Z. Parasitenkd. 58, 115–139 (1979)

Zeitschrift für
Parasitenkunde
Parasitology Research

Sarcocystinae: *Nomina Dubia* and Available Names

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Summary. Examination of the original descriptions of the species of *Sarcocystis* in cattle, sheep, and swine, and of isosporid oocysts shed sporulated by dogs, cats, man, and other carnivores, has shown that it is not possible in most instances to identify unambiguously recently recognized taxa. The original descriptions are insufficient, and because no type specimens exist, could apply to two or more of the presently recognized taxa. We consider the following *nomina dubia:*

Sarcocystis hirsuta	*Isospora bigemina (S. bigemina)*
S. miescheriana	*I. hominis (S. hominis)*
S. tenella	*I. buteonis (Frenkelia buteonis)*
S. cruzi	
S. bertrami	

Because the former type species, *Sarcocystis miescheriana,* is an indeterminate *nomen dubium,* we are proposing *S. muris* as the new type species. Historically, it was the first species described clearly and unambiguously even in the light of present knowledge, and the stages of its life cycle are probably completely known; it was the second species to be named. Old and recent descriptions are reviewed, and definitions are proposed for the following taxa:

S. bovifelis	*S. ovifelis*	*S. suihominis*	*S. equicanis*
S. bovicanis	*S. ovicanis*	*S. suicanis*	*Frenkelia microti*
S. bovihominis	*S. muris* (type species)		*F. glareoli*

for which neotypes[1] will be prepared and deposited with designated institutions and curators. A new subfamily, Cystoisosporinae, is created.

Introduction

The recognition of predator-prey type life cycles for several *Sarcocystis* spp. (for review, see Levine, 1977) has made possible the definition of certain taxa by their morphology and their host specificity. While this has permitted us

[1] The Committee of Nomenclature now (Warschau, 1978) proposes to create '*hapantotypes*' in Protozoa comprising of all significant stages of a life cycle.

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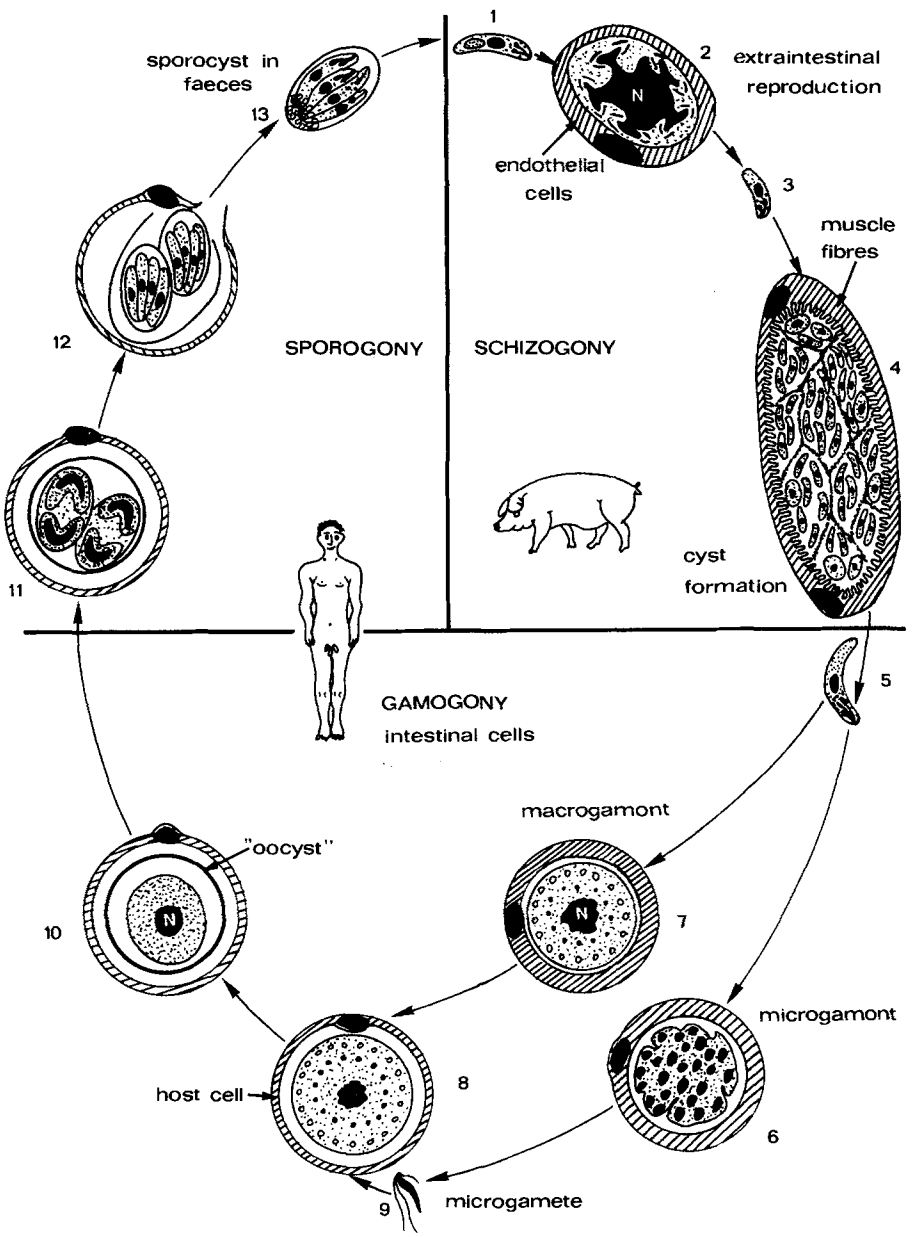

Fig. 1. Diagrammatic representation of the life cycle of *Sarcocystis suihominis*. **1.** Sporozoite. **2.** Within endothelial cells two generations of schizonts are formed giving rise to 50–90 merozoites (each) by simultaneous division of the giant nucleus. **3.** Merozoite. **4.** Cyst formation within muscle fibers with globoid metrocytes and elongate bradyzoites. **5.** After eating raw meat containing cysts, bradyzoites are set free within the intestine of man. **6., 7.** Micro- and macrogamonts develop in a parasitophorous vacuole within the cells of the lamina propria. **8, 9.** The stationary macrogamete (**8**) is fertilized by a motile microgamete (**9**). **10.** The zygote is surrounded by a wall and becomes an 'oocyst.' **11.** Two sporocysts are formed in the interior of an oocyst while still in the host cell. **12.** The oocyst wall is broken and the two sporocysts are set free, containing four sporozoites

to separate a number of taxa previously thought to be one, it has also given rise to considerable uncertainty concerning nomenclature.

In order to designate the newly defined taxa, Heydorn et al. (1975) proposed new specific names that combined the names of the intermediate and final hosts. However, because they did not formally designate available names under the Code of Zoological Nomenclature, and *nomina dubia* with individual justifications, their proposal became a subject of controversy and of attempted rectifications.

