INTRODUCTION

Earlier studies in the Philippines had documented infection of water buffaloes (= carabaos) with *Sarcocystis fusiformis* (Railliet, 1897) Bernard & Bauche, 1912, and *Sarcocystis levinei* (Dissanaike & Kan, 1978) Huong, Dubey & Uggla, 1997. Worldwide, three different species of *Sarcocystis* are known to infect cattle, *Sarcocystis cruzi* (Hasselman, 1926) Wenyon, 1926 (syn: *Sarcocystis bovicana*), *Sarcocystis hominis* (Heydorn & Rommel, 1972; Heydorn et al., 1975; Bottner et al., 1987; Pacheco et al., 1978, Dubey et al., 1989a; 1989b). In 1978, Tongson & Pelagio reported the presence of zoites in ground beef sold in some selected supermarkets and wet markets in Metro Manila. Considering the high prevalence of bubaline *Sarcocystis fusiformis* then, and the absence of records of bovine sarcocystosis locally, they conjectured that the ground beef sold could have been a mixture of water buffalo and cattle meat (= carbeef). However, infection of cattle with *Sarcocystis* parasite was not confirmed then. In a recent survey on sarcocystosis in both Philippine homegrown and imported cattle, Claveria et al. (1999) had found round and fusiform-shaped sarcocysts in skeletal, striated and heart muscle, and they suggested possibilities of cattle infection with at least two of the species reported worldwide. In this paper, *S. cruzi* infection in Philippine domesticated cattle (*Bos taurus*) is documented.

MATERIALS AND METHODS

Eighty-eight sample sets, each consisted of muscle tissues from the diaphragm, pharynx, esophagus, neck, upper and lower limbs, and the heart...
Figs A-D. — *Sarcocystis cruzi* in bovine cervical muscle tissue section. A. Mature sarcocyst. Bradyzoites (arrowhead); Metrocytes (arrows). Bar: 13 μm. B, C. Young sarcocysts with cross, longitudinal and tangential sections of villar protrusions (VP). Nucleus (N); Amylopectin granules (arrowhead). Bar: B = 2.5 μm; C = 1.7 μm. D. Portion of sarcocyst and its cyst wall. Ground substance (G); Bubble-like undulations (arrowhead); Conical tufts (arrows). Bar = 1 μm. Note marked damage to host muscle tissue (HT) including displacement of Z-line.
Ultrastructure of *Sarcocystis cruzi*: Philippine cases

Round or globular to oval, but mostly fusiform-shaped microscopic sarcocysts were found in the cervical, esophageal, pharyngeal, diaphragm, fore- and hind limbs, and heart muscle tissues. Serial tissue sections showed the presence of 2-to-6 sarcocysts. Mature sarcocysts measured 183-578 μm long (average: 374 μm) and 20-98 μm across, and had numerous bradyzoites and some merocyttes within well defined septae (Fig. A). The sarcocyst wall or parasitophorous vacuolar membrane, 1.37-2.75 μm thick consisted of closely-packed villar protrusions (VP), 80-400 nm in dm (Figs. B-D). Middle and distal segments of VP were bent approximately 90 degrees parallel to the cyst wall surface (Figs. C-D). The villar core lacked microtubules, and at some points, the distal ends of the VP collectively formed conical tufts (Fig. D). Primary cyst wall had numerous 70-100nm bubble-like undulations (Fig. D), and the ground substance (= ground layer) was 0.25-0.5 μm in thickness (Fig. D). Cyst wall ultrastructural descriptions typify the Type 7 sarcocyst wall (Dubey *et al.*, 1989a).

**RESULTS**

The variation in the number of sarcocysts noted in serial tissue sections suggests a difference in the grade, and age of *Sarcocystis* infection. While we noted some differences in the size of *S. cruzi* sarcocysts relative to those earlier reported, its cyst wall ultrastructure bears close similarities with that described by Mehlhorn *et al.* (1976), Pacheco *et al.* (1978), and Dubey *et al.* (1989b). *Sarcocystis cruzi* also shows resemblance with the Type 7 cyst wall of *Sarcocystis arieticanis* in sheep (Heydorn & Mehlhorn, 1987), *Sarcocystis rangi* in reindeer (Gierde, 1985), *Sarcocystis biricicanis* in goats (Heydorn & Unterholzner, 1983), and *S. levinei* infecting water buffaloes in Vietnam (Huong *et al.*, 1997) and in the Philippines (Claveria & Cruz, 2000).

