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ORIGINAL ARTICLE

# A new species of plasmodiidae (Coccidia: Hemosporidia) from the blood of the skink *Scincus hemprichii* (Scincidae: Reptilia) in Saudi Arabia



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## KEYWORDS

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**Abstract** *Fallisia arabica* n. sp. was described from peripheral blood smears of the Skink lizard, *Scincus hemprichii* from Jazan Province in the southwest of Saudi Arabia. Schizogony and gametogony take place within neutrophils in the peripheral blood of the host. Mature schizont is rosette shaped  $17.5 \pm 4.1 \times 17.0 \pm 3.9 \mu\text{m}$ , with a L/W ratio of  $1.03(1.02-1.05) \mu\text{m}$  and produces 24(18–26) merozoites. Young gametocytes are ellipsoidal,  $5.5 \pm 0.8 \times 3.6 \pm 0.5 \mu\text{m}$ , with a L/W of  $1.53(1.44-1.61) \mu\text{m}$ . Mature macrogametocytes are ellipsoidal,  $9.7 \pm 1.2 \times 7.8 \pm 1.0 \mu\text{m}$ , with a L/W of  $1.24(1.21-1.34) \mu\text{m}$  and microgametocytes are ellipsoidal,  $7.0 \pm 1.1 \times 6.8 \pm 0.9 \mu\text{m}$ . with a L/W of  $1.03(1.01-1.10) \mu\text{m}$ . In comparison to the described *Fallisia* species, this new taxon has rosette schizonts and is larger than *F. dominicensis*, in Hispaniola, *F. bipocrati*, *F. poecilopi*, in Panama, *F. thecadactyli* in Venezuela, and *F. effusa*, *F. simplex*, *F. modesta*, in Brazil. *F. arabica* has fewer merozoites than *F. effusa*, *F. poecilopi*, *F. thecadactyli* and *F. siamense* in Thailand. This new species has more merozoites than *F. dominicensis* and *F. modesta*. All of these species belong to diverse saurian families (Agamidae, Gekkonidae, Polychrotidae, Scincidae and Teiidae) parasitize only thrombocytes or lymphocytes and some species parasitize immature erythroid cells and leucocytes.

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## 1. Introduction

Limited information is available about hemosporidians of Saudi Arabia. The first attempts to shed some light on this matter were made by Al Sadoon and Bahrawy (1998), Al-Sadoon et al. (1999). Additional studies in this regard came recently from Al Farrag (2008) and Alyousif and Al-Shawa



**Figures 1–3** Light micrographs of *F. arabica* from *Scincus hemprichii*. (1) Mature schizont (SCH). (2) Young Gametocyte (YG). (3) Mature macrogametocyte (MA) and Mature microgametocyte (MI). Scale bar = 10 µm.

(2011). *Fallisia* was created by Lainson et al. (1974) but later considered as a synonym of *Plasmodium* (Levine, 1985). Telford (1986) then described *Plasmodium siamense* as a new species, which led to the resurrection of *Fallisia* as a subgenus of *Plasmodium*. Telford (1974, 1988) later recognized *Fallisia* as a genus of Plasmodiidae after Gabaldon et al. (1985) demonstrated the absence of an erythrocytic cycle following experimental transmission of an avian *Fallisia* sp. Three species of *Fallisia* have been described from Polychrotidae, i.e., *F. biporcati*, *F. dominicensis*, and *F. poecilopi* from the lizards *Anolis biporcati*, *Anolis cybotes* and *Anolis poecilopus*, respectively, and 1 species of *Fallisia* from a gekkonid, *F. thecadactyli* from the lizard *Thecadactylus rapicaudus* (Valkiunas, 2005). *Fallisia simplex* was described from an iguanid lizard *Plica umbra* and 2 species, *F. effusa* and *F. modesta*, from the lizards, *Neusticurus bicarinatus* and *Tropidurus torquatus*, respectively (Lainson et al., 1974, 1975). All of these species were described from Central and South America (Neotropical region). In addition to these species, *F. copemani* was described from a skink *Carlia rhomboidalis* in Australia and *F. siamense* from the flying dragon *Draco maculatus* in Thailand. Here, we describe a new species of *Fallisia* from the lizard, *Scincus hemprichii*, from Saudi Arabia.