To this end, Tadros and Laarman (1976) reviewed the classification, accepting certain old and some new species names. However, they complicated their proposal by creating a substitute genus with the same type species as *Sarcocystis*, which is inadmissible under the Code. They also reduced a number of other genera to subgenera of *Isospora*, in order to emphasize the coccidian nature of these organisms and to conform to the periodic table of Hoare (1956). Levine (1977) carefully reviewed and discussed the nomenclature of *Sarcocystis* and of the fecal coccidia of dogs and cats, and also accepted certain old and some new species names, without proposing changes of generic rank. Interestingly, his assignment of *Sarcocystis* spp. does not always correspond to that of Tadros and Laarman (1976). Indeed, this characterizes the central problem: when one critically reviews the old descriptions, one cannot identify the recently recognized taxa with any degree of certainty. For example, Tadros and Laarman (1976) and Levine (1977), by using reasonable assumptions and logical processes, arrived at opposite conclusions when attempting to identify *S. cruzi* and *S. hirsuta*. Therefore, instead of arguing which old name is more probably applicable to the new taxa, and in the absence of type specimens, it appears preferable to declare the indeterminate designations *nomina dubia*, to re-define the species, and to create neotypes.

In the following we will review the relevant descriptions of species level taxa. In regard to the generic designations, we consider it in the interest of conservatism, communication, and future expandability of the classification to retain the current generic concepts, which place emphasis on the unique diversity of the cyst stages (Levine, 1977; Frenkel, 1977). This will be more advantageous than to follow the first useful, but still primitive classification of Hoare (1956), which places emphasis on the sameness of the isosporid oocysts (Tadros and Laarman, 1976).

SARCOCYSTIS spp.

Original Descriptions From Intermediate Host

The intramuscular cysts of *Sarcocystis* were first described by Miescher (1843) in skeletal muscles of a house mouse, but no scientific name was given. When, in the following years, similar cysts were observed in muscles of other vertebrates, they were referred to as Miescher's tubes, Rainey's bodies, or psorospermes (itching seed – an archaic term for protozoan tissue cysts). Binomial terms were first used by Lankester (1882), who proposed *Sarcocystis miescheri*, thus introducing a genus and a species. This naming was incidental to describing a blood parasite of frogs, to which *S. miescheri* was compared. To quote the original text (beginning on p. 59, last two lines):

'I think it, however, important to draw attention to the close resemblance between the Drepanidium of Frog's blood and the falciform corpuscles which are described as occurring within the spores of a very remarkable Sporozoon – the *Sarcocystis Miescheri*. This organism occurs as a cell-parasite within the striated muscular fibres of such animals as the Pig, Sheep, and Man, and was first described by Miescher, and afterwards (in 1857) by the English anatomist, Rainey.'

Table 1. List of *nomina dubia* and new species names

Intermediate host	To be considered as *nomina dubia*	New species names
Sheep	*Sarcocystis tenella* Moulé, 1888 Syns. *Miescheria tenella* Railliet, 1886 *Balbiania gigantea* Railliet, 1886 *Coccidium bigeminum* Stiles, 1891 *Isospora bigemina* (Stiles, 1891) Lühe, 1906 *pro parte*	*Sarcocystis ovifelis* Heydorn et al., 1975 for the sheep-cat cycle *Sarcocystis ovicanis* Heydorn et al., 1975 for the sheep-dog cycle
Cattle	*Sarcocystis hirsuta* Moulé, 1888 Syns. *S. fusiformis* Railliet, 1897 of Babudieri (1932) and following *auctores*, *S. blanchardi* Doflein, 1901 *pro parte* *Miescheria cruzi* Hasselmann, 1923 *Isospora bigemina* (Stiles, 1891) Lühe, 1906 *pro parte* *Isospora hominis* Railliet and Lucet, 1891 *pro parte*	*Sarcocystis bovifelis* Heydorn et al., 1975 for the cattle-cat cycle *Sarcocystis bovicanis* Heydorn et al., 1975 for the cattle-dog cycle *Sarcocystis bovihominis* Heydorn et al., 1975 for the cattle-man cycle
Pig	*Sarcocystis miescheriana* (Kühn, 1865) Labbé, 1899 Syns. *Isospora bigemina* (Stiles, 1891) Lühe, 1906 *pro parte* *Isospora hominis* Railliet and Lucet, 1891 *pro parte*	*Sarcocystis suihominis* (Tadros and Laarman, 1976) Heydorn, 1977 for the swine-man cycle *Sarcocystis suicanis* Erber, 1977 for the swine-dog cycle
Horse	*Sarcocystis bertrami* Doflein, 1901 Syn. *Isospora rivolta* Gassner, 1940; Levine and Ivens, 1965 *pro parte*	*Sarcocystis equicanis* Rommel and Geisel, 1975
Voles *Microtus agrestis* (field vole)	*Isospora buteonis* Henry, 1932 Syns. *Toxoplasma microti* Findlay and Middleton, 1934	*Frenkelia microti* (Findlay and Middleton, 1934) Biocca, 1968 (type species) transmitted by *Buteo buteo;* see Krampitz and Rommel, 1977
Clethrionomys glareolus (bank vole)	*T. glareoli* Erhardova, 1955 *Frenkelia clethrionomyobuteonis* Rommel and Krampitz, 1975 *Endorimospora buteonis* (Henry, 1932) Tadros and Laarman, 1976	*Frenkelia glareoli* (Erhardova, 1955) Biocca, 1968; for description see Enemar, 1963; transmitted by *Buteo buteo;* see Rommel and Krampitz, 1975

From this it is clear that the author apparently believed that the species described parasitizes several hosts. However, we now know at least two species of *Sarcocystis* from the pig, two from sheep, and one from man as intermediate hosts, and the list is growing. Furthermore, the description given by Lankester is so deficient that it cannot now be identified with one taxon. *As a consequence, a type species cannot be fixed for the genus Sarcocystis from the first description. However, the genus Sarcocystis should be preserved because it has been used*

universally for almost 100 years (in accordance with Articles 23 and 79, International Code of Zoological Nomenclature, 1964). A new type species, *S. muris,* has been chosen from those species where the complete life cycle is known.

In the years following Lankester, sarcocysts were found in muscles of many animals, and it was thought that each animal species is parasitized by *only one* sarcosporidian species, which received one name (or erroneously some synonyms), e.g.:

S. tenella (Railliet, 1886) Moulé, 1888 of sheep,
S. miescheriana (Kühn, 1865) Labbé, 1899 of pigs,
S. hirsuta Moulé, 1888 of cattle (Table 1)

However, through transmission experiments it was shown recently that more than one *Sarcocystis* species occurs in naturally infected cattle, sheep, and swine. Actually we know at present three in cattle, two in sheep, and two in swine (Table 2).

The several species in each host resemble each other to some degree, but the cyst wall and the enclosed organisms within each species may look different depending on their age. In addition, the cyst wall may appear different in the fresh and the fixed state. It is important to know, therefore, how the cysts were prepared when first described. For example, although one can readily see radial striations or cyst wall processes in sections of cysts of the cattle-man cycle, they are not evident in sections of cysts of the cattle-dog cycle, although such processes are visible in fresh preparations of the latter cysts (for details, see Table 3).