The similarities in the ultrastructure of *S. cruzi* cyst wall in the present study with the Vietnam and the Philippine strain of *S. levinei* (Table I), and the utilization of dogs as definitive host of *S. cruzi* (Dubey, 1982) and *S. levinei* in Vietnam (Huong *et al.*, 1997) suggest pos-

<table>
<thead>
<tr>
<th>Features</th>
<th><em>S. cruzi (P)</em></th>
<th><em>S. levinei (P)</em></th>
<th><em>S. levinei (P)</em>*</th>
<th><em>S. levinei (P)</em>**</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Sarcocysts</td>
<td>Bradyzoites in compartments</td>
<td>Same</td>
<td>Same</td>
<td>Same</td>
</tr>
<tr>
<td>Basophilic</td>
<td></td>
<td>Same</td>
<td>Same</td>
<td></td>
</tr>
<tr>
<td>183-417 μm long</td>
<td>20-98 μm dm</td>
<td>13-48 μm dm</td>
<td>100-120 μm</td>
<td>13-48 μm dm</td>
</tr>
<tr>
<td>Skeletal, esophageal, pharyngeal, cervical, diaphragm &amp; heart muscle</td>
<td>Skeletal, esophageal, tongue &amp; diaphragm muscle</td>
<td>Skeletal, esophageal, tongue &amp; myocardium</td>
<td></td>
<td></td>
</tr>
<tr>
<td>II. Parasitophorous vacuolar membrane (cyst wall)</td>
<td>Type 7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Villar protrusions</td>
<td>1.37-2.75 μm thick</td>
<td>2.3-2.75 μm thick</td>
<td>0.3-0.6 μm thick</td>
<td></td>
</tr>
<tr>
<td>Lacks microfilaments</td>
<td>Same</td>
<td>Same</td>
<td>Same</td>
<td></td>
</tr>
<tr>
<td>With conical tufts</td>
<td>No data</td>
<td>No data</td>
<td>80-500 nm dm</td>
<td></td>
</tr>
<tr>
<td>80-400 nm dm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Basal cyst wall</td>
<td>With bubble-like undulations</td>
<td>Dome-shaped + undulations (0.08-0.5 μm wide)</td>
<td>Dome-shaped + undulations (0.08-0.5 μm wide)</td>
<td></td>
</tr>
<tr>
<td>(70-100 nm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>III. Ground substance</td>
<td>0.25-0.5 μm thick</td>
<td>0.42-0.5 μm thick</td>
<td>0.4-0.9 μm thick</td>
<td></td>
</tr>
</tbody>
</table>

* Present study; ** Claveria & Cruz, 2000; *** Huong *et al.*, 1997.

Table I. - Comparison of the ultrastructure of *Sarcocystis cruzi* with the Philippine and the Vietnam bubaline *Sarcocystis levinei*.

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sibilities of parasite cross-transmission between cattle and water buffaloes, and the likelihood that S. cruzi and S. levinei are of the same species utilizing two different intermediate hosts. In a related study on cross-transmission, buffalo calves were not infected with the bovine S. cruzi (Jain & Shah, 1985). Interestingly, Wang et al. (1992) had reported successful cross-transmission of the bovine S. cruzi to buffalo calves that developed acute sarcocystosis, and subsequently died. The esophageal content used, and the dogs' status at the time of their exposure to sarcocysts however, were not established. With the detection of round or globular to oval sarcocysts in this study, we have not precluded the possibility of finding other Sarcocystis spp. infecting cattle. The isolation of other morphologic forms of bovine sarcocysts for ultrastructural evaluation is continuing in our laboratory. Finding the definitive host(s) of S. cruzi in domesticated cattle in the country is worth pursuing.

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