – 11.2 × 15.6–17.4 (10.5 × 16.7); L/W ratio 1.6 – 1.8 (1.7). Stieda body present, nipple-like, 1.1 high × 2.4 wide; sub-Stieda present, trapezoidal, irregular base, 1.8 high × 4.5 wide; para-Stieda body absent; sporocyst residuum present, consisting of scattered spherules of different sizes (Fig. 1B; Table 1). Sporozoites 4, vermiform, with single posterior refractile body and centrally located nucleus. Phototypes and line drawings of sporulated oocysts are deposited and available in the Collection of the Avian Microbiology Laboratory, Centro de Investigación y Estudios Avanzados en Salud Animal. The repository number is ESV-23/2017.

Histological examination of tissues helped detect endogenous stages in the epithelial cells of duodenum (Fig. 2). Endogenous stages develop extranuclearly in the cytoplasm of duodenal epithelial cells. Most of the endogenous stages were observed mainly into epithelial cells along the length of the villi. Meronts were surrounded by a parasitophorous vacuole (Fig. 2) (see Fig. 3).

4. Discussion

Up to now, the concept of intra-familial specificity of *Isospora* spp. of passerine birds has been maintained (Berto et al., 2011). The sporulated oocysts obtained in this study were compared in detail with coccidian parasites from other birds that belong to the same host family (Duszynski and Wilber, 1997). The morphology and morphometry of the *I. bioccai* oocysts allow differentiating it from other *Isospora* species passerines from the same family (Table 1).

*Isospora bioccai* was first described from Chloris [Carduelis] sinica in Italy (Cringoli and Quesada, 1991). Phylogenetic analysis of the Fringillidae, showed *C. sinica* cluster separately from congeneric species and form a distinct lineage in the *Serinus-Chloris* complex (Zuccon et al., 2012). Further morphometric and phylogenetic analysis of coccidia from Fringillidae are need (Ogedengbe et al., 2016; Yang et al., 2017). In the canary *S. canaria* have been identified following *Isospora* species: *I. canaria* in USA and Brazil (Box, 1975; Berto et al., 2013), *I. chloridis* in England and Spain (Anwar, 1966; Romero Rodriguez, 1973), *I. lacazei* in England and Spain (Anwar, 1966; Romero Rodriguez, 1973), *I. serini* and *Wilber (1997)* and *Berto et al. (2014)*, were made using a Nikon Eclipse 80i microscope coupled to a digital camera Nikon DS-Fi2.
in USA (Box, 1975, 1977), and I. serinuse in Australia (Yang et al., 2015). Unidentified species of coccidia have been reported in captive canary S. canaria in Brazil, (de Freitas et al., 2003; Lima et al., 2017). Similarly, unidentified species of coccidia have been identified in other Fringillidae (Svobodová, 1994; Brown et al., 2010). In addition to new locality, this is the first description of I. bioccai from S. canaria. Fringillidae birds were one of the most common avian families in reported international trade (Bush et al., 2013). In the State of Mexico where Toluca Valley is located, Fringillidae (C. notata, C. psaltria and S. canaria) were one of the most frequent birds reported in bird markets (Álvarez et al., 2005). We speculate bird trade as the origin of I. bioccai infection in S. canaria.

Declarations of interests

None.

Conflicts of interest

The authors declare that they have no conflict of interest.

Ethical approval

All applicable national and international guidelines for the care and use of animals were followed (NOM-033-SAG/ZO0-2014; AVMA, 2013).

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