Short Communication

Morphology and Blood Value of Cuscus *Spilocuscus papuensis* Endemic to Waigeo Raja Ampat Island

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Abstract | The present study was carried out to determine morphology based on body hair patterns (spots) and physiology based on the blood values of adult males, adult females, and juvenile *Spilocuscus papuensis* (*S. papuensis*). In total, nine *S. papuensis ex situ* in the Manokwari Region of Papua (three adult males, three adult females, and three juveniles) were used in this study. Morphological observations of *S. papuensis* were based on body hair pattern and blood values, including erythrocyte count, leukocyte count, hemoglobin level, hematocrit number, platelet count, and leukocyte differentiation by laboratory analysis. Descriptive morphological data and quantitative data were analyzed using ANOVA testing. The adult cuscus appeared to have more spots (the male spotted pattern was larger than that of the female) than the juvenile cuscus, where the body pattern had not formed spots (spread). Based on such an obvious spot pattern, the sexes of *S. papuensis* could be distinguished by males having larger spots than females. The *S. papuensis* juveniles had few spots, and they were seen only in the fur pattern. However, the spots will grow as the cuscus age. The basic color of the body hair of *S. papuensis* in juveniles was yellowish white, but after adulthood, it changed to grayish white. Higher PCV and HB values in males and the number of erythrocytes and leukocytes (the highest number of neutrophils), respectively, were higher than the results in the foregoing study. Conclusion: There are different body hair patterns in male and female *S. papuensis*. Additionally, obvious differences in certain blood values of cuscus are generally assumed to be common phenomena in vertebrates, especially mammals.

Keywords | Blood value, cuscus, endemic, morphology, Papua

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INTRODUCTION

Cuscus is a type of marsupial mammal that comprises two genera: Phalanger and Spilocuscus. The genus Phalanger is a cuscus that has a dorsal line, while Spilocuscus does not have a dorsal line; however, it has a spotted color pattern on males (Flannery, 1995a). The cuscus is a protected animal in Indonesia, based on the Regulation of the Minister of Environment and Forestry of the Republic of Indonesia, number: P.20/MENLHK/SETJEN/KUM.1/6/2018.

One way to preserve cuscus is *in situ* and *ex situ* conservation. For this process to be successful, it is necessary to study biological data, such as morphological, physiological, and molecular characterizations. Many studies of such cuscus characterizations have been carried out. Based on the sequence of the 16S rRNA gene, the Indonesian cus-

cus descended into two clades, known as the group of the genus Phalanger and the group of the genus Spilocuscus (Widayanti et al., 2020). The results of the phylogenetic tree demonstrated that *S. maculatus* is closely related to *P. Gymnotis* and that *P. orientalis* is closely related to *P. urinus* (Usmany and Kakisina, 2019). Based on the COX3 gene, *S. maculatus* from Halmahera comes from Papua (Kunda et al., 2017). Kasi et al. (2019) stated that the main characteristics of *S. maculatus* are light brown to reddish brown dorsal coat color, dark brown to reddish spots on the anterior, and black spots on the posterior, which are irregularly located on a dirty white background. Dwiranti et al. (2017) investigated the number of leukocytes and counted the types of leukocytes and the ratio of neutrophils to lymphocytes in the cuscus Family Phalangeridae in Manokwari Papua.

One type of cuscus from the genus Spilocuscus is *S. papuensis*. This cuscus is commonly called *S. Waigeo,* or the scham-scham cuscus. This cuscus is endemic to the Waigeo Islands. Helgen et al. (2016) stated that the conservation status of *S. papuensis*, according to The International Union for Conservation of Nature , is "vulnerable," which indicates that this species is facing extinction in the wild in the future. To date, there have been no studies on the morphology (body coat color) and physiology (blood value) of adult males, adult females, and juvenile *S. papuensis*. Therefore, the present study was carried out to determine the morphology based on the pattern of body hair (spots) and the physiology based on the blood values of adult males, adult females, and juvenile *S. papuensis*.

MATERIALS AND METHODS

Ethical approval

This research and all its processes were approved by the Ethics Committee of the Faculty of Animal Husbandry, University of Papua.