From these considerations, it can be concluded:

1. The original descriptions of the *Sarcocystis* of cattle, sheep, and pigs are so vague as to be indeterminate, and they do not identify any of the two to three taxa presently identified in each host.

2. Because it is impossible for a contemporary revisor to identify precisely certain names originally given to cysts in muscles, and to apply them to the taxa now recognized, these original names are *nomina dubia,* and we have asked the International Commission on Zoological Nomenclature to formally suppress these names.

Original Descriptions From Intestine and Feces of Final Host

The *Sarcocystis* nomenclature is further complicated by the fact that what we now recognize as sporulated oocysts, or sporocysts, of *Sarcocystis* spp. have previously been described as species of *Isospora* Schneider, 1881 (Table 2). Oocysts and sporocysts from different species and genera (*Toxoplasma, Hammondia,* and *Sarcocystis*), and from different hosts had been described as *I. bigemina.* With the list still growing, at present there are recognized at least four different species of sporocysts of similar size and morphology in the dog, six in the cat, and two in man (Mehlhorn et al., 1976; Mehlhorn and Heydorn, 1978) that have been described from natural and sometimes mixed infections by single names (Table 2): *I. bigemina* var. *canis, I, bigemina* var. *cati, I. hominis.*

Table 2. Some *Sarcocystis* spp. transmitted by cats, dogs, and humans; correlation of old names applied to sporocysts with proposed new designations

Final host	Cat				Dog					Man	
Old names of oocysts and sporocysts	*Isospora bigemina* (Stiles, 1891) Lühe, 1906 *pro parte*				*Isospora bigemina* (Stiles, 1891) Lühe, 1906 *pro parte*					*Isospora hominis* Railliet and Lucet, 1891	
	shed as unsporulated oocyst		shed as sporulated sporocyst		unsporulated oocyst		sporulated sporocyst			sporulated sporocyst	
	small form of *I. bigemina*		large form of *I. bigemina*		small form of *I. bigemina*		large form of *I. bigemina*				
Cyst phase of life cycle	*Besnoitia*[b] *Toxoplasma*[b] *Hammondia*[b]		Sarcosporidia[a] of		*Hammondia*[b]	Sarcosporidia[a] of				Sarcosporidia of	
			sheep	cattle	mice		sheep	cattle	swine	horse	cattle	swine
Proposed new names			*S. ovi-felis*	*S. bovi-felis*	New type species *S. muris*		*S. ovi-canis*	*S. bovi canis*	*S. sui-canis*	*S. equi-canis*	*S. bovi-hominis*	*S. sui-hominis*

[a] And several others
[b] Species not listed

Table 3. Original descriptions, methods employed in study, and reasons why description is doubtful

Text of the original species description	Methods employed in study	Reasons why this description is doubtful
Sarcocystis tenella Railliet, 1886		
a. page 130: ... La psorospermie du porc... on lui donne aujourd'hui le nom de Sarcocyste de Miescher (*Sarcocystis Miescheri* Rey Lankester). Celle du mouton, au contraire, a pour enveloppe une membrane très mince: elle appartient par suite au genre *Miescheria* R. Blanchard. Elle me parait d'ailleurs constituer une forme spécifique nouvelle, à laquelle on pourrait donner le nom de Mieschérie délicate (*Miescheria tenella*).	Sections and fresh material of naturally infected, slaughtered animals	
b. page 134: ... offrent avec les sarcosporidies que M. Blanchard a observées dans le tissu conjonctif sous-muqueux de l'intestin d'un kangourou. Celles-ci sont devenues le type d'un nouveau genre (*Balbiania* R.Bl.), caractérisé par son siège dans le tissu conjonctif et sa membrane d'enveloppe mince et anhiste. Après comparaison des deux formes ... je ne pense pas qu'il soit possible de les séparer génériquement, et, par suite je classe la psorospermie de l'oesophage du mouton parmi les Balbianies, sous le nom *Balbiania gigantea.*		As can be seen in the quotations, Railliet and Moulé observed two cysts within sheep: a small one and a large ovoid one. From the large one they thought that it develops in connective tissue (therefore calling it *Balbiania*). This is incorrect as we know from electron microscopic studies: both large and small cysts develop within a muscle fiber. Thus it is impossible to decide from their descriptions whether the observed small cysts (called *Miescheria tenella*) are identical with those of the now known 'sheep-dog' cycle, or are only young developing cysts of the large ones ('sheep-cat' cycle). Because they studied natural infections, both species can be expected to occur in the same animal.
Sarcocystis tenella Moulé, 1888		
pages 10–11: A l'état jeune, elles sont petites, ovoides; mais à l'état adulte, elles prennent un aspect fusiforme, et dilatent le faisceau primitif... Leur dimension est en moyenne $^1/_2$ millimètre de long et de 60 à 100 μ de large... Si on les examine avec des objectifs plus forts... on voit qu'elles sont entourées d'une membrane régulièrement ciliée, beaucoup plus apparente vers les extrémités que sur les parties latérales. Seulement ces cils sont extrémement fragiles, tellement fragiles...	Squeezed, fresh preparations of naturally infected, slaughtered animals	
C'est ce qui nous avait induit en erreur... et fait classer ce parasite dans le genre *Miescheria,* alors que par sa structure il appartenait plutôt au genre *Sarcocystis.*		

Table 3 (continued)

Text of the original species description	Methods employed in study	Reasons why this description is doubtful
page 11: ... Pour en finir avec les sarcosporidies du mouton, je crois, qu'après les avoir rangées dans le genre *Sarcocystis*, il serait bon de leur conserver l'épithète que leur avait donnée primitivement M. Railliet; l'épithète de *tenella* (délicate) qui caractérise bien la delicatesse et la fragilité de leur membrane d'enveloppe (*S. tenella*)		
Sarcocystis hirsuta Moulé, 1888 page 15 (beginning with the last two lines): Par leur dimensions, les sarcosporidies des bovinés se rapprochent beaucoup de celles de la chèvre; comme elles, elles sont situées dans l'intérieur des faisceaux primitifs... elles sont entourées d'une membrane ciliée assez résistante qui laisse échapper par la pression des corpuscules réniformes ou falciformes pourvus de plusieurs points brillants... Si on les examine à un assez fort grossissement... en faisant varier la vis micrométrique, la bordure ciliée se trouvant sur un plan inférieur, devient moins nette et on voit apparaitre à la surface... des cils ou des prolongements filiformes qui lui donnent un aspect hirsute, ce qui m'engagerait, sous toutes réserves, à donner à cette *Sarcocystis* l'épithète de *hirsuta*.	Squeezed, fresh preparations of naturally infected, slaughtered animals	This name remains doubtful because in squeezed preparations, all three species of *Sarcocystis* of cattle may appear with finger-like protrusions. From our investigations we know that all three species may occur within a naturally infected animal. Thus it is impossible to decide to what species the name *S. hirsuta* should be assigned.
Miescheria cruzi Hasselmann, 1923 Cited after Hasselmann, 1926 page 311: A especie parasita apresentava caracteres estructuraes proprios, o que bastou para que eu a considerasse nova, sob a denominacao de *Miescheria crusi*, em nota previa que fiz publicar no Brasil Medico de Dezembro de 1923... page 312: Lesões parenchymatosas-O parasito, de que ora me occupo, tem sua sede no parenchyma do coracao, não se encontrando em qualquer outro musculo do talho.	Frozen sections of cardiac muscle from naturally infected animals of various ages	From the pictures given in the paper, it is impossible to decide whether Hasselmann had a pure infection with the *Sarcocystis* of the 'cattle-dog' cycle or whether younger cysts of the two other species were mixed between, which would be the most reasonable. If *S. cruzi* indeed occurs only in cardiac and not in skeletal muscle, it would not correspond to any of the three bovine *Sarcocystis* species investigated experimentally.