## 2. Materials and methods

*S. hemprichii* is a small sand-colored scincid lizard, which lives in semi-arid desert localities, particularly in open areas, with few shrubs. Twenty-five *S. hemprichii* were collected during March 2011 from Jazan Province in Saudi Arabia which lies in the southwest corner of Saudi Arabia. Animals were identified according to Arnold (1986). Blood samples were taken by snipping the tail tip of the animals. Blood films were dried, fixed in methanol, and stained in 3% Giemsa stain prepared in phosphate buffer (PH 7.4) for at least 1 h then mounted in Canada balsam (Abdel-Ghaffar et al., 1994) and examined with a Zeiss-1 Universal Photo-Microscope III in 100× objective lenses. Measurements in µm were made by using a calibrated ocular micrometer.

## 3. Results

### 3.1. Taxonomic summary

Genus: *Fallisia arabica* n. sp. (Family, Garniidae)

Type host: *S. hemprichii* (Weigmann, 1837) (Squamata: Scincidae).

Site: Mature neutrophil cells of peripheral blood.

Type locality: Jazan Province, southwestern region of Saudi Arabia.

Prevalence: Eight of 25 (32%) lizards infected.

Etymology: The species name “*arabica*” was derived from the name of the country.

Type slide: Held in the Parasitological Collections of the Zoological Museum, College of Science, King Saud University, Riyadh, Saudi Arabia, as KSUC 555.

## 4. Description

This parasite infects principally mature neutrophil cells of peripheral blood. Double, triple, and numerous infections of single host cells are observed (Fig. 1). Host cell is distorted by the displacement of nucleus by schizonts and gametocytes. Unruptured mature schizonts are rosette shaped, often filling the entire host cell (Fig. 2), measuring  $17.5 \pm 4.1 \times 17.0 \pm 3.9$  ( $n = 25$ ), with a L/W ratio of 1.03(1.02–1.05); 24(18–26) merozoites. Young gametocytes appear early in infection when schizogony ceases. Some of invading merozoites do not undergo nuclear division, but enlarge and become recognizable as young male and female gametocytes (Fig. 1). Young male and female gametocytes soon become distinguishable by staining reaction (Fig. 1). Gametocytes do not develop azurophilic granules in cytoplasm; they are ellipsoidal in shape and occupy the polar position of the host cell. Triple infections are seen, with 3 young gametocytes infecting the same host cell without distortion (Fig. 1). Young gametocytes  $5.5 \pm 0.8 \times 3.6 \pm 0.5$  ( $n = 20$ ), are with a L/W ratio of 1.5 (1.44–1.61) µm, mature microgametocytes  $7.0 \pm 1.10 \times 6.8 \pm 0.9$  ( $n = 20$ ), with a L/W ratio of 1.03 (1.01–1.10); delicate rose-pink in color, with scattered nuclear material and distinct nucleolus. Mature macrogametocytes  $9.7 \pm 1.2 \times 7.8 \pm 1.0$  ( $n = 20$ ); are with a L/W ratio of 1.24 (1.21–1.34); stained bright blue, sometimes with dense peripheral rim and a rather cyst-like appearance (Fig. 3). Nucleus is well defined. No azurophilic granules are seen in any of the gametocytes or asexual stages.

## 5. Discussion

There are 10 species of *Fallisia*, including this new species, *F. arabica* (Table 1). The description of the new taxon as a distinct species is based primarily on differences in structural features, host family, host specificity, and geographical distribution. *F. arabica* differs from all *Fallisia* species by