Sample collection and observation variables

The current research was conducted on nine *S. papuensis ex situ* in the Manokwari District of Papua. The chosen sample comprised three adult males, three adult females, and three juveniles. The determination of sex was based on observations of reproductive organs, and age was based on interviews with owners. Blood collection was carried out at the base of the tail, with up to 3 ml each inserted into a tube containing ethylenediaminetetraacetic acid. Blood samples were immediately stored in a cooled box at a temperature of around 4°C (Sofyan et al., 2020).

The observation variable was the morphology of *S. papuensis* based on body hair patterns according to Kasi et al. (2019), and blood values included erythrocyte count, leukocyte count, hemoglobin level, hematocrit number, platelet count, and leukocyte differentiation by laboratory analysis according to Dwiranti et al. (2017).

Data analysis

Descriptive morphological and quantitative data were analyzed with an ANOVA test using SPSS 23 (IBM Corp.).

RESULTS AND DISCUSSION

The color of the body hair and the spotted pattern of adult males, adult females, and juvenile *S. papuensis* and their sketches can be seen in Figs. 1 and 2. The adult cuscus appeared to have more spots (the males' spotted pattern was larger than that of the females) than the juvenile cuscus, where the body pattern had not visibly formed spots. According to Flannery (1995b), *S. papuensis* has a grayish-white body covered in spots. The color pattern of *S. papuensis* is different from that of other Spilocuscus species in that this cuscus has black spots and not colorful spots. The female *S. papuensis* is also spotted, unlike other cuscus, where only the male has a spotted color pattern. According to Kasi et al. (2019), *P. orientalis* has white body hair and is yellow on the underside of the neck, and the dorsal area in the middle has black fur forming a straight line from the head to the tail. *S. maculatus* has reddish body hair and black spots or spots on the back of the body to the base of the tail, and the ventral or belly is white.

Figure 1: *Spilocuscus papuensis*: (a) adult male, (b) adult female, and (c) juvenile

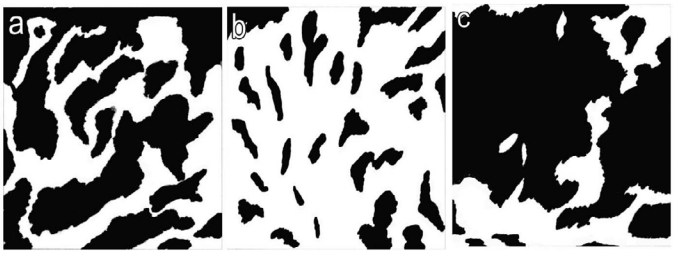

Figure 2: Body pattern sketch of *Spilocuscus papuensis*: (a) adult male, (b) adult female, and (c) juvenile

Based on such obvious spot patterns, the sexes of *S. papuensis* can be distinguished by males having larger spots (Figs. 1a and 2a) than females (Figs. 1b and 2b). These results are similar to the findings of Pine et al. (2017), who

Table 1: Average values of erythrocytes, leukocytes, hemoglobin, hematocrit, and platelets in each type of cuscus

Cuscus Type	Erythrocytes (10^6/µL)	Leukocytes (10^3/µL)	Haemoglobin (g/dL)	Hematokrit (%)	Trombosit (%)
Adult Male	7,28	8,6	12,8	338	309
Adult Female	7,83	14,2	8,6	26	120
Child	6,32	6,3	7,6	23	320

Table 2: Mean differential leukocyte values in each type of cuscus

Cuscus Type	Basophils	Eosinophils	Neutrophil band	Segmented neutrophils	Lymphocytes	Monocytes
Adult Male	0,00	6,00	2,00	50,00	40,00	2,00
Adult Female	0,00	4,00	4,00	42,00	46,00	4,00
Child	0,00	10,00	6,00	40,00	38,00	6,00

discovered that male *S. papuensis* has a white-to-yellowish base color and medium-sized blackish-brown spots with faded borders. However, they are considerably different from the findings of a study conducted by Dimomonmau (2000), which stated that male and female Waigeo Island cuscus (*S. papuensis*) have the same type and color pattern, which is similar to the color of the male *S. maculatus* Desmarest. Such an obvious difference is believed to be related to Dimomonmau (2000) only demonstrating patterns on the body in general and not distinguishing spot size when all Spilocuscus had spots on their bodies. Additionally, Flannery (1995a) stated that, in general, Spilocuscus did not have a dorsal line like the Phalanger but did have a spotted color pattern on the male sex. In this regard, Menzies and Pernetta (2009) also stated that the sex of the cuscus (*P. orientalis*) can be distinguished (sexually dimorphic) based on coat color.