Sarcocystis (Balbiania) fusiformis Railliet, 1897

This species was thought (erroneously) to be parasitic in cattle (perhaps due to the error of Babudieri, 1932). It was, however, described for the water buffalo:

page 377: ... recueillis dans l'oesophage du buffle... atteignant 5 à 15 mm de longueur sur une largeur maximum de 2 à 4 mm. On peut les désigner ... sous le nom *Balbiania fusiformis*. Ce sont vraisemblablement les mêmes qui ont été observées à Java sur les buffles par de Jongh.

This species is assigned to one of the *Sarcocystis* found in water buffalo (*Bubalus bubalus*); see Dissanaike et al., 1977.

Synchytrium miescherianum Kühn, 1865
Sarcocystis miescheriana Labbé, 1899

Kühn, 1865, page 75: Bis zur vollständigen Aufklärung der Naturgeschichte der in Rede stehenden Gebilde möchte ich daher vorschlagen, sie der genannten Gattung anzuschließen und nach ihrem ersten Entdecker als *Synchytrium? miescherianum* zu bezeichnen. – Die von Rainey zuerst erwähnten ... Flimmerborsten, welche den ganzen Körper der Miescher'schen Schläuche umgeben sollen, habe ich zwar vielfach gesehen, ohne mich aber davon überzeugen zu können, daß sie dem Gebilde selbst angehören. In sehr zahlreichen Fällen habe ich bei vollständiger Isolierung der Schläuche nur eine einfache strukturlose Hüllmembran ohne jeglichen Anhang von Flimmerfäden wahrgenommen...

Squeezed preparations of fresh cysts from naturally infected animals

From this description it is impossible to decide whether Kühn had observed the cysts of the 'pig-man' cycle or the 'pig-dog' cycle because both have a smooth cyst wall when young. Although with maturity they both develop the protrusions and look similar for some time, the protrusions of cysts of the 'pig-man' cycle eventually become folded over, thus again presenting the appearance of a smooth cyst wall.

Sarcocystis bertrami Doflein, 1901

page 219: Ich hielt es für geeignet, dieser allerdings noch ungenügend characterisierten Art um der präziseren Bezeichnung willen, einen Speziesnamen zu geben und benenne sie zu Ehren desjenigen Forschers, welcher seit einem Jahrzehnt fast den einzigen Fortschritt auf dem Gebiet der Sarkosporidienkunde gebracht hat. Die Art scheint nach den Beschreibungen *S. miescheriana* sehr nahe zu stehen. Die Schläuche erreichen eine Länge von 9–10 mm. Auch hier findet sich die Stäbchenstruktur der Cuticula und die Kammerung des Schläuches.

Sectioned material for light microscopy

In the description the author says that this species is not sufficiently defined. Thus it is impossible to decide from this naturally infected material to which of the now known *Sarcocystis* species of horses differentiated largely by attributes in the final host, *S. bertrami* should be assigned.

Table 3 (continued)

Text of the original species description	Methods employed in study	Reasons why this description is doubtful
Sarcocystis muris (Blanchard, 1885) Labbé, 1889 Original description by Miescher, 1843 page 198: Bei der Untersuchung dieser Maus... fiel mir gleich beim Abziehen des Fells ein sonderbares gestreiftes Aussehen der Muskeln... in die Augen. Dasselbe rührte von milchweißen ziemlich starken Fäden her... Sämtliche Muskeln des Rumpfes, der Extremitäten, des Halses und Gesichtes, die Augenmuskeln so wie auch das Zwerchfell zeigten diese Beschaffenheit... alle unwillkührlichen Muskeln, nämlich die des Herzens, der Speiseröhre und des Darmcanals verhielten sich normal... page 199: ... jeder einzelne Faden ist genau so lang als die Muskelpartie in welcher er liegt... Unter dem Mikroscop stellt sich nun jeder einzelne Faden als einen cylindrischen... Schlauch dar, welcher... in unregelmäßigen Zwischenräumen leichte Einschnürungen zeigt... Die Dicke der Schläuche beträgt ungefähr 1/11–1/52... Par. Linie. Eine einfache durchaus structurlose Membran bildet die Wandungen der Schläuche; aus dicht gedrängten und wie untereinander zusammengebackenen Körnern besteht der Inhalt derselben... page 200: die meisten sind länglich und nierenförmig gebogen; ihre Länge beträgt 0,0034–0,0054‴ Par. bei einer Dicke von 0,0014–0,0024... andere in kleinerer Anzahl sind sphärisch und von ziemlich gleichbleibender Größe; ihr Durchmesser variiert von 0,0027–0,0031.	Inspection and light microscopy of fresh material	This excellent description by a professor of physiology and pathology applies to only one of the five *Sarcocystis* known from mice (*Mus musculus*). *S. muris* is the only presently known species with cysts measuring up to 5–6 mm in length. The cysts of *S. dispersa* transmitted by *Tyto alba* (barn owl) from Czechoslovakia measured 80–90 × 20–30 µm (Cerna, 1977). The cysts of a similar species transmitted by *Tyto novae-hollandiae* from Tasmania measured up to 1.8 mm × 30–60 µm (Munday, 1977). The cysts of a species transmitted by cats in Hawaii measured 220 × 65–80 µm and occasionally longer (Wallace, 1973). The cyst walls of the above species are smooth. *Sarcocystis* with villous projections was observed in a laboratory mouse in Oak Ridge, Tennessee; the calcified cysts measured possibly up to 2 mm in length and a viable cyst measured 62 × 78 µm in diameter and the villous projections about 5 µm (Slide 67–22400 supplied by Dr. G.E. Cosgrove; Ruiz and Frenkel, 1976); the final host is not known. The cyst thickness was given as 45–210 µm. What were probably bradyzoites were measured in the fresh state (in cyst, free in saline?) as 7.6–12.2 µm in length and 3.2–5.4 µm in thickness. What were probably metrocytes were measured as 6.1–7.0 µm. According to Ruiz and Frenkel (1976), bradyzoites are 14–16 µm in length and 4–6 µm in thickness in dried impression films stained with Giemsa. In view of the differences in techniques and the uncertain accuracy of measurements in 1843, the measurements do not appear inconsistent (Rooseboom, 1968; Harting, 1859).