**Table 1** Comparative data of known species of genus *Fallisia* from lizards.

Species	Host	Schizonts		No. of merozoites	<i>Gametocytes</i>				Geographical distribution
		Shape	Size ( $\mu\text{m}$ )		<i>Microgametocytes</i>		<i>Macrogametocytes</i>		
					Shape	Size ( $\mu\text{m}$ )	Shape	Size ( $\mu\text{m}$ )	
<i>F. biporcati</i>	<i>Anolis biporcatus</i>	Round or oval	13.3 × 11.5	11 (9.1–38)	Triangular or Rectangular	12.6 × 9.0	Triangular	12.6 × 9.0	Panama
<i>F. copemani</i>	<i>Carlia rhomboidalis</i>	No data	No data	No data	No data	No data	No data	No data	Australia
<i>F. dominicensis</i>	<i>Anolis cybotes</i>	Round or Oval	6.0 × 4.8	12.4(8–22)	Round, Oval or	6.6 × 5.0	Round, Oval or Elongate	6.6 × 5.0	Hispaniola
<i>F. effusa</i>	<i>Neusticurus bicarinatus</i>	Round or Oval	10.0 × 14.0	100(50–150)	Elongate Oval	8.0 × 5.0	Elongated or Oval	10.0 × 6.	Northern Brazil
<i>F. modesta</i>	<i>Tropidurus torquatus</i>	Round or Oval	5.5 × 5.0	16(12–24)	Round or Oval	7.0 × 5.5	Oval	7.5 × 5.5	Northern Brazil
<i>F. siamense</i>	<i>Anolis poecilopus</i>	Oval or Elongate	7.7 × 4.7	31.0(20–51) 18(8–28)	Round or Elongate	10.1 × 8.0	Round or Elongate	10.1 × 8.0	Panama
<i>F. poecilopi</i>	<i>Anolis poecilopus</i>	Oval	7.8 × 6.5	No data	Round	7.9 × 5.6	Oval sausage	8.2 × 6.5	Northern Brazil
<i>F. simplex</i>	No data	No data	No data	No data	No data	No data	No data	No data	No data
<i>F. thecadactyli</i>	<i>Thecadactylus rapicaudus</i>	Oval, oblong or Triangular	10.3 × 8.0	40.2 (26–61)	Round, Oval or Triangular	10.4 × 7.0	Elongate or oval	10.4 × 7.0	Panama and Venezuela
<i>F. arabica</i> (This study)	<i>Scincus hemprichii</i>	Rosette	17.5 × 17.0	24(18–26)	Ellipsoidal	7.0 × 6.8	Ellipsoidal	9.7 × 7.8	Saudi Arabia

occurring primarily in neutrophils rather than thrombocytes or lymphocytes. The only species that infect neutrophils are *Plasmodium audaciosa* formally *Fallisia audaciosa* (Edilene et al., 2006; Lainson et al., 1975) and *Plasmodium leucocyta*, in Caribbean lizards. The new species differs from all *Plasmodium* species by the absence of hemozoin (Telford, 1974). *F. arabica* differs from *P. audaciosa* by the absence of azurophilic granules in both asexual (schizonts) and sexual stages (gametocytes); the former species also produces far fewer merozoites (18–26) in comparison to 50–150. The new species differs from *P. leucocyta* by the absence of azurophilic granules in both schizonts and gametocytes; schizonts are also smaller, i.e.,  $8\text{--}13 \times 6\text{--}10$  in *P. leucocyta* in comparison to  $17.5 \pm 4.1 \times 17.0 \pm 3.9$  in *F. arabica*. *P. leucocyta* parasitizes at least 7 types of white blood cells including neutrophils, while *F. arabica* infects mainly neutrophils (schizonts and gametocytes); finally, *F. arabica* produces far fewer merozoites (18–26) in comparison to 43–80 in *P. leucocyta*.

Genome analysis has created some confusion among taxonomists by challenging traditional systematic hypotheses, both within *Plasmodium* as well as relationships among the currently recognized genera (Escalante and Ayala, 1994; Escalante et al., 1995; Escalante et al., 1998; Martinsen et al., 2007; Perkins and Schall, 2002; Qari et al., 1996). One of the assertions suggests that a distinctive feature defining *Plasmodium*, i.e., schizogony in the vertebrate host erythrocytes, has been secondarily lost several times within the clade, signifying multiple shifting between avian and reptilian hosts (Perkins and Schall, 2002). While there is substantial genetic and morphological diversity among avian *Plasmodium* species (Bensch et al., 2004; Edilene et al., 2006 and Valkiunas, 2005), it seems that the number of reptilian *Plasmodium* species is still far behind compared to those of avian and mammalian hosts. However, a few of these lineages have been linked with morphospecies (Krizanauskiene et al., 2006; Sehgal et al., 2006). Some of the species in GenBank are misidentified not only at the species level, but at the generic and family levels as well (Valkiunas et al., 2008). We have concluded that the absence of pigment and azurophilic granules and the development of schizogony and gametogony in leucocytes by all species of *Fallisia* no doubt confirm that *F. arabica* possesses sufficiently unique features to distinguish it from other hemosporidian species.

### Competing Interests

Authors declare no competing Interests.

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