The spots on *S. papuensis* juveniles are mainly seen in the fur pattern (Figs. 1c and 2c). These spots will form bigger spots as the cuscus ages. The basic color of the body hair of juvenile *S. papuensis* is yellowish white, but after adulthood, it changes color to grayish white.

According to Usmany et al. (2015), the spotted cuscus (*S. maculatus*) has a distinctive appearance of alternating black and white hairs, with a few gray and light brown hairs; the gray cuscus (*P. vestitus*) has a characteristic appearance of white hair and a few black and yellow hairs; the white cuscus (*P. urinus*) has the appearance of white hair color with a slight brownish yellow; and the brown cuscus (*P. orientalis*) shows the appearance of brown hairs and a few black hairs, forming a dorsal stripe.

The average blood values of adult males, adult females, and juvenile *S. papuensis* can be seen in Tables 1 and 2. There are differences in blood values between the males, females, and juveniles. In this case, the higher PCV and HB values in the males can be explained because males have greater body mass compared to females (Promislow, 1991); thus, differences in several hematological parameters between sexes are common among vertebrates, particularly among mammals (including marsupials), and have been directly associated with sex hormones, estrogens and androgens, in erythropoiesis (Barnes et al., 2008; Murphy, 2014). Differences in erythrocyte, HGB, and PCV concentrations due to age and sex have also been demonstrated in *Didelphis virginiana* (Zepeda-Espinosa et al., 2019).

The number of erythrocytes and leukocytes in this study was higher than the results of the study on *S. maculatus*; namely, the number of erythrocytes was 5.2 ± 0.4 (10^6/µL) (Runtuboi, 2016), and the number of leukocytes was 6.98 x 10^3/µL (Riliati, 2017). It is believed that this crucial difference is due to species differences. In this regard, Tibbo et al. (2004) stated that the number of erythrocytes is influenced by gender, race, and maintenance management. Furthermore, Bossart et al. (2001) stated that in addition to gender, blood parameters can be influenced by the age, sex, muscle activity, psychological condition, season, air pressure, and living habits of the species.

The leukocyte differentiation in this study showed the highest number of neutrophils. This study is in line with that of Wells et al. (2000) on the marsupial *Trichosurus vulpecula*. Neutrophils represent the predominant cell type in the blood of many, but not all, mammals (Tizard, 2018). All cuscus individuals appear to have no basophils, which aligns with the research conducted by Satyaningtijas et al. (2014). Notably, the cuscus does not experience inflammation or allergies (Ohnmacht and Voehringer, 2009).

The females' leukocytes being higher than the males' were similar to the results of Barbour's (1972) study on marsupials (*T. vulpecula*). Other than a physiological characteristic, it may be the result of either pathological leukocytosis due to the use of a potentially diseased animal (Godwin et al., 1964) or associated with blood removal (Jones et al., 1947). The amount of hemoglobin in females was lower than in males, while the number of erythrocytes was higher in this

study, in accordance with the results of studies of hemoglobin levels in mammals. Murphy (2014) mentioned that sex differences in mean hemoglobin levels and red blood cell mass are generally due to the direct stimulating effect of androgens in males and the inhibitory effects of estrogens in females. Androgens increase hemoglobin levels in males and females, while estrogens decrease them. Murphy et al. (2014) added that higher adult male hemoglobin levels occur in almost all mammalian species studied to date, including marsupials and monotremes.

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NOVELTY STATEMENT

The present study showed that cuscus *S. papuensis* has a different pattern of body hair between male, female, and juvenile animals.The obvious differences in some blood values of the cuscus are generally assumed to be a common phenomenon in vertebrates, especially mammals. To our knowledge, this is the first study to describe the differences in the pattern of body hair (spots) between males, females, and juvenile cuscus *S. papuensis*.

AUTHORS' CONTRIBUTIONS

F. Dwiranti and U.P. Maker: Formulated ideas and designed the experiment. F. Dwiranti, N. Fadhilah, and U.P. Maker: Conducted the experiment and analyzed the data. F. Dwiranti and P. Sambodo: Prepared the article for publication and analyzed the data. F. Dwiranti, N. Fadhilah, U.P. Maker, and P. Sambodo: Reviewed and edited the manuscript.

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