It is readily seen that *none* of the old names can be related accurately to one of the present diagnosed sarcosporidian life cycles. We have asked the Commission to reject these *nomina dubia.*

Proposed Definitions

We have asked the Commission to admit the following defined taxa to the official List of Specific Names in Zoology.
Genus *Sarcocystis* Lankester, 1882, polyzoic cysts typically in striated muscle of the intermediate host, with an obligatory two-host cycle (=heteroxenous).

In the Intermediate Host:

Merogony occurs in two consecutive phases:

a. In endothelial or tissue cells (one or several generations)

b. Predominantly in skeletal or cardiac muscles leading to cyst formation (two types of zoites: (1) non-infectious metrocytes, and (2) infectious bradyzoites, cystozoites, cyst-merozoites)

In the Final Host:

a. Gamogony and sporogony take place in the intestinal mucosa of a predator

b. Oocysts with a very thin wall, without micropyle, containing two sporocysts, each with four sporozoites and a residual body; no Stieda body. They sporulate in the mucosa and are shed usually as sporocysts over a period of several weeks.

As type species, we have chosen *Sarcocystis muris* (Blanchard, 1885) Labbé, 1899 because this is the first sarcosporidian species observed in 1843 by Miescher. The life cycle and other details were described by Ruiz and Frenkel (1976). Because the definition of each species includes usually one intermediate and one or more final hosts, these are listed in Table 4, together with the hosts to which experimental transmission was not successful (to be noted in view of many false attributions in the literature).

Type species *Sarcocystis muris* (Blanchard, 1885) Labbé, 1899

(Syn. *Miescheria muris* Blanchard, 1885
Coccidium bigeminum (Stiles, 1891) Lühe, 1906 *pro parte*
Coccidium bigeminum var. *cati* Railliet and Lucet, 1891 *pro parte*
Sarcocystis musculi (Blanchard, 1885) of Kalyakin and Zasukhin, 1975 *lapsus linguae*)

Intermediate Host

Mus musculus only

Pre-cystic schizogony in liver

Cyst formation in skeletal muscle beginning $\simeq$25 days after infection

Cyst wall: Thin (less than 1 μm) in fixed material. Ultrastructurally it is a 0.1 μm layer with irregular, bleb-like projections extending to a total thickness of 0.2 μm (Sheffield et al., 1977).

Table 4. Animals experimentally tested for susceptibility to sporocysts and tissue cysts of *Sarcocystis*

Sarcocystis species	Sporocyst excretion after ingestion of cysts		Cyst formation in muscle following ingestion of sporocysts	
	Positive results	Negative results	Positive results	Negative results
S. muris	Domestic cat (*Felis catus*)[33b]	Dog (*Canis familiaris*)[34] Snakes (*Boa constrictor*)[34] *Corallus enydris*[34] *Agkistrodon contortrix*[34]	Mouse (*Mus musculus*)[33]	Guinea pig (*Cavia cobaya*)[33] Rat[a] (*Rattus norvegicus*)[33] Hamster[a] (*Mesocricetus auratus*)[33]
S. ovifelis	Cat (*F. catus*)[1, 2, 22]	Dog (*C. familiaris*)[1, 22] Man (*Homo sapiens*)[3] Mouse (*M. musculus*)[18]	Sheep (*Ovis aries*)[22, 24]	Cattle (*Bos taurus*)[24] Mouse (*M. musculus*)[18] Rabbit (*Oryctolagus cuniculus*)[18] Cat (*F. catus*)[23]
S. ovicanis	Dog (*C. familiaris*)[3-5, 22] Red fox (*Vulpes vulpes*)[6]	Cat (*F. catus*)[1, 22] Man (*H. sapiens*)[19]	Sheep (*O. aries*)[22, 25-28]	Cattle (*B. taurus*)[9, 24] Goat (*Capra aegagrus hircus*)[18]
S. bovifelis	Cat (*F. catus*)[3, 7-10] Wild cat (*Felis silvestris*)[3]	Dog (*C. familiaris*)[9, 10] Man (*H. sapiens*)[9, 10] Rhesus monkey (*Macaca rhesus*)[10]	Cattle (*B. taurus*)[9]	Cat (*F. catus*)[23] Mouse (*M. musculus*)[18] Rabbit (*O. cuniculus*)[18]
S. bovicanis	Dog (*C. familiaris*)[7, 11, 12] Wolf (*Canis lupus*)[3] Red fox (*V. vulpes*)[3, 13] Coyote (*Canis latrans*)[14] Raccoon (*Procyon lotor*)[13]	Cat (*F. catus*)[9, 13] Striped hyena (*Hyaena hyaena*)[3] Brown bear (*Ursus arctos*)[3] Rhesus monkey (*Macaca mulatta*)[13] Domestic pig (*Sus scrofa domestica*)[13]	Cattle (*B. taurus*)[9, 29-31]	Sheep (*O. aries*)[9, 13, 24, 25] Pig (*S. scrofa dom.*)[13, 19] Rat (*R. norvegicus*)[13] Mouse (*M. musculus*)[13] Rabbit (*O. cuniculus*)[13] Rhesus monkey (*M. mulatta*)[13]
S. bovihominis	Man (*H. sapiens*)[9, 10, 15] Baboon (*Papio cynocephalus*)[10] Rhesus monkey (*M. rhesus*)[10]	Cat (*F. catus*)[9] Dog (*C. familiaris*)[9, 10]	Cattle (*B. taurus*)[9, 32]	Pig (*S. scrofa dom.*)[21]

S. suicanis	Dog (*C. familiaris*)[3, 16, 17] Wolf (*C. lupus*)[17] Red fox (*V. vulpes*)[17]	Chimpanzee (*Pan troglodytes*)[16] Rhesus monkey (*M. rhesus*)[16] Cat (*F. catus*)[3, 16, 17] Tiger (*Panthera tigris*)[17] Swamp lynx (*Felis chaus*)[17] Brown bear (*U. arctos*)[17] Polar fox (*Alopex lagopus*)[17]	Pig (*S. scrofa dom.*)[3, 16, 17] Wild pig (*Sus scrofa scrofa*)[17]
S. suihominis	Man (*H. sapiens*)[15, 20, 21]	Dog (*C. familiaris*)[20, 21] Cat (*F. catus*)[20, 21] Pig (*S. scrofa dom.*)[18]	Pig (*S. scrofa dom.*)[17, 21] Wild pig (*S. scrofa scrofa*)[17]
S. equicanis	Dog (*C. familiaris*)[35]	Cat (*F. catus*)[35]	

[a] Hypercorticoid

[b] References: [1] Rommel et al., 1972; [2] Mehlhorn and Scholtyseck, 1974; [3] Rommel et al., 1974; [4] Ford, 1974; [5] Munday and Corbould, 1974; [6] Ashford, 1977; [7] Heydorn and Rommel, 1972a; [8] Heydorn and Rommel, 1972b; [9] Gestrich et al., 1975; [10] Heydorn et al., 1976; [11] Fayer and Leek, 1973; [12] Fayer, 1974; [13] Fayer et al., 1976; [14] Fayer and Johnson, 1975; [15] Rommel and Heydorn, 1972; [16] Tadros and Laarman, 1976; [17] Erber and Boch, 1976; [18] Heydorn, unpublished; [19] Munday, 1976; [20] Heydorn, 1977a; [21] Heydorn, 1977b; [22] Munday and Rickard, 1974; [23] Fischle, 1973; [24] Rickard and Munday, 1976; [25] Gestrich et al., 1974; [26] Ford, 1975; [27] Munday et al., 1975; [28] Heydorn and Gestrich, 1976; [29] Fayer and Johnson, 1973; [30] Fayer and Johnson, 1974; [31] Johnson et al., 1975; [32] Heydorn et al., 1974; [33] Ruiz and Frenkel, 1976; [34] Frenkel and Ruiz, unpublished; [35] Rommel and Geisel, 1975

Cyst measurements: Up to 5–6 mm in length, 100–200 μm in width. Cysts contain thousands of bradyzoites measuring approximately 3×13–15 μm[2] in section and 14–16×4–6 μm in impression films stained with Giemsa. Metrocytes exclusively present for 65 days, infectious bradyzoites present after 76 days (Ruiz and Frenkel, 1976).

Pathogenicity: slight for mice

Final Host

Felis catus

Sporocysts in feces of cat: 7.5–9.0 (8.5) × 8.7–11.7 (10.3) μm

Prepatent period: 5–11 days, patency up to 81 days

S. bovicanis Heydorn et al., 1975

(Syn. See Table 1)

Intermediate Host

Cattle (*Bos taurus*)

Cyst formation in skeletal and cardiac muscle and occasionally in brain beginning about 30–40 days after infection

Cyst wall: In fixed cysts the wall of the mature cyst appears thin (less than 1 μm) and smooth. By means of electron microscopy a small number of 0.6–3.0 μm long, flattened protrusions without fibrils are visible following an irregular course along the surface of the cyst, being visible also in native preparations.

Final Host

Domestic dog (*Canis familiaris*)

Wolf (*Canis lupus*)

Coyote (*Canis latrans*)

Red fox (*Vulpes vulpes*)

Sporocysts from the feces of the dog: 14.3–17.4 (16.3 ± 1.0) × 8.7–13.3 (10.8 ± 1.1) μm

Prepatent period: 9–10 days

Pathogenicity: sporocysts of the dog highly pathogenic for calves.

S. bovifelis Heydorn et al., 1975

(Syn. See Table 1)

Intermediate Host

Cattle (*Bos taurus*)

Cyst formation in skeletal and cardiac muscles beginning about 30–40 days after infection

Cyst wall: In formol fixed sections the wall of the mature cyst appears up to 5.4 μm thick and radially striated. By electron microscopy numerous 3.8–5.5 (4.7) μm long, straight, and commonly sloping protrusions containing 200–300 fibrils become visible.

Final Host

Domestic cat (*Felis catus*)

[2] Due to crowding and the curvature of *S. muris* in cysts, this measurement was derived from a few rare organisms that appeared isolated. Measurements from electron micrographs appeared slightly smaller

Feral cat (*Felis silvestris*)
Sporocysts from the feces of domestic cats: 10.8–13.9 (12.5 ± 0.8) × 6.9–9.3 (7.8 ± 0.6) µm
Prepatent period: 7–9 days
Pathogenicity: sporocysts not, or only slightly pathogenic for calves.

S. bovihominis Heydorn et al., 1975
(Syn. See Table 1)

Intermediate Host
Cattle (*Bos taurus*)
Cyst formation in skeletal and cardiac muscles beginning about 30–40 days after infection
Cyst wall: In formol fixed sections the wall of the mature cyst appears up to 6.9 µm thick and radially striated. By electron microscopy 4–7 (5.9) µm long, straight, and upright protrusions with numerous fibrils are visible.

Final Host
Man (*Homo sapiens*)
Rhesus monkey (*Macaca rhesus*)
Baboon (*Papio cynocephalus*)
Sporocysts from human stools: 13.1–17.0 (14.7 ± 0.8) × 7.7–10.8 (9.3 ± 0.5) µm
Prepatent period: 9–10 days
Pathogenicity: sporocysts from human stools not, or only slightly pathogenic for calves.

S. ovicanis Heydorn et al., 1975
(Syn. See Table 1)

Intermediate Host
Domestic sheep (*Ovis aries*)
Cysts: Microscopic in size
Cyst formation in skeletal and cardiac muscle and occasionally in brain beginning about 30 days after infection
Cyst wall: In formol fixed sections the wall of the mature cyst appears thick (up to 2.5 µm) and radially striated. By means of electron microscopy numerous 2.0–3.5 (2.8) µm long, palisade-like protrusions without fibrils become visible.

Final Host
Domestic dog (*Canis familiaris*)
Sporocysts: 13.1–16.1 (14.8 ± 0.8) × 8.5–10.8 (9.9 ± 0.7) µm
Prepatent period: 8–9 days
Pathogenicity: sporocysts highly pathogenic for lambs.

S. ovifelis Heydorn et al., 1975
(Syn. See Table 1)

Intermediate Host
Domestic sheep (*Ovis aries*)
Cysts: Ovoid, up to 1.5 cm in size

Cyst formation predominantly in esophagus, seldom in skeletal muscle; bradyzoites becoming infectious 8–14 months after infection (Munday, 1978)

Cyst wall: With numerous cauliflower-like protrusions 1.0–4.5 (3.5) μm long. Protrusions contain numerous fibrils. The parasitized host cell is enclosed in connective tissue forming a secondary cyst wall. Limiting membrane, a homogeneous layer 3.5 μm thick.

Final Host

Domestic cat (*Felis catus*)
Sporocysts: 10.8–13.9 (12.4 ± 0.8) × 7.7–9.3 (8.1 ± 0.5) μm
Prepatent period: 11–14 days
Pathogenicity: sporocysts not pathogenic for lambs.

S. equicanis Rommel and Geisel, 1975
(Syn. See Table 1)

Intermediate Host

Horse (*Equus caballus*)
Cysts: Microscopic in size, up to 350 μm
Cyst formation in skeletal and cardiac muscle
Cyst wall: In formol fixed sections the wall of the cyst appears thin (less than 1 μm) and is not striated. By electron microscopy a small number of 0.4–2.0 μm long protrusions following a course along the surface become prominent.

Final Host

Domestic dog (*Canis familiaris*)
Sporocysts: 15.0–16.3 (15.2 ± 0.4) × 8.8–11.3 (10.0 ± 0.3) μm
Prepatent period: 8 days
Pathogenicity: not investigated.

S. suicanis Erber, 1977
(Syn. See Table 1)

Intermediate Host

Domestic and wild pig (*Sus scrofa*)
Cysts: 50–1,500 × 15–100 μm
Cyst formation in skeletal and cardiac muscle beginning about 20–30 days after infection
Cyst wall: With numerous palisade-like processes which always stand upright, being 2.2–4.8 μm long. Filaments are present within these processes but are randomly arranged.

Final Host

Dog (*Canis lupus familiaris*)
Fox (*Vulpes vulpes*)
Wolf (*Canis lupus lupus*)
Sporocysts: 12.7 (± 0.5) × 10.1(± 0.3) μm
Prepatent period: 9–12 days
Pathogenicity: sporocysts are pathogenic for swine.

S. suihominis (Tadros and Laarman, 1976) Heydorn, 1977
(Syn. See Table 1)

Intermediate Host
Domestic and wild pig (*Sus scrofa*)
Cysts: Up to 5 mm in length
Cyst formation in skeletal and cardiac muscle and occasionally brain beginning about 20–30 days after infection
Cyst wall: In formol fixed sections of old cysts, a thin wall (1 μm) appears. In electron microscopy first upright protrusions become visible in young cysts, which in older cysts are folded over. In fresh preparations of old cysts, hair-like processes up to 14 μm in length appear. These processes contain filaments arranged in pairs.

Final Host
Man (*Homo sapiens*)
Sporocysts: 11.6–13.9 $(13.5 \pm 0.5) \times 10.1$–$10.8$ (10.5 ± 0.1) μm
Prepatent period: 9 days
Pathogenicity: pathogenic for man and pigs.

FRENKELIA spp.

The genus *Frenkelia* Biocca, 1968 was created for meronts in lobulated or spherical, and compartmented tissue cysts in the brain and spinal cord of certain rodents which could not be subinoculated directly from mouse to mouse. An obligatory heteroxenous cycle was recently described between *Frenkelia* of two microtene rodents and the common European buzzard, *Buteo buteo* (Rommel and Krampitz, 1975; Krampitz and Rommel, 1977). This predatory bird transmits *F. glareoli* (Erhardova, 1955; Enemar, 1963) from *Clethrionomys glareolus* (bank vole; Rötelmaus) and also *F. microti* (Findlay and Middleton, 1934) from *Microtus agrestis* (common vole; Erdmaus). Although brain cysts were fed to cats, dogs, and five to six genera of birds of prey, only the common buzzard, *Buteo buteo* (Mäusebussard), shed free mature sporocysts for a prolonged period of patency (Table 5).

Tadros and Laarman (1976, p. 34) assumed these sporocysts from European *B. buteo* to be 'identical' to those previously described as *Isospora buteonis* (Henry, 1932) from California. Tadros and Laarman (1976, p. 59) asserted that Henry's name had priority over several others from European mice, and on p. 83 (*loc. cit.*) proposed the name *Endorimospora buteonis* (Henry, 1932) comb. nov.

However, *I. buteonis* was described from three hawks in California, *Buteo borealis* (red-tailed hawk), *B. swainsoni* (Swainson's hawk), and *Accipiter cooperi* (Cooper's hawk), and from a short-eared owl (*Asio flammeus*) from Seattle, Washington. The sporocysts which were shed sporulated could, according to our present state of knowledge, belong to either *Frenkelia* or *Sarcocystis* in the Western United States. Interestingly, each of the two European *Frenkelia* was transmitted by only *B. buteo,* although six species of predatory birds were tested for their ability to transmit *F. glareoli* and five for their ability to transmit *F. microti.* Because of the apparent specificity in the final host (Table 5), it

Table 5. Animals experimentally tested for susceptibility to sporocysts and tissue cysts of *Frenkelia*

Frenkelia species	Sporocyst excretion after ingestion of cysts		Cyst formation in brain following ingestion of sporocysts	
	Positive results	Negative results	Positive results	Negative results
F. microti	*Buteo buteo*[2a] (Common European buzzard)	*Falco tinnunculus*[2] *Asio otus*[2] *Strix alucro*[2] *Tyto alba*[2]	*Microtus agrestis*[2] *M. arvalis*[2] *Apodemus sylvaticus*[2] *A. flaviocollis*[2] *A. agrarius*[2] *Rattus norvegicus*[2] *Mesocricetus auratus*[2] *Mus musculus*[3] *Mastomys natalensis*[3] *Cricetus cricetus*[3] *Chinchilla laniger*[3] *Oryctolagus cuniculus*[3]	*Clethrionomys glareolus*[2] *Cricetulus griseus*[3] *Meriones unguiculatus*[3] *Cavia cobaya*[3] *Erynaceus europaeus*[3] *Ovis aries*[3]
F. glareoli	*Buteo buteo*[1]	*Falco tinnunculus*[1] *Accipiter gentilis*[1] *Asio otus*[1] *Strix alucro*[1] *Tyto alba*[1] *Felis catus*[1] *Canis familiaris*[1]	*Clethrionomys glareolus*[4]	*Microtus arvalis*[4] *M. agrestis*[4] *A. sylvaticus*[4] *A. flavicollis*[4] *Mus musculus*[4]

[a] References: [1]Rommel and Krampitz, 1975; [2]Krampitz and Rommel, 1977; [3]Rommel and Krampitz, 1977; [4]Krampitz et al., 1976

appears likely that the sporocysts described from three California hawks and one owl also belong to specific cycles and probably at least four separate cycles. In view of their geographic isolation, in the Western US and Europe respectively, and the apparently single final host, there is little likelihood that even one of the American predatory birds would transmit *F. glareoli* or *F. microti*.

Therefore, *I. buteonis* is regarded as a *nomen dubium* and application has been made to the Commission to reject this binomial. Instead the binomials *F. glareoli* and *F. microti* should be preserved, and we have requested the Commission to enter them into the official List of Specific Names in Zoology. No names are proposed for American *Frenkelia* because their life cycles are not known.

Type species *Frenkelia microti* (Findlay and Middleton, 1934) Biocca, 1968 (Syn. See Table 1)

Intermediate Host

Common European vole (*Microtus agrestis*); for experimental hosts, see Table 5

Cysts: 0.2–1.0 mm, irregularly lobate, in brain and spinal cord

Cyst wall: Irregularly folded bilayer, thin, less than 1 μm (Tadros et al., 1972)

Final Host
Common European buzzard (*Buteo buteo*)
Sporocysts: 11.7–14.6 (12.2 ± 1.8) × 8.7–11.6 (9.9 ± 1.7) μm
Prepatent period: 7–8 days
Patency: 5–7 weeks
Pathogenicity: not mentioned, apparently slight.

F. glareoli (Erhardova, 1955) Biocca, 1968
(Syn. See Table 1)

Intermediate Host
Bank vole (*Clethrionomys glareolus*)
Schizogony in liver: 5–8 days
Cysts: Up to 400 μm, spherical in brain and spinal cord
Cyst wall: Irregularly folded with membrane and inner osmiophilic layer, both less than 1 μm thick (Kepka and Scholtyseck, 1970)

Final Host
Common European buzzard (*Buteo buteo*)
Gametogony in small intestine
Sporocysts: 11.3–13.8 (12.5 ± 0.38) × 7.8–10.0 (8.8 ± 0.79) μm
Prepatent period: 7–9 days
Patency: up to 57 days
Pathogenicity: polydipsia and polyuria.

Discussion

Considering the complex information required, new sarcosporidian species should only be described when all the essential critical data have been determined. Thus the premature designation of specific names for at-the-time unnamed taxa, such as *S. suihominis, S. murifelis, Besnoitia wallacei* (Tadros and Laarman, 1976), *S. porcifelis* (Dubey, 1976), and others, without personal study, new data, or even material for study appears ill-considered because it may introduce new *nomina dubia* or *nomina nuda*. The creation of new species is best left to those who experimentally studied the species and who can designate type material. Type specimens will be prepared from the eleven species redefined here and will be deposited with the following institutions and individuals, when the species names are accepted:

P. Beaver, Department of Parasitology, Tulane University, New Orleans, Louisiana, USA
R. Fayer, Animal Parasitology Institute, Agricultural Research Center, Beltsville, Maryland, USA
J.K. Frenkel, Department of Pathology, University of Kansas Medical Center, Kansas City, Kansas, USA
P.C.C. Garnham, Imperial College Field Station, Ashurst Lodge, Ascot, Berks. England
A.O. Heydorn, Institut für Parasitologie, Freie Universität Berlin, Berlin, Federal Republic of Germany
N.D. Levine, Department of Pathology and Hygiene, College of Veterinary Medicine, University of Illinois, Urbana, Illinois, USA
J.R. Lichtenfels, Animal Parasitology Institute, Agricultural Research Center, Beltsville, Maryland, USA

Table 6. Heteroxenous coccidia forming tissue cysts

	Cystoisosporinae	Toxoplasmatinae			Sarcocystinae	
In cysts		Bradyzoites only			Metrocytes and bradyzoites	
Propagative stages in final host	+	+	+	+	−	−
Oocysts		Sporulated outside host			Sporulated in gut	
Cysts	Monozoic		Polyzoic		Polyzoic	
Location	Lymphoid + ? other cells	Many cells	Fibroblasts	Striated muscle		Neurons
Wall	Inside cell		Includes cell		Inside cell	
Host cell nucleus	±	±	Hypertrophy, hyperplasia	±	±	Hypertrophy, lobulation?, hyperplasia?
Genus	*Cystoisospora*	*Toxoplasma*	*Besnoitia*	*Hammondia*	*Sarcocystis*	*Frenkelia*

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G. Piekarski, Institut für Medizin. Parasitologie, Universität Bonn, Bonn, Federal Republic of Germany
M. Rommel, Institut für Parasitologie, Tierärztliche Hochschule, Hannover, Federal Republic of Germany
A. Ruiz, Facultad de Medicina, Universidad de Costa Rica, San José, Costa Rica
W. Tadros, Instituut voor Tropische Hygiene, Amsterdam, Netherlands

This detailed discussion of the specific nomenclature of several members of the Sarcocystinae would be deficient without a brief review of the genera into which these species fit. Study of several species within most genera has yielded complete life cycles, permitting re-definition of each genus and proposals of new genera (Frenkel, 1977). The distinguishing features of the six genera of heteroxenous coccidia forming tissue cysts are shown in Table 6. They can be grouped into three subfamilies, within the family Sarcocystidae or Eimeriidae.

Distinguishing features of the Sarcocystinae are:

1. Lack of propagative stages in the final host
2. Sporulation of oocysts in the gut prior to shedding
3. Two morphologically distinct generations of zoites within the cyst:

a. The multiplying metrocytes present early
b. The infectious bradyzoites which develop after an interval of several weeks or months.

The Toxoplasmatinae show:

1. Several generations of propagative stages in the gut of the final host
2. Oocysts that are shed unsporulated
3. Polyzoic cysts that contain multiplying infectious bradyzoites only.

A newly proposed subfamily, Cystoisosporinae, is created for taxa with monozoic cysts.

The genera are formally defined elsewhere (Frenkel, 1977). The distinctive features of *Sarcocystis* are the formation of cysts in cardiac or skeletal muscle (occasionally aberrant cysts were found in brain), with cysts compartmented, and no significant change of the nucleus of the host cell in which the cyst is found. *Frenkelia* forms cysts in neurons, all those known are compartmented, and the host cell nucleus hypertrophies. Both have the additional attributes of the Sarcocystinae (v.s.).

The Toxoplasmatinae embrace three genera with cysts containing only bradyzoites. *Hammondia* typically forms non-compartmented, thin-walled cysts within skeletal and heart muscle fibers. *Besnoitia* induces a thick cyst wall around host cell fibroblasts, the nuclei of which are induced to undergo hypertrophy and hyperplasia. The bradyzoites develop in a cytoplasmic vacuole. *Toxoplasma* forms thin-walled cysts within many cell types, principally brain and muscle (smooth, skeletal, and cardiac).

Cystoisospora has been created for isosporid coccidia formerly thought to be homoxenous, which form cysts containing a single zoite in lymphoid and other tissues of intermediate hosts (Frenkel, 1977). Because it is sufficiently different from the Toxoplasmatinae, the subfamily Cystoisosporinae n. subfam. is suggested, with characters of the genus.

Life cycles have been studied from two or more species in each genus, except for *Toxoplasma* which we regard as monospecific. However, Levine (1977) considers *Hammondia hammondi* a species of *Toxoplasma,* and has added several morphologically defined taxa from reptiles and amphibians, in effect changing the genus into a collective group. This of course would diminish the information the present classification is designed to supply. Another controversy exists over the interpretation of the single zoite of *Cystoisospora* which some like to call 'waiting sporozoite,' 'dormozoite', or 'hypnozoite' rather than bradyzoite (Mehlhorn and Markus, 1976; Markus, 1976). Whether these forms are slow, sleeping, or soporific, interest in the group of heteroxenous coccidia forming tissue cysts has been alive the last 10 years.

The new, improved classification affects the status of only some coccidia of man. *Sarcocystis bovihominis* and *S. suihominis* replace *Isospora hominis.* Although their sporocysts differ but little, they are highly specific for only *one* intermediate host. *S. suihominis* is more highly pathogenic for man and pig than is *S. bovihominis* for man and cattle. The human *Sarcocystis lindemanni* is probably a species normally found in another host; the final host, from whose feces man infects himself occasionally, and the usual intermediate host have not yet been identified. *Isospora belli* has been found to have schizogony in the human intestine, and as oocysts are shed unsporulated, its taxonomic position is at present not in doubt. However, its oocysts have not yet been fed to potential intermediate hosts.

Classification in the last analysis is a tool of scientific communication. Concepts of what are essential measurements have changed, and the lack of type specimens cannot always be made up by historical inquiry. For those instances where recognized taxa could no longer be communicated precisely and

unambiguously following the provisions of the International Code (1964), we devised alternate means to express taxonomic information. It is our hope that the precision and expandability of the proposed terminology will promote the future stability of nomenclature of the Sarcocystinae and that they will facilitate communication if generally acceptable.

Acknowledgements. This collaborative analysis was facilitated by an award from the Alexander von Humboldt Foundation to the senior author and by research grant AI-07489 from the National Institute of Allergy and Infectious Diseases.

Prof. Dr. Mehlhorn was supported by DFG.

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Received July 31, 